Studies on eOrganisation and Market Engineering 1

Dirk G. Neumann

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A Structured Design Process for Electronic Markets

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Universität Karlsruhe (TH)

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A Structured Design Process for Electronic Markets

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Preface

Electronic markets are increasingly gaining importance in the coordination of goods, services and financial payments. This trend is still ongoing, though not as visible as it was during the Internet hype. Markets that heavily rely on the use of electronic media are widespread ranging from one-shot allocation UMTS licenses, over to frequent inter-organizational coordination activities in supply networks, to the multi-billion dollar business of stock exchanges. All those electronic markets inherently need a deliberate design process. For any electronic market it is essential to define the rules of the game, specifying the transaction possibilities of the market participants, and to implement them in software. Market Engineering is designated to providing a structured approach on matching demand and supply against each other, executing the resulting transactions and finally supporting the technical implementation of real world systems.

In most of the cases, the design and implementation tasks of market engineering will be assumed by the market organizer, which is not independent in his decision making but frequently influenced by the many stake holders who are interested in different parts of the market venue. Among the most common stake holder groups, one can typically identify traders as customers, regulators and providers of complementary services (e.g. transportation, payment), each of them having rather different interests. Requirements from those stake holders will enter the market design depending on the particular role and importance of the stake holders and thus possibly contribute to a skewed decision making.

Still a fundamental lesson learned from Economics is that the conscious design of electronic markets is crucial for its working. Even worse, small changes in the design can have a significant effect on the results leading to markets that cannot satisfy the requirements of its key stake holders anymore. Besides these challenges, market engineers are regularly confronted with the problem of very large design spaces, as the set of commonly considered market parameters is rather huge. Thus, market engineering requires conscious design.

This insight gave rise to the development of a structured market engineering approach. With his work Mr. Neumann is focusing exactly on the support of electronic market design. For this purpose, he developed a market engineering methodology that spawns around two pillars. The first pillar is a design process that decomposes the holistic design challenge into smaller, less complex tasks for which solving methods already exist. As such, the second pillar of market engineering is a toolbox of particular methods. As with all prescriptive design process models, the market engineering process is a merely a best practice recommendation on how to proceed, not a law. This recommendation character accounts for the individual needs of the designers. Creativity is typically not as straightforward, as the design process model would suggest. Behavioral studies have shown that designers often zigzag on different design levels leaving the prescriptive design path. Any deviation from the design process model, however, creates uncertainty concerning the overall design process, resulting in trade-off between creativity and certainty. Thus, design methods support the designer in this create act of setting up electronic markets.

In this book, Mr. Neumann provides a complete process for electronic markets design together with the required engineering methods. As such the book is unique applying techniques from engineering design to modern Information Systems and Economics. Mr. Neumann succeeds in presenting a generic but coherent approach that is an indispensable aid in designing markets.

This book is the primer of the series on “Studies on eOrganisation and Market Engineering” that has been set up at the University of Karlsruhe. It presents a cornerstone in modern e-market design – many other books will follow along the lines laid out by Mr. Neumann’s seminal work.

December 2006 Christof Weinhardt

Universität Karlsruhe (TH)

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At this point, I would like to thank Professor Dr. Siegfried Berninghaus, Professor Dr. Andreas Geyer-Schulz and Professor Dr. Detlef Seese from the University of Karlsruhe for supporting my work.
I am indebted to the e-negotiation research group around Gregory Kersten and Martin Bichler for the many fruitful and inspiring discussions at various occasions about auctions and negotiations. This work has also been partially funded by the Social Sciences and Humanities Research Council of Canada (SSHRC) and the Alexander-von-Humboldt foundation within the scope of the TransCoop program.
Much of the content of this book was inspired by countless discussions with my colleagues of the Chair for Information Management and Systems at the University of Karlsruhe. The idea of Market Engineering was initially bred out in collaboration with Carsten Holtmann. It was a long way from the very beginning in Giessen to the establishment of a graduate school titled Market Engineering – a way that has passed many crossroads and filling stations.
Particular thanks deserve Daniel Rolli and Henner Gimpel for critical discussions that improved the ideas considerably. In this context, I would also like to thank Ilka Weber for her support in developing the knowledge system and Stefan Seifert for his critical objections.
Several other colleagues deserve thanks for reading my papers, (never ending) chapters and sharing ideas. In particular Clemens Czernohous, Juho Mäkiö, Björn Schnizler and Matthias Kunzelmann are to mention here. Additionally, for paving the way through the administrative jungle I am indebted to Daniel Veit for his experienced support. I would also like to thank my current and former colleagues who created a pleasant atmosphere that is prerequisite for assiduous work. In this respect, I would like to name Thomas Honekamp and Stefan Strecker.
Lastly, I would like to thank all my friends who do not fit into one of the former groups.
Personally, I would like to thank my parents, Paul and Erika, my brother Kai Uwe and his wife Agnieszka and my little niece Louisa. I completed this book also because of your encouragement, continuous support, enduring patience and love. I dedicate this work to you.

Dirk G. Neumann
Karlsruhe December 11, 2006

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1 Introduction

"The biggest challenge is convincing customers to switch their behavior, not simply beating a rival exchange to market" (Day, Fein et al. 2003, 141)

Once an unknown consulting firm noticed in one of their white papers, *"B2B markets work better in theory than in practice"*. This statement tediously concludes what many observers felt after the decline of the electronic market industry. The formerly celebrated stars of the new economy that were predicted to revolutionize the whole economy either survived with floundering transaction volumes or passed away. Not only the business-to-business market industry was shaken but also almost all other segments. Only the electronic stock markets and some other electronic markets, such as the almighty consumer marketplace eBay, opposed this negative trend. Despite those best practices the enthusiasm about electronic markets has sharply declined.

From the theoretical standpoint, a market embodies a coordination mechanism that allocates given resources. Ideally, the coordination mechanism should direct the resource to those members of a society who value them most. Other coordination mechanisms such as hierarchies using authority can also perform this allocation function fairly well. However, in cases where knowledge about the individual values is dispersed among the members, markets are the panacea to this allocation problem burdened by incomplete information. The marvel of coordination mechanism *"market"* rises in the price system that efficiently communicates the private information. The electronification of the coordination mechanism *"market"* to electronic markets even intensifies these positive communication and coordination effects. By means of electronic links the coordination mechanism can furthermore speed up business processes, provide access to global buyers and sellers, reduce search costs and provide a whole new array of transaction methods. Altogether is the potential of electronic markets to reduce the transaction costs between buyers and sellers undisputed (Malone, Yates et al. 1987).

Apparently, the prediction of theory is promising while the practice is – with exceptions – dull. The discrepancy between predicted and actual potential allow two interpretations. Firstly, theory is too optimistic or secondly there are severe implementation problems involved in the establishment of an electronic market.

The first interpretation is compelling: Theories concerned with coordination mechanisms such as mechanism design, auction theory and market microstructure theory analyze markets in well-defined and restricted environments. Accordingly, electronic markets are merely conceived as a conceptual construct where demand and supply meets. This view apparently concentrates on the coordination capability of electronic markets only, omitting technical issues of the trading platform as well as entrepreneurial aspects. Those technical and entrepreneurial issues can, however, cause effects that counter the positive effects arising from the coordination power of markets blurring the total effect. It is thus straightforward to assume that theory is too optimistic. Interestingly, despite these omissions, for stock exchanges and other highly standardized markets, those optimistic theories can mirror the real world in an acceptable way. Extensive use of IT and competition among different exchanges presumably keep those countering effects at minimum.

In less standardized markets such as B2B markets those optimistic theories may, however, not adequately reflect the reality. On the contrary electronic markets must – beside offering low operational costs – also "*provide an extremely compelling reason for moving tightly integrated business processes to a marketplace*" (Gartner Group 2000). To offer compelling reasons electronic markets thus need to have an in-depth understanding of the above trading processes and how the electronic market can improve them (Kambil and van Heck 2002). Comprising, it can be stated that theory is too optimistic, as it explains only parts of phenomenon electronic market.

The second interpretation aims at the complexity of electronic markets. As aforementioned, electronic markets are not only theoretical matching and allocation functions, but multifaceted systems. Those systems are not just evolving, but they have to be carefully designed (Roth 2000). For any electronic market that is about to go on line, it inevitably arises the problem of identifying *"compelling opportunities for value creation"* (Kambil and van Heck 2002, 54). Once these reasons are identified, a concept must be established how these opportunities can be developed. Ideally, this concept founds on the existent body of theories. Lastly, the concept must be deployed in practice. As such, *„the successful deployment and operation of an online auction system requires knowledge of mechanism design, system architecture, and successful Internet business practices"* (Wurman 2003). Apparently, implementation problems of electronic markets can occur at these stages of the design process:

- the identification of the compelling opportunities might be inadequate,
- the intended concept to unleash those value propositions might be flawed,
- the implementation of the concept into a software system might be erroneous.

Comprising, the second interpretation why electronic markets have been frequently failing addresses the problem of designing electronic markets. Due to their inherent complexity, electronic markets often make serious design flaws that may eventually force them out of business. *"Although based on sound design principles, implementation of marketplaces has been much more problematic than originally envisioned"* (Powell 2001, 11).

In summary, the first interpretation of too optimistic theory is presumably correct, as economic theory is indeed simplifying the real world. When leaving the model world, various other effects will counter the positive coordination effect of the market. If faulty designed, it can happen that negative effects outweigh the positives. Then, electronic markets cannot enfold their potential. As such, the design plays a critical role to find the right configuration of electronic markets.

1.1 Market Engineering

Both rather general interpretations are adequate to describe the discrepancies in theory and practice. By doing so, these two interpretations unveil two shortcomings in electronic markets. The first one refers to a deficit in theory. In the traditional economic theory, the market is only viewed as virtual matching and allocation function. As such, other influencing variables are assumed away. The second shortcoming is concerned with the design process. Few design processes exist, but for the very general level (cf. Lublinsky 2001; Kambil and van Heck 2002). This degree of abstraction, however, diminishes their applicability to a great extent.

This work can certainly not remove the first shortcoming. A comprehensive theory of electronic markets comprising many different models addressing several different aspects is needed. As markets are still not that well understood, this shortcoming will prevail. Accordingly, this book attempts to develop a framework of electronic markets. In essence a framework seeks to capture the real world by identifying and structuring the relevant influencing variables. One important part is concerned with the interactions between those influencing variables (Porter 1994). Thus, the primary contributions of this framework are the following:

- The framework structures all potential variables in one single framework. As such, it reveals the potential design space.
- The framework exhibits all the interdependencies among the influencing variables and may hint at potential interferences when applying different theories upon a phenomenon.
- The framework can serve as a meta-language for analyzing diverse theories. In other words, the framework can indicate, which influencing variables have been omitted in certain models. Thereby the total effect upon the objective of the electronic market can be assessed for the real world. The assessment, in turn, can take place by linking various economic models and hence combining their partial effects.

Furthermore, this book seeks for developing a systematic design process for electronic markets. Systematic processes are desirable, as they decompose the entire design task in several smaller, less complex design tasks. Design processes may become more tractable, reproducible, and more reliable. The systematic design process for electronic markets is termed market engineering. The primary contributions in the field of market engineering are the following:

- The foundation of market engineering derived from the previously mentioned framework for electronic markets.
- The transfer of the systematic engineering design process to electronic markets.
- The elaboration of the stages and phases of design process on an abstract level.
- The provision of dedicated design methods

As the proposed design process for market engineering is still on a very abstract level, this book concretizes the crucial phases of the design process and suggests appropriate design methods on a theoretical level.[1] More precisely, this book develops a strategy for designing coordination mechanisms that reconciles diverse economic models with experiments. Subsequently this book also suggests a design method how to refine the resulting coordination mechanism into a model with sufficiently low level of abstraction that traditional software engineering techniques may be applied in order to implement it.

1.2 Organization of this Book

Those two areas of contributions already hint at the point that the present book is concerned with two primary areas of research: The first area – headlined as design object – refers to the adequate description of the phenomenon electronic market. The second are – the design process – is concerned with the design of the parameters of the design object and it predicted impact on the outcome of the market. Those two areas embed the thread of this book, as Figure 1 illustrates.

[1] For practical approaches to market engineering it is referred to the book *"Making Markets"* by Kambil and van Heck (Kambil and van Heck 2002). Although the book is instructive, as many practical cases and lessons learnt from the market industry are presented, it widely omits the provision of a detailed prescriptive design process – that is concrete enough to be of any practical help but also is abstract enough such that many different cases can be subsumed.

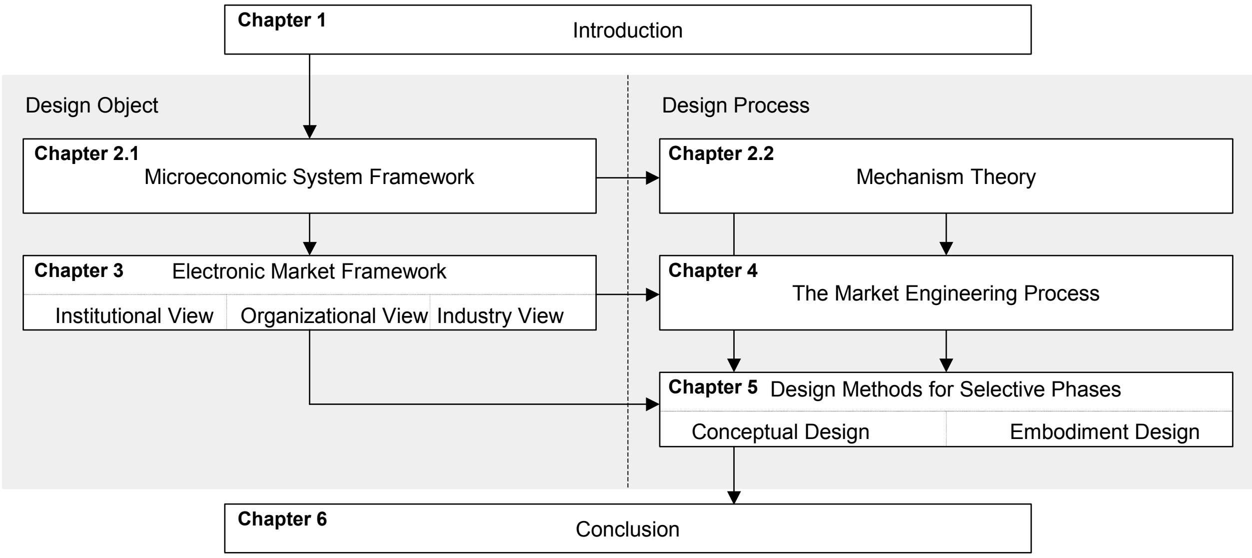

Figure 1: Organization of the Book

<u>*Chapter 2*</u> is devoted to an institutional analysis of the term market. As such, it is a contribution to economists who have ever been analyzing markets since their establishment as an independent discipline. In essence chapter two is divided into two parts. The *first part* characterizes the market as microeconomic system. More precisely, the market can be defined as an abstract mechanism that transforms offers from the market participants into outcomes, i.e. allocations of resources and corresponding payments. The microeconomic system consists of a few numbers of concepts that coin the market as institution, i.e. a set of rules. The set of rules are derived on a basis of a comprehensive literature survey, which reconciles two different disciplines, economics and computer science, into one, coherent framework. The computer science literature on mechanisms, so-called computational mechanism design, can be considered as natural extension of economic theory. In essence, computational mechanism design relies on the economic principles, but additionally adds computational aspects[2] to the analysis. As such, computational mechanism design extends the notion of institutional rules in various ways. By combining those two disciplines, this book provides an integrative framework on markets.
Based upon this coherent framework numerous theories can be established how the market performs in different environments. Accordingly, this book offers in the *second part* a broad overview about the different streams in theory. The emphasis is, thereby, on economic principles, as they provide insight of how the market is working.
As depicted in Figure 1, chapter 2 is the only chapter that covers both two areas of research, the design object and process: While the illustration of the microeconomic system framework clearly pertains to the design object, the theories study either the design of mechanisms for certain environments, or the impact of mechanisms on the outcome in given environments.

<u>*Chapter 3*</u> extends the microeconomic system framework to electronic markets. This distinction is necessary as chapter 2 isolates the analysis of markets to the study of the coordination mechanisms. Electronic markets are, however, more than just pure coordination mechanisms. They comprise also a technical and entrepreneurial infrastructure. The extension, thus, requires the relaxation of several implicit assumptions that were previously need for isolating the pure effect of coordination mechanisms. The most critical assumption that is dropped refers to the transaction costs of carrying out mechanisms. In reality operating electronic mar-

[2] Mainly the description of adjustment process rules and the analysis of computational tractability and feasibility are stemming from computational mechanism design.

kets is associated with costs that can be even substantial. This relaxation has major ramifications, which are deduced in the following: Since the operation is no longer free, an entrepreneur is needed that takes risk and establishes the electronic market. For the electronic market framework this implies that the institutional view on markets alone is insufficient to explain how electronic markets work. It is also essential to introduce the position of the entrepreneur as the opposite side of the same coin *"electronic market"*. Chapter 3 accounts for the entrepreneurial view in the so-called organizational view. When operating electronic markets becomes an entrepreneurial activity, it is naïve to consider electronic markets to be monopolists. Potential (super-normal) profit attracts other competing entrepreneurs also entering the market for providing electronic markets. As such, the introduction of the organizational view also requires the analysis of the industry view. In essence, this industry view observes not only one entrepreneur operating the electronic market, but also all competing entrepreneurs in the industry.

Chapter 4 introduces market engineering in analogy to the mechanism theory (chapter 2.1). While mechanism theory provides several insights concerning how to implement mechanisms in various environments, market engineering attempts to provide insights concerning how to implement electronic markets. There are, however, major differences between mechanism theory and market engineering. Mechanism theory understands implementation in pure theoretical sense. That is, a mechanism is a game-theoretic concept that achieves a certain desiderata is said to implement this desiderata. Market engineering extends this implementation definition to first define the (game-theoretic) mechanism and subsequently implement it into software. From this description it becomes apparent that mechanism theory is concerned with well-structured problems, whereas market engineering faces inherently ill-structured problems. While in mechanism theory it is possible to compute either the desired mechanism or the outcome of mechanism, computations are impossible in market engineering computation. Design decisions have to be made without any prior knowledge. Furthermore, the extension of the design object –from the market as mechanism to the electronic market as software system – entails an increase in complexity of the design problem. Market engineering thus applies the systematic design methodology introduced by the discipline of engineering design to the design of electronic markets. Accordingly, the problem is decomposed into several smaller tasks. In this context chapter 4 introduces a process for market engineering. As this process is highly interdisciplinary, this book combines marketing and management instruments and couples them with the engineering design methodology.

Chapter 5 takes a closer look on the crucial design stage conceptual and embodiment design. While chapter 4 illustrates the design process on a more general level, chapter 5 dives deeper into the design problem. Based upon the engineering design process, the market engineering process follows from the abstract to the concrete. The conceptual design phase is on a very abstract level and proposes abstract solutions to main design problems of market engineering. Essentially the electronic market is described according to its functions it executes. Those functions are further refined until an abstract solution principle can be found. One crucial function of electronic markets is concerned with the resource allocation process. In other words, the electronic market embodies a (game-theoretic) mechanism that needs design. Chapter 5 proposes the concept of a heuristic method – namely parametric design – that constructs the mechanism on the basis of mechanism theory. Since design knowledge is extremely context sensitive, it is naturally limited. Due to those limitations, the applied case-based reasoning approach cannot always fully solve the design problem. Thus, the suggested parametric design method may require manual input from experiments or other sources.
Since the results of this design method are fairly abstract, it needs refinement until it can be implemented. Chapter 5 also introduces a procedure how to transform the abstract concept of

the resource allocation process into a model of sufficiently low level of abstraction that traditional software engineering techniques may be applied in order to implement it. The suggested model or blueprint is based on AUML – an UML derivate – that explicitly accounts for the decentralized nature of markets. Furthermore, this book adapts a design methodology from agent literature, namely the Gaia methodology, to move from the abstract concept to the (semi-) formal blueprint in AUML.
Comprising, chapter 5 offers a coherent procedure that leads from the design requirements over the development of appropriate trading rules to the conceptualization into an implementable blueprint.

Finally, *chapter 6* summarizes the contributions of this book from the derivation of the framework, over the introduction of a market engineering process to the development of design methods. Chapter 6 closes with the discussion of future work directions, which comprises the enhancement of the market engineering process and its computer support.

2 The Institutional View on Markets

> *"Understanding of phenomenon is crucial to science; prediction without understanding does not build science"* (Sunder 2004**,** 503)

Traditionally, the discipline of Economics has been devoted to the study of markets. From the beginning of the discipline, markets have been viewed as a coordination mechanism. Adam Smith, the founder of modern Economics, coined the image of *invisible hands* characterizing the coordination ability of markets. By the interplay of demand and supply, the price system achieves (Pareto-) optimal resource allocations. This interplay is dubbed invisible hands because the free market forces achieve optimal results without interference by the government. *"Smith understood that knowledge was dispersed in the market system, and that the individual, knowing his local situation, could better judge than the "statesmen or the lawgiver" how to employ his capital to its greatest value"* (Smith 2003b**,** 991).

The Smithsonian view has been widely adopted by the neoclassical theory, which assumes the absence of interdependencies between the agents, i.e. so-called externalities. In such a situation coupled with perfect information[3] the market can solve the resource allocation problem. The resource allocation problem represents the *economic problem of society* in a way that consumer and producer plans must be brought into balance. Such a situation is commonly defined as competitive equilibrium. Competitive equilibrium is achieved if the agents of the economy have perfect information or if the agents are price takers, who cannot affect the price. The Coase theorem, furthermore, extends this theory in a way that the market will also attain competitive equilibrium, even in the presence of externalities. The Coase theorem, however, requires the absence of so-called transaction costs. In other words, the exchange of goods does not create search and information costs, bargaining and decision costs, policing and enforcement costs. The main contribution of neoclassical theory can broadly be interpreted as follows: the market will take care of the allocation problem, if permitted to do so (McAfee 1998).[4]

Hayek argues that the above stated problem is <u>*not*</u> the economic problem of society. *"The world of zero transaction costs turns out to be as strange as the physical world would be with zero friction"* (Stigler 1972, 12). Hence, the conditions under which competitive equilibrium are achieved is meaningless, as the underlying assumptions are unrealistic. Hayek reformulates the economic problem of society into *"how to secure the best use of resources known to any of the members of a society"* (Hayek 1945**,** 520). In a world of perfect information this is easy to achieve because the economic actors have all information about taste, social and physical constraints etc. However, in the absence of perfect information the actors have to decide over their consumption or production plans, without having all necessary information about the others. This coordination problem is solved by the price system. It is the price that summarizes and conveys all information about the other that are relevant for an allocation decision (Hayek 1945).

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3 From a game theoretic standpoint perfect information implies that any agent knows the payment matrix of all other agents.

4 In the original paper McAfee pinpoints this view by the statement "market design doesn't matter" (McAfee 1998).

Following these insights the market is the economic place of exchange that employs institutional rules in order to achieve an efficient allocation. The institutional rules of the market are commonly summarized under the term price system. The price system thus comprises all rules that are devoted to price discovery. However, there is not just one price system but many, since each industry has its own peculiarities, and technological conditions and organizational features that may be reflected in the markets within the industry and the markets that connect it with others (Smith 2003b).

This brief historical round up may clarify that markets are inherently connected with the price system. The price system in turn is not some sort of ambiguous construct but an institution. When markets are analyzed on the micro-level under quite realistic assumptions[5], it is indispensable to draw attention to institutions.

The purpose of this chapter is to give an overview about the notion and functionality of markets. This knowledge about markets will later on form the basis for the subsequent analysis of electronic markets. The chapter is divided into two parts. In the first part (chapter 2.1) the most important concepts of a *"market"* are introduced. In the second part (chapter 2.2), based on these definitions an overview about theory streams analyzing the impact of institutions and design institutions is given. The chapter concludes with a summary (chapter 2.3).

2.1 Microeconomic System Framework

Nobel laureate Vernon Smith introduced in 1982 in his influential paper the microeconomic system framework (Smith 1982), which will also mark the frame for this chapter and for the electronic market framework that will be introduced in the next chapter. Basically, Smith realized that the analysis of alternative institutions always share a common view on the structure of the economic system (Hurwicz 1959; Hurwicz 1969; Hurwicz 1973; Reiter 1977). This common foundation gave rise to the development of the formal framework, which is subsequently termed microeconomic system framework.

2.1.1 Overview

The microeconomic system framework sketches an economic system that consists of a very few well-accepted concepts: At heart it distinguishes between the economic environment and, a body of rules and regulation, the institution. Comparable with a machine, the microeconomic system is fed with inputs, the basic data of the economic environment and yields as its output an allocation of resources among the participating agents (Reiter 1977). This machine metaphor may explain why the term *"institution"*, which simply describes the set of rules, is closely associated with the term *"mechanism"*: A mechanism or more precisely an allocation mechanism can be viewed as a dialogue between agents that leads to an allocation of resources. Now the institution comes into play as its rules govern the dialogue process. Within the boundaries of the institutional rules the participating agents formulate their needs in terms of an order language the institution provides. Apparently, institutions limit the agents' response behavior, without uniquely prescribing it (Hurwicz 1973). Subsequently, the institution also determines the outcomes of the mechanism, which means the concrete assignment of the resources. The fundamental example of an institution is the "*market*", where essentially the price determines the outcome. At last, outcomes are subsequently evaluated with respect to the environment. Figure 2 clarifies the chain of causalities of the framework.

[5] This excludes models assuming perfect information and absence of transaction costs.

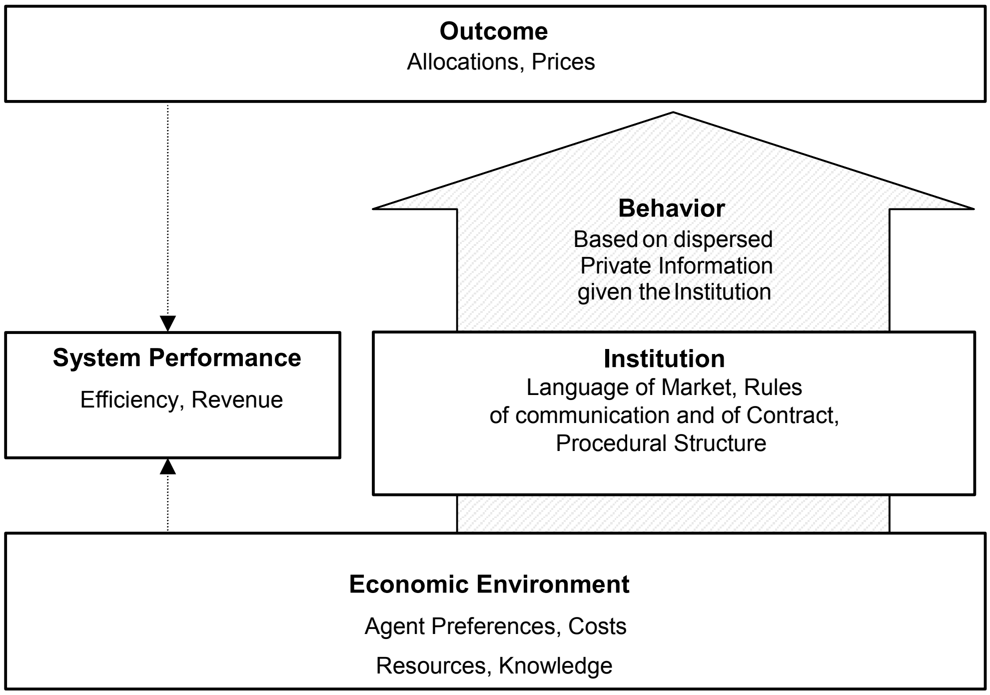

Figure 2: Microeconomic System Framework

Having described the general dependencies of the microeconomic system framework, it is necessary to understand the precise nature of the concepts and its sub-concepts. In the following the basic concepts economic environment, institution, agent behavior and performance characteristics are explained in depth.

2.1.2 Economic Environment

The study of resource allocation mechanisms requires the definition of the economic environment, for which mechanisms are analyzed in terms of performance measures. For example, traditional microeconomic theory finds out that for the narrow class of environments[6] the perfectly competitive mechanism satisfies allocative efficiency. If one of the restrictive assumptions are violated the competitive mechanism has different properties. This implies that a mechanism designer has to specify the economic environment. The economic environment summarizes all factors that affect demand and supply. The basic assumption inherent to the economic environment is that the mechanism designer cannot influence the environment.
Arifovic and Ledyard nicely summarize this definition as follows: *"First we take as given the environment, which is the set of all things outside the control of the mechanism designer which affect the performance of any mechanism"* (Arifovic and Ledyard 2002**,** 3).
In a related way, Hurwicz denotes in his seminal paper all elements of a system, which are exogenously given, as belonging to the economic environment (Hurwicz 1959; Mount and Reiter 1974). The emphasis lies on the exogenously given character of the economic environment.

Definition 1: Economic Environment

The economic environment describes the set of circumstances that have an impact on the performance of the system but are exogenously given.

[6] Namely those environments possess the divisibility and convexity properties without external effects. Furthermore it is required that a sufficiently large number of agents participate in the mechanism.

Nonetheless, the definition appears to be still very cloudy, since the set of circumstances allows a variety of factors. Vernon Smith states the economic environment more precisely, by defining it by the collection of all agents' characteristics (Smith 1989). But again this definition is too broad. Accordingly, a comprehensive enumeration of all those factors does not exist.

Economic theory has refined the definition of the economic environment towards a list of ingredients. It basically refers to the characteristics of the resources, preferences and initial endowments of the participating agents. Without being exhaustive, the main parameters include (Hurwicz 1959):

- the agents
- the characteristics of the agents
- the resource characteristics, and
- the individual resource endowments determining the feasibility of an allocation.

Nonetheless, these parameters determining demand and supply schedules (Smith 1989) are sufficiently comprehensive in order to characterize the environment. In the following those parameters are introduced and if necessary formally defined. Furthermore, it is explained why these parameters are important for the environment. Those readers who are familiar with standard microeconomic concepts can skip the discussion and jump directly to chapter 2.1.2.5, which contains a summary of the previous discussion and provides a formal description of economic environment.

2.1.2.1 Agents

The environment comprises the number of actors or actor groups[7] – say households, plants, agencies, or governments – who participate in the resource allocation process (Hurwicz 1959). If the number of actors is tantamount to the population of the system, no interpretation difficulties arise. However, the number of actors could also mean a subset of the population. This already hints at the possibility that the right to participate can be restricted by some sort of qualification e.g. a license, certificate or registration (Rothkopf and Park 2001). Reflecting the general definition for economic environment, the decision whether an actor is admitted to the market is exogenously given and not influenceable by the mechanism designer. This strong assumption will thus be held upright throughout the following sections but will be relaxed in section 3.1.1.1.
In market settings the participants typically can adopt different roles such as "seller" or "buyer". The number of participating agents adopting those roles affects the potential market power that single agents can exercise. Traditionally, the discipline of economics has analyzed the effects of the number of agents on the buy- and sell-side on the outcome. Roughly speaking, the general conclusion reads as follows: "the more competitive the market is, the less contingency is left for a single agent to significantly influence the outcome". As known from standard price theory, in a monopoly situation where one seller faces a large number of buyers, the seller can set the price. If the number of sellers is successively increased[8], the former monopolist gradually loses his ability to direct the prices. This intuition may point out the importance of the number of agents as a parameter of the economic environment.

[7] Actor groups are only permitted in the case that the group acts as one.
[8] The "Bertrand competition" demonstrates that two sellers are enough for competition. This conclusion follows from the idea of a ruinous competition: by mutually undercutting the prices in order to increase the own market share on expense of the other seller, the price reaches the competitive equilibrium (Vives 1999). Selten comes in his *"four are few six are many"* to a different conclusion (Selten 1973).

Formally, it is assumed that the environment consists of list of n agents N = {1,…,n}. In other words, the society N denotes the set of all n agents. Note that a distributed resource allocation problem requires n > 1, that is at least two agents must participate[9].

Example 2.1-1: Mechanism Designer

The term mechanism designer refers here to a theoretical benevolent planner, who selects the most suited mechanism for the society to attain a given goal set. Note that the mechanism designer first specifies the mechanism before the agents submit their demands. Accordingly, the mechanism designer does not actively take part in the market process and is consequently not part of the economic environment.
At this point the question arises why the mechanism designer does not adjust the mechanism once the agents submitted their demands. The answer refers to the long liveliness of the mechanism. Suppose it is costly to change the institutional rules, the mechanism designer will forfeit the chance to attain better outcomes in the face of the high switching costs (Jackson 2001).

2.1.2.2 Characteristics of the Agents

The characteristics of the agents are used here as a proxy for agents' decision making behavior. Complying with economic theory, agents are assumed to act in such a way that their expected utility (von Neumann-Morgenstern utility function) is maximized.
This statement implies that the agents may have different tastes and expectations. These different utility beliefs are normally expressed by a mathematical function, called utility function. Usually it depends on the level of consumption of resources evaluated with their individual preferences and, since consumption is uncertain, with their individual risk aversion.

2.1.2.2.1 Preferences

The preferences of agents are typically not alike. For instance, agent *i* might prefer allocation a to b, whereas agent j reversely prefers b to a. By introducing the idea of "types[10]" as an aggregate for the agent's characteristics, the microeconomic framework accounts for a diversity of agents. In a distributed resource allocation problem, a type expresses the preferences of an agent over different allocations. Preferences are accordingly intended to express how the alternatives are related to one another. In other words, preferences yield an ordering of all alternatives (preference ordering) (Debreu 1951).
In accordance with standard microeconomic analysis, each agent is assumed to have complete and transitive strict preferences over all outcomes (allocations).[11] Completeness of the preferences assures that any two allocations can be compared; so either allocation a is preferred to allocation b or vice versa[12]. By demanding strict preferences, indifference between two allocations is excluded. Transitivity is imposed on the preferences in order to avoid contradictory judgments[13].
Then, the preference ordering over allocations are numerically represented by a continuous utility function, which assigns a value to each allocation dependent on the *type* and on some *public information*.

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9 The case of one agent is trivial since there is only one feasible allocation of resources. If two agents are present – one buyer and one seller – the agreement process describes a typical bargaining process.

10 In literature, the term signal is often used as synonyms for type (Milgrom and Weber 1982).

11 Debreu first formulized the axioms for the theory of preferences of consumers (Debreu 1954).

12 Accordingly, constructs such as incomparability of two allocations are excluded. For a treatment of incomparable preferences see for example Faratin and van der Walle (Faratin and Van der Walle 2002).

13 If an allocation set A is preferred to set B, and B is preferred to set C, than the expression set C is preferred to set A contradicts the previously made statements.

The *type* is not directly observable such that the agents are indistinguishable. Accordingly, the type can be interpreted as a private signal. This does not inevitably imply that the agent knows the exact value of his private information, but at least he can estimate them. Those private signals can be either one-dimensional or multi-dimensional. In the easiest case, a one-dimensional signal can directly represent an amount of money that an agent is willing to pay for a certain item.[14]

Beside the private characteristics of an individual also some *public information* affects the utility function. These public information accounts for those information that are publicly known. Some information components may be observable by all agents, some other components are only vaguely known. Again, the agents have to make a guess about the value of the uncertain components. Suppose the drilling rights on a designated oil field are being auctioned. In this case the utility of the agents is clearly dependent on some public information. The oil field is observable and the same for all agents. Nonetheless, the supply of oil is uncertain.

Let x_i denote the outcome, i.e. amount of resources that is assigned to agent i, where the domain of x_i is X. The private information individual agents hold is represented by type $\theta_i = (\theta_{i1},...,\theta_{im})$, which lies in a type set Θ_i. Furthermore, it is assumed that agent i's valuation depends on the vector of private information θ_i and on a vector *s* of public information. Analogously public information can be either one or multi-dimensional, so $s = (s_1,...,s_l)$, where $s \in S$. The preference relation of individual i, v_i, is specified by $v_i : X \times \Theta_i \times S \rightarrow \Re_+$.

Example 2.1-2: "Independent Private Value Model"

Theories that analyze institutions naturally have to model the economic environment in which the institution works. As such, those theories are naturally apt to draw vivid examples from. In auction theory, the Milgrom-Weber model hallmarks a general treatment of single-sided auction environments (Milgrom and Weber 1982).

Suppose an art-dealer wants to sell a painting using an auction. In an extreme scenario the preferences of the participating agents can be totally independent of each other, assuming that the agents have a different taste and resale is not an option. In this extreme scenario the utility of an agent is only contingent on a single factor, the own taste. Since taste is neither observable nor affected by the taste of someone else, the utility depends on private information only. This setting is usually dubbed "Independent Private Value Model" (henceforth IPV).

In mathematical terms, the IPV model can be characterized by individual i's preference relation $v_i : X \times \Theta_i \times S \rightarrow \Re_+$, where $S = \varnothing$. Hence, θ_i is one-dimensional and the set of public information is empty.

Example 2.1-3: "Pure Common Value Model"

Another frequently applied setting denotes the so-called "Pure Common Value Model". The pure common value model simply asserts that the utility of all agents is only dependent on a public signal (information).[15] However, the difficulty is that this public signal is only vaguely known. Thus, the agents have to guess the proper value. The previously

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[14] As Milgrom and Weber pointed out, representing the type as a one-dimensional value requires two substantial assumptions. Firstly, the signal must account for the entire information set the agent has about the value of a resource. Secondly, the signal must also mirror all signals received by the other agents ((Milgrom and Weber 1982).)

[15] The pure common value model is a special case of the common value model. The common value model also allows the preferences to be dependent on private signals (Dasgupta and Maskin 2000).

mentioned drilling right auction beautifully epitomizes the common value model. The value of the drilling right is for all agents the same, meaning the amount of oil available is fix. However, it is nebulous what the exact amount of oil is. Each agent is left with estimating the total amount.

The pure common value model is represented by the individual preference relation $v_i : X \times \Theta_i \times S \rightarrow \Re_+$, where the public signal $s \in S$ is one-dimensional $s = s_1$ and $\Theta_i = \varnothing$.

Example 2.1-4: "Affiliated Value Model"

In the previous two examples, it was assumed that the private information is independently distributed among the agents. In many cases, this assumption may be too restrictive. Recall, that private information is also cloudy; hence the agents have to make their best guesses. Now it can occur that the agents have to revise their previous estimate, because they received other (private) signals. For example, in the drilling rights auction, it can happen that the agents correct their present estimates based on the information they received along the bidding process of the auction. More precisely, if an agent with superior information – say the agent possesses an oil field adjacent to this field and has already conducted geological surveys – places a new "highest bid" the other (less informed) agents tend to increase their previous bids. On an abstract level, the private signals are positively correlated: if one agent experiences a high signal it is very likely that other agents also received a high signal. These informational externalities, i.e. strong form of positive correlation, is denoted as affiliation (Milgrom and Weber 1982; Krishna 2002). The formal description of the affiliated value model can be found at (Milgrom and Weber 1982).

2.1.2.2.2 Risk Attitude

The preference relation renders the value agent i attaches to the allocation $x_i \in X$. As it can be assumed that the allocation is uncertain, the agent strives for maximizing expected utility. Note that there exists a "sure" amount of money that equals the expected value of the allocation. The agents can now express their risk attitude by choosing among the sure money and the risky allocation:

The risk-attitude of an agent is said to be *risk-averse*, if the agent prefers the money for sure to the risky allocation. Risk-averse bidders thus have a concave utility function. On the contrary, a risk-seeking attitude is characterized by the fact that an agent prefers the expected value of the risky allocation to the sure money. Lastly risk-neutrality assumes the agent is indifferent between both alternatives.

Risk-neutrality is characterized by the fact that the expected utility can be additively separated into two parts. That is the expected utility is quasi linear, as it is calculated by the expected valuation less the amount of money. The (expected) value of an allocation can thus be interpreted in terms of monetary units, say €. Altering the amount of money an agent possesses changes his (expected) utility exactly by the altered amount. The change in (expected) utility is independent of the amount of money the agent holds (Krishna 2002). Quasi-linear utility functions are, moreover, convenient as utility can be transferred via side-payments or transfers. For simplicity reasons it is common to assume agents to have quasi-linear utility functions (Parkes 2001; Jackson 2002a).

Formally, the agent i's utility function is defined as $u_i = v_i(x_i, \theta_i, s) - t_i$, where t denotes the transfers that have to be paid.

Example 2.1-5: Quasi-linear utility function

Suppose in an auction, a single item x is offered for sale. The auctioneer determines the allocation and the corresponding price. Agent i values the item with $v_i(x,\theta_i) = 100\ €$ and thus his utility function is given by $u_i = 100 - t$. With other words the agent receives a positive utility as long as the price is below 100.

2.1.2.3 Characteristics of the Resources

Unlike mechanisms, literature frequently prescinds from solidly formulating the characteristics of the commodities that are to be allocated. For example, Smith merely states about the commodities that there is *"[...] a list of commodities or resources {1,..., k}" (Smith 2000)*. This brief remark suggests – beside the number of commodities – that the units are discrete.

Usually the formal description of commodities abandons the physical characteristics of the resources but concentrates on their abstract essence such as:[16]

- Nature of the resource
- Discreetness
- Number of resources
- Number of units
- Degree of Homogeneity
- Substitutability and Complementarity
- Additional Attributes

The *nature of resources* is bivalent either private or public. Public goods[17] are characterized by two main properties. First, the principle of exclusion does not apply. This means that no agent can be excluded from consuming the resource. Second, the principle of non-rivalry (or non-subtractive) states, that the consumption of one agent does not diminish the amount of resources available to other agents (Varian 1992). Due to these properties, the (private) allocation of public goods is rather difficult. The reason stems from the fact that agents have an endemic opportunity to free ride. This means it is possible to enjoy the benefit of the public good without paying for it. Free riding is possible since a pay-per-use is impossible because of the two aforementioned principles. Since all agents of a society might have the incentive to free ride, the public good might not be produced at all. In the case of private goods, the resource allocation is still a challenging task although excludability and rivalry are possible.[18]

The *discreetness* of a resource specifies whether it can be consumed in discrete amounts only. Otherwise the resource is said to be continuous. Traditionally, organized markets discretize the continuous resources by the introduction of (discrete) tick sizes, a specific amount of resources forming the smallest tradable unit (round lot). This simplification reduces the granularity of the units considerably (Lomuscio, Wooldridge et al. 2003).

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16 This enumeration is again not meant to be exhaustive; it is intended to give an idea about the primary characteristics.

17 Traditional economics treats resources as goods. This treatment may surprise on the first view but having in mind that traditional economics regards services as immaterial goods it becomes clear why goods are prevalently used (Marshall 1920).

18 If information is dispersed among the participants, the well-known Myerson-Satterthwaite Theorem detects no exchange can be efficient, budget balanced and individually rational (Myerson and Satterthwaite 1983).

Let the vector x_i represent the amount of resources assigned to agent i. X denotes the domain of x_i which embodies an ordered set in $\Re_+^N$. When X consists of a number of integers, the resource is said to be discrete otherwise continuous.

The difficulty of the resource allocation problem increases with the *number of resources* to be sold. In the easiest case there are two resources: the one to be allocated and money. Money is the numeraire and assumed to be divisible. In the special case where only two resources (including money as numeraire) are present interdependencies among resources do by definition not occur.

The difficulty of resource allocation problem increases the more *units* of the resources are to be sold. In the easiest case only a single unit is contracted out. In literature, most of the distributed resource allocation problems have been devoted to environments where a single unit of a resource is allocated.[19] Recently, the attention has shifted to multi-unit auctions where the following differentiations are necessary.

Another characteristic of resources is their degree of *homogeneity*. Two goods are said to be homogeneous when agents consider them identical, i.e. they are indistinguishable from each other.[20] Otherwise the goods are said to be heterogeneous. In order to determine the notion of heterogeneity, it is convenient to recapitulate the origin of agents' preferences more precisely. Hitherto, it was assumed that the preferences of the agents are depending on private and public information. *Private information* is given by exogenous factors such as taste. As in incomplete games in game theory, nature determines the type out of the possibility set. By employing the fictitious player nature, agents receive heterogeneous tastes over allocations. Model theoretically this approach is fairly elegant since it captures the private nature of information. It does, however, not unfold the causes of the intrinsic preference ordering. Presumably, the preferences are not independent from the underlying resource that is to be allocated.
Homogeneity of goods is now derived from both information components, private (or intrinsic) as well as public (extrinsic). In the case of homogeneity the goods supposably share the same (physical) characteristics. If goods are heterogeneous they differ in certain characteristics. For example, in procurement situations, the resources may vary in performance or quality characteristics such as (promised) technical characteristics, delivery date, and managerial performance (Che 1993).

As in standard microeconomic analysis, the value of two items of heterogeneous resources must not necessarily equal the sum of values of each item. In the case the two resources are complements the value attached to a bundle is higher than the sum of their values attached to the single items. In informal words, synergies among resources constitute *complementarities*. Substitutes are conversely those resources whose value as a bundle is lower than the values *attached* to the single items (Kreps 1990). Substitutability and complementarities can thus be expressed by the preference structure of the society.

In addition to those attributes, the resources are characterized by *other physical or material conditions* that affect the preferences. For example, the quality of resources may vary. Again quality differences can be captured in the preference structure.

[19] *"By far the most commonly studied auction is that of a single object"* (Engelbrecht-Wiggans 1980). Although this citation is more than twenty years old, it is still valid.

[20] Homogeneous goods are characterized by the requirement of constant marginal rates of substitution equal to 1.

Example 2.1-6: Characteristic of the resource "stock"

Taking the aforementioned criteria into consideration the characteristics of the commodity *stock* is as follows. A stock represents a share in the ownership of an incorporated company. This share is naturally a private good, since principles of exclusion and non-rivalry do apply. If agent A possesses five stocks, no one else can hold those five stocks. Furthermore, the number of stocks is fixed since the number and its nominal value reflect the total nominal amount of money the company issued at the capital market. Since stocks are per definition standardized, they are homogeneous. Stocks are also per nature discrete – it is impossible to acquire non-integer shares.

At the bottom line, traditional economic theory expresses the characteristics of the resource in terms of the Debreuian preference ordering over discrete or continuous resources. Clearly, this approach cannot explain, why exactly two goods are substitutes and two others are not. For example, butter and margarine are by intuition substitutes whereas wood and butter are not. In microeconomic theory this is explained by the cross price elasticity (Varian 1992). Principally, wood and butter can be substitutes, as theory does not regard for some intrinsic characteristics why wood and butter cannot be substitutes (Lancaster 1966b). Nonetheless, introducing all potential characteristics would provide a rich description of a good, but also would be of less help, as generalizations are difficult to draw. Thus, economics usually focus on a subset of characteristics and on special descriptions of preferences (Tirole 2000).

In summary, expressing the resource characteristics in terms of agents' preferences, the commodity space and the space of feasible consumption sets allow describing the resource characteristics as a vector $\{\mathcal{H}, v, X)$. $\mathcal{H}$ denotes the set of resources in the society. Thereby the resources can be either discrete or continuous. The preference profile v comprehends substitutability relationships between goods and the degree of homogeneity. Lastly, the admissible consumption set defines how the resources can be consumed. Thereafter resources can be consumed only in specific proportions or more than one agent can consume resources, e.g. public goods.

Remark 2.1-1: Complex markets

Hitherto, it was implicitly assumed that the commodity to be allocated is accurately specified from the outset. This must, however, not necessarily be the case. *"[...] in some of today's complex markets the physical definition of the traded objects is not always clear"*(Jehiel and Moldovanu 2003**,** 273). For example, in procurement auctions the most appropriate object is investigated along the bidding process.

2.1.2.4 Endowment

The endowment specifies the feasibility of a resource allocation determined by the individual endowments and technology (Hurwicz 1973; Gjerstad and Dickhaut 1998). This implies that the mechanism can only allocate those resources that are lying idle in the storage or that can be produced given a certain technological level.

- Resource Endowment
- Technological endowment

The *resource endowment* states for each resource the number of units that are stored at the beginning of the observation period. The resources can be either the one that is to be allocated or input factors that are used to produce units of the former resource. Let w^i denote the vector of the initial endowment of the i-th agent. Hence, the total initial endowment of the system is $w = \sum_{i=1}^{N} w^i$.

One common way to describe technology of an agent is to specify his production function. The technological endowment of the agents delimits the feasible production plans, where *technological endowment* denotes the knowledge gathered along the production process in a "Learning by Doing" manner (Arrow 1962). The more experienced the agent is, the cheaper will the production process become. Technological endowment can be artificially divided into two parts (Romer 1990). The first part denotes the private, idiosyncratic component of knowledge that is generated by the agents through investments in research and development. Assuming that the (commoditerized) factor knowledge is completely kept secret appears to be unrealistic taking the immaterial nature of knowledge into consideration. As a side effect of private knowledge production, there also emerges a public component of knowledge through diffusion.

The technological endowment is naturally not constant over time, especially if the time horizon of growth theorists is adopted. However, talking about resource allocation processes the time horizon is rather short-termed. Accordingly, it is reasonable to assume the production processes of the agents to be fixed. Let T^i denote the technology of the i-th firm, which captures both the private as well as the public component of the firm's technology.

2.1.2.5 Environment Description

Having discussed the most relevant exogenous factors that influence the system performance, the concept of the economic environment can be tighter defined. The economic environment contains as basic data a set of all participating units (agents), the set of economic commodities, the initial resource endowments, the technology used in the production process and the preferences of the agents.

The used notation and terminology for describing the economic environment is as follows:

- $N = \{1,\ldots,n\}$: the set of economic agents $i = 1, \ldots, n$
- $\mathcal{H} = \{0,\ldots,K\}$: the set of $K + 1$ resources, where the 0-th commodity denotes the denominator money
- X: the admissible consumption set
- X^i: the i-th projection of X $\forall\, i = 1,\ldots,n\, , i \in N$
- w^i: the initial resource endowment of the i-th agent, where $w^i \in X^i$, and $w = (w^1, w^2,\ldots, w^n) \in X$
- v_i: the preference relation of the i-th agent on X[21]
- $v = (v_1, v_2, \ldots, v_n)$: the preference profile
- T^i: the initial knowledge endowment of the i-th agent (delimiting the feasible production set)
- $T = (T^1, T^2, \ldots, T^n)$: the technology profile

Depending on the effect the model is designed to explore, the assumptions impose a structure on some or all of these determinants of the environment.
Generally, an economic environment e is defined as: $e = (N, \mathcal{H}, X, w, v, T)$

[21] Assuming risk neutral agents the quasi-linear utility functions can be expressed by the preference sets.

Using the description of Ledyard *"the economic environment describes the problem and the range of possible parameter values including, if necessary, the structure of knowledge and beliefs about the likelihood of any particular environment"* (Ledyard 1993).

An *exchange environment* confines the definition of economic environments to those without production (Ledyard 1968). This definition becomes handy, as only trade relationships are observed. In the sequel, the term environment is used as a synonym for exchange environments.

The current definition environment can be further decomposed into pieces. This assumption appears not to be farfetched since "the data from which the economic calculus starts are never for the whole society given to a single mind" (Hayek 1945). Agents are accordingly assumed to have knowledge about their own preferences and endowments only. Knowledge about the agent characteristics is dubbed local environment since it contains mainly private information that is naturally associated with the (local) agent (Mount and Reiter 1974). An economic environment is said to be *"informationally decentralized"*, if the environment can be separated into *n* local environments. In other words, each agent has only partial knowledge about the environment, namely his own characteristics e_i of e. The i-th agent is characterized by the local environment $e_i = (w^i, v_i)$. Note that this definition already refers to exchange environments, as the technology effects are already removed.

Informational decentralized economic environments are then specified by the n-tuple of local environments. An informationally decentralized economic environment is defined as the totality of dispersed knowledge $e = (e_1, e_2, \ldots, e_n)$. Note that this definition of an informationally decentralized economic environment does not exclude that agents can adapt their preferences along the exchange process. In this case the environment would contain the determinants for altering tastes and knowledge (Smith 1982).[22] A major drawback of this formulation is that it precludes the presence of externalities (Hurwicz 1972). This certainly diminishes the applicability of this class of environment. Where a divergence from the assumption of informational decentralization is at hand, it will be specifically marked.

2.1.3 Institutions

Apparently, in resource allocation problems the mechanism itself *„[…] becomes a variable of the problem rather than a given invariant"* (Ledyard 1968, 227). In order to make this problem meaningful, it is necessary to define "some domain of variation" for this unknown variable. Hitherto, the term mechanism was broadly used to mean some sort of resource allocation process. In literature, the term mechanism is more precisely defined as a formal model of agent equilibrium behavior *under* a certain institution (see mechanism definition in chapter 2.1.6).

Institutions in general can be conceived as *"humanly devised constraints imposed on human interaction"* (North 1991b, 4). These constraints can be either formal or informal. Formal constraints denote strict norms, codes, laws or similar rules, whereas informal constraints are (more or less) self-imposed codes of conduct. Both types of constraints govern the interaction among the humans that deal with each other in an institutional setting. In the context of resource allocation institution thus denotes the totality of rules specifying the actions, which are required, permitted or prohibited.

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22 In this case, it is advisable to follow Postlewaite's proposal to apply a Lancastrian formulation of the utility function (Postlewaite 2001).

Beside these rules, institutions also define the enforcement characteristics if one or more rules are violated. As such, the effectiveness of enforcement determines the degree to which the objectives of the rules imposed by the institution match the individuals' decision-making behavior. The more severe these rules are enforced, the more costly the violation becomes. However, economic theory often ignores the regulation and enforcement aspects when comparing alternative institutions. It is traditionally assumed that the rules of the game are automatically followed and the resulting allocations and payments are with certainty enforced.

Definition 2: Institutions

Institutions denote the totality of rules imposed on human interaction processes.

Stated differently, the institutions expose the property rights an agent is granted in the interaction process. Property rights pertain in this context to the communication process and not as usual to commodities. This rather unfamiliar view is easy to understand if the right to speak, the right to demand the resource, or the right to demand transfer payments are conceived as private property. Those private properties are defined and constituted by the institution (Smith 1982).

Example 2.1-7: Institution of a stock exchange

An electronic stock exchange appears to be a meaningful example of an institution in order to allocate distributed resources. The resources that have to be allocated are stocks, which are naturally immaterial. Distortions incurred by transportation and storage can thus be neglected without any consequences. Furthermore, the institutional rules are formally defined. The operator usually takes care of the compliance of these rules.

Example 2.1-8: Institution of an auction

In an auction, the institution does not allow to place bids without serious intention to adhere to the bid specs. If someone fails to comply, the institution takes care of the sanctioning. One sanction could be the enforcement by law and the exclusion on subsequent auctions.

The difference between mechanisms and institutions lies in the additional assumptions of mechanisms. Different than institutions mechanisms are more specific to the economic environment, in particular to the allocated resources. This adherence is manifested by the value distributions of the agents on those resources (Krishna 2002).[23] From a practical standpoint, it becomes obvious that any mechanism is difficult to implement in practice as it depends on those fine details. The appeal that mechanisms should work well irrespective of the details has become known as *"Wilson doctrine"* after the advocate of detailed-free institution-design Robert Wilson (Maskin 2003). Nonetheless, in the following the term mechanism will be used in connection with some distributional assumptions, whereas institutions and resource allocation process will be used as detailed-free rules.

Detailed free institution design is currently not even in its infancy. Rather is the determination of the impact different institutions having on the performance dependent on those assump-

[23] An easy example may elucidate the difference between institutions and mechanisms. The institution determines how the resources are allocated among the agents: the highest bid for instance may receive the good. Mechanisms also contain this institutional rule. Moreover, mechanisms contain information about the preferences of the agents. As such a probability distribution can be determined who receives the allocation.

tions. Learning about the effects of mechanisms requires a deep understanding of the institutional rules. But which rules are crucial for the analysis. Since myriads of rules are conceivable in complex allocation situations, *"[...] scholars have been trapped into endless cataloguing of rules, sometimes in ways unrelated to theoretical theories"* (Ostrom 1998, 73). Nonetheless classification is a first towards developing a science. In the following institutions are decomposed into four types of rules language, choice rule, transfer rule, and adjustment process rules (Smith 1982; Wurman, Wellman et al. 1998; Parkes 2001; Jackson 2002a).

2.1.3.1 Language

The language determines the set of permissible actions an agent can perform along the market process. Conceiving the market process as a dialogue among the agents, these actions describe the exchange of messages. Accordingly, the language defines the nature and content of the admissible messages. These messages can be bids, offers, proposals of actions, or as they may contain information about the environment (Hurwicz 1973).

Example 2.1-9: Language of Exchanges

The stock exchange may allow the traders to submit market, limit, and stop orders. Another example for a language is taken out of the business-to-business (B2B) context. In e-procurement settings, it is common that a buyer posts a request for a certain contract[24] into the electronic marketplace. The participants are the sellers who compete against each other in a reverse auction by submitting descending bids.

Principally, the allowable messages cannot be identically available to every trader. One trader or trader group, respectively, can have additional messages at hand. In the previous stock market example, a market maker can enter a quote meaning a simultaneous buy and sell order. Messages are an expression of the agent' strategy, which generally can be a complex function of its preferences, other agent's messages, the institutions, etc.

Definition 3: Language

The language defines for all agents the set of feasible messages.

Formally, a language $M = M_1 \times M_2 \times \ldots \times M_N$ defines the set of feasible messages (message space) a generic agent i can send. The message[25] $m_i \in M_i$ is an element of the set of feasible message valid for agent i. Note, that the set feasible messages are not identical for all N agents. This accounts for different roles among the traders in the market process or may reflect privileges given to some traders[26]. The collection of all joint messages $m = (m_1, \ldots, m_N)$ is referred to as the message profile.

2.1.3.2 Choice Rules

The choice rules[27] govern the transition from messages to decisions. As such, the choice rules indicate the final resource assignment to all agents based on the submitted messages. That is, the choice rule is a mathematical function, either deterministic or stochastic, that maps the bids into an allocation.

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24 This is commonly denoted as a RfP, i.e. request for proposal (Saffady 2000).

25 The strategies the agent would like to play are confined by the message space. In chapter 2.2 the messages do not describe the set of feasible messages but the strategy of the agent.

26 The intuition behind those privileges is explained in more detail in section 2.1.6.5.

27 Sometimes the choice rules (Parkes 2001) are called allocation rules see for example ((Smith 1982))

Definition 4: Choice Rule

The choice rule determines the mapping of messages into an allocation.

Formally, the set of choice rules $X = (h^1(m), \ldots, h^N(m))$ consists of the individual outcome rules for each agent i. The superscript of h^i indicates that the applicability of the choice rule is restricted to agent or agent group i. Since the institution can support a vibrant exchange of messages, *m* refers here to the final message profile $x_i \in X$ denotes the outcome that is awarded to agent i.

Example 2.1-10: Choice rule of an auction

The choice rules of an ascending auction (e.g. English auction) awards the highest bidder with assignment of the good, all other bidders receive an allocation of zero. Different from the previous English Auction example, the institution can comprise more than one choice rule (Smith 1982). This heterogeneity of choice rules account for the different roles an agent or agent group can assume in an institutional setting. In the stock exchange example, the specialist, e.g. the market marker, is subject to other rules than other traders.
In the example of an ascending auction the outcome rule are identical for all i. The outcome rules are $x_i = h^1_{English}(m_1, m_2, \ldots, m_N) = 1; x_l = h^l_{English}(m_1, m_2, \ldots, m_N) = 0 \ \forall \ l \neq 1,$ where the messages are arranged in an ascending order so that $m_1 > m_2 > \ldots > m_N$, and i = 1 holds the highest bid.[28] This means that the auctioned item is awarded to the highest bidder i =1 whereas all other bidders receive nothing.

Example 2.1-11: Rationing rules

If two or more messages are equally good, e.g. offer the same price, rationing (or tie-breaking) rules must reject one or more of these offers (Wilson 2001). An English Auction for example applies the principle of *"first come first serve"*. Most theoretical models do not account for rationing rules as they assume preferences to be a continuous random variable. Then, the probability that the preferences of two agents match each other is zero.

2.1.3.3 Transfer Rules

The transfer rules show the transfers, i.e. payments that have to be made by the agents as a function of the message profile *m*. In order to produce adequate outcomes (e.g. efficient in a sense that the agents who value the items most are awarded with the items), the institutions usually have to provide incentives to the agents such that they behave in a desired manner.[29]

Example 2.1-12: Transfer rules

A vivid example where transfers are necessary is taken from the financing of public projects (Jackson 2002a). Consider a decision situation where N agents decide over the realization of a public project, say a public library. Further assume that the decision is binary either the library is completely built or not at all meaning that the scale is binary [0,1]. The costs for this public library are for convenience purposes assumed to be a constant amount C, which is a priori known. The utility the agents derive from this public library is given by u^i. The utility the society derives from it are thus the sum of all individual utilities. In case, the institution asks all the agents for their utility and then decides to build the library

28 To simplify matters, it is assumed for the moment that there are no ties.
29 This issue will be discussed in detail in chapter 2.2.1.1.

only if the utility of the society $\sum_{i=1}^{N} u_i \geq C$. If the costs are equally divided among all agents, the utility for agent i is given by $u_i - \frac{C}{N}$. If the net utility, i.e. the utility less the establishing costs is greater than 0, the agent will opt in favor of the project. However, this agent could be better off, if he announces a utility greater than u_i. Without incurring the danger to get higher charged, an overreport will only increase the possibility that the net society utility is greater than 0. Conversely, agents whose net utility is negative tend to understate their true utility. Clearly, this strategic behavior can lead to undesired (inefficient) decisions taking into consideration that public projects are not undertaken although their net utility is positive et vice versa.

This type of inefficient decisions can be fixed if the gainers/losers of the library are proportionally higher taxed/subsidized. Transfers are thus necessary to direct the users to a desired behavior.

Definition 5: Transfer Rule

The transfer rule determines the mapping of messages into corresponding payments or subsidies.

Formally, the set of transfer rules $t = (t^1(m), \ldots, t^N(m))$ comprises the individual transfer rules for each agent i. A transfer rule is represented by a function $t^i : M \rightarrow \Re^n$. Similar to the choice rules, the superscript of t^i indicates that the applicability of the transfer rule is restricted to agent or agent group with the denomination i. However, as Smith pointed out (Smith 1982), transfer rules are redundant since it could have been included in the definition of the choice rules. The decomposition into choice and transfer rules allows the separation of the resulting allocation and the transfers.

Remark 2.1-2: Transfers and prices

The transfers can be interpreted as prices either uniform or non-linear, which determines the exchange rate of resources. For getting an allocation of the resource the agent has to pay t^i units of money.

2.1.3.4 Adjustment Process Rules

The adjustment process rules specify under what conditions messages can be introduced, modified or repudiated along the market process. Hitherto, it was assumed that the allocation and the transfers are determined as a result of the message exchange. However, this view abstracts from the fact that message submission can also be subject to some constraints. The space of all adjustment process rules is naturally very huge, taking the many conceivable constraints[30] into consideration. The description is thus reduced to three rule types, which are general enough to capture a fairly complete set of adjustment process rules. Adjustment process rules consists of the following rules:

- Opening rules: $g^i(t_0, \ldots, \ldots)$
- Transition rules: $g^j(\ldots, t, \ldots)$
- Closing rules: $g^k(\ldots, \ldots, T)$

[30] The constraints can generally be distinguished into event, time, and state-oriented constraints.

Definition 6: Adjustment Process Rules

The adjustment process rules govern the control of the message flow.

Formally, the adjustment process rules are described as a set $G = \left(g^{1}\left(t_0, t, T\right), \ldots, g^{N}\left(t_0, t, T\right)\right)$[31]. Basically, these adjustment rules specify under what conditions messages can be introduced, modified or repudiated. As previously described, adjustment rules must contain an opening rule, transition rules, and a closing rule. The opening rule determines the condition $g^{i}\left(t_0, \ldots, \ldots\right)$, when the message exchange may commence. Transition rules $g^{j}\left(\ldots, t, \ldots\right)$ govern the flow of messages, whereas the closing rules $g^{k}\left(\ldots, \ldots, T\right)$ state the closing conditions.

2.1.3.4.1 Opening Rules

Opening rules define the beginning of the message exchange process. This time-period may be fix or dependent on the incidence of an event. Fix opening rules are pretty common in most auction formats. Frequently, the message exchange process commences at a particular time. Event-triggered opening rules also determine the start of the message exchange process but are less obvious than time-triggered rules.

Example 2.1-13: Opening rule of the German stock exchange

The German stock exchange accepts orders not before 7.30 a.m. At this time the pre-trade phase starts. Buy or sell orders can be entered into the system as a preparation for the subsequent trading phase. As this phase merely serves the order management, the agents do not receive any information feedback of the other messages. In the following phase, the messages are matched and executed against each other at a time, heralding the subsequent continuous trading phase.

In contrast to time-dependent rules, suppose the message exchange process only commences on the submission of a certain message by one agent. For example, in thin (illiquid) markets the submission of bid-messages commences with a request from a buyer or seller. This rule temporarily concentrates the messages at an arbitrary time.

2.1.3.4.2 Transition Rules

The transition rules state the conditions how the sequencing and the exchange are governed. The following list gives an overview over the most prominent transition rules.

- Internal dominance rules

  Dominance rules in general require, newly introduced messages, say bids, to dominate the previous highest bid in some specified form. Internal dominance requires the newly introduced bid to dominate the previous bids of the same agent. It is conceivable that internal dominance rules can apply not only to the buying but also to the selling agents. In the case of a double auction both sides – buying and selling side – are allowed submitting bids. Then, internal dominance rules for both sides are necessary.[32] Typically, internal dominance rules are either ascending or descending. Ascending (descending) internal dominance demands superior bids than the previous ones in terms of a higher (lower) price. More complex internal dominance rules can also account for multi-dimensional bids, where dominance is more difficult to define (Wurman, Wellman et al. 1998).

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[31] Usually, the arguments of the adjustment rules are assumed to be common knowledge (for a mathematical treatment of common knowledge see for example (Aumann 1976)), i.e. all agents know them in advance.

[32] No restrictions upon own bids are also a dominance rule.

- External dominance rules
  External dominance rules require that the newly introduced messages, say bids, do dominate the previous highest bid of other agents. For example, in an English auction not only the own highest bid must be surpassed but also the standing highest bid of all agents. The applied concept of external dominance (Wurman, Wellman et al. 2002) is again dependent on the resource that is to be distributed among the agents. Suppose the resource is a stock, implying a discrete and standardized good, respectively. In those cases dominance is often defined by a higher price at constant quantities.[33] For a more detailed description of dominance rules see for example Wurman, Wellman et. al. (Wurman, Wellman et al. 1998).

Example 2.1-14: External dominance rules

Stock Exchanges usually apply the principle of price-time priority as a dominance rule. This means that the first dominance criterion is the offered price. In case the price of several orders is equal, the time when the order was submitted becomes the criterion to determine dominance. Since early orders provide the market with additional liquidity, early orders are dominating late orders.

- Activity rules
  Activity rules are another intriguing example of transition rules. Basically, activity rules are intended to encourage truthful bidding in every stage of the market process (Milgrom 2000; Wilson 2001). The gist of activity rules is to confront the agents with an "to bid for it or lose it" (DeMartini, Kwasnica et al. 1998) decision at any stage of the process. If the agent fails to meet a certain minimum bid requirement, the agent is excluded from the subsequent market process.
  This exclusion reflects the idea of revealed preferences: by posting a bid the agent is partly revealing his preferences. The observed choice represented by the bid (e.g. a price-quantity combination) allows inferring the agent's utility. This inference can be used to impose bounds on the agent's subsequent bids (Kreps 1990; Varian 1992). If an agent fails to post a bid inside these bounds, he is excluded from the bidding process. Based on a single bid, the bounds are not very tight. However, as the bidding process progresses the bounds can become very close together. In this case there is only small or none room for strategic behavior left (Wilson 2001). In summary, activity rules prevent agents from improving their messages late in the process withholding information that might have been valuable for the other agents along the process.[34]

Example 2.1-15: Activity rules of the FCC-Spectrum auction

The Federal Communications Commission (FCC) -Spectrum auction is probably one of the most prominent examples in auction theory. Its design provides an easy version of an activity rule. The activity rule manages the eligibility status of all bidders. A bidder is regarded eligible, if he either holds the highest bid from the previous round or if he submits a bid which exceeds the previous round's high bid by at least the amount of the minimum bid increment. During the auction every bidder is granted a number of automatic waivers from this activity rule. If the bidder fails to maintain the demanded level of activity, i.e. uses up all waivers, he loses his eligibility status and is excluded from subsequent bidding rounds (Cramton 1997).

[33] Dominance is easy to define if the resources that are to be allocated are perfect substitutes, i.e. standardized. If the resources differ in their appearance, i.e. non-standardized, the concept of dominance is more difficult to formalize. Examples can be found under (Che 1993; Branco 1997; Wurman 1999).

[34] The success of activity rules in auction design is controversially discussed (Wilson 2001).

- Withdrawal Rules
  Withdrawal rules dictate whether the institution permits withdrawals and if so it specifies the time when withdrawals are feasible. As such, the withdrawal rules control the commitment with which the messages are released. The more stringent the messages are, the less room is left for strategic behavior. On the other hand, very restrictive withdrawal rules, e.g. no repudiation, remove much of flexibility away from the participating agents. Suppose the agents realize that their previous message is inappropriate they may not have a chance to revoke it. Usually, the current implementations of withdrawal rules are somewhere between those extremes. Revocation is only permitted at a particular time. Furthermore, revocation can come along with a penalty, say a fee. The size of this penalty can also vary depending on the time the message was withdrawn (Porter 1999).

  Example 2.1-16: Withdrawal Rules

  In most of the commercial applications, full commitment is required. As such, withdrawal is usually not possible. For example Moai's Livestock auction allows no withdrawal rules (c.f. Neumann, Benyoucef et al. 2003). In the FCC auction the high bidders can withdraw their bids. This is, however, coupled with a bid withdrawal penalty (c.f. Cramton 1997).

2.1.3.4.3 Closing Rules

Closing rules indicate the condition under which the message exchange process is ceased. Principally, there are several different ways to determine the closing of the messaging. Wurman identifies four common closing policies (Wurman 1999):

- Scheduled
  Analogous to the opening rules, closing rules can specify a particular time at which the bidding process is stopped. This so-called closing time is normally published in advance. The fixed-end closing rule is very straightforward. Nonetheless, this rule has recently attracted a lot of interest from the economic community, because it may cause a behavior called late bidding.[35] Note that processes that are performed in one-shot must have a scheduled end.

  Example 2.1-17: Scheduled closing rules

  A vivid example of scheduled closing rules associated with late bidding is eBay's second price auction. The bidder can enter a reservation price, which is posted to a proxy agent. The proxy agent always bids just one increment above the previous highest bid until the reservation price is reached. This format was intended to encourage early bidding, since it does not incur any detrimental effects. The proxy bidder adjusts the bids according to the actual bidding process. The auction is terminated at a specific point of time, which is public knowledge.
  Despite the fixed closing time, a lot of agents submitted their bids in the last seconds before the auction closes. Such a massive "snipping" behavior suggests that there are not only non-strategic but also strategic reasons. As the more informed bidders are reluctant to reveal their superior knowledge early in the auction, they prefer late bidding, such that the other bidders cannot react on their bids (Roth and Ockenfels 2002).
- Random
  Random closing rules refer to the case where the matching and allocation is scheduled at a random time. The ending time is usually following a previously specified distribution. In-

[35] Late bidding behavior does not necessarily occur in any institution embodying scheduled closing rules. For example activity rules can alleviate the effect of late bidding.

tended to prevent the agents from strategically bidding, the rule is also apt to heal the problems of scheduled closing rules. This is straightforward to explain taking into account that the agents simply do not know the exact closing time. By bidding late the agents run the risk of submitting their bids too late. On the other hand, late bids – which are revealed too early – may still grant the other agents time to react upon the new information before expiration.

Example 2.1-18: Random closing rules

Crossing networks epitomize institutions that embody a random closing schedule as one of their fundamental rules. Crossing networks refer to institutions, which allocate goods, usually stocks, at a so-called *crossing price* that is derived from another market that trade the same goods. The intuition underlying crossing networks becomes clear, if their primary area of application is closer delineated.

In stock markets, few professional traders[36] manage a large share of the total amount of stocks. Accordingly, their trading volume per order can be very large[37]. The trading size of these "block trades" can, however, induce a negative price effect. This price effect denotes the difference between the price before the block trade was submitted and the reaction of the other traders. One perspicuous explanation[38] refers to the set of private information. The potential traders may suspect that they have less precise information about the stock and thus run the risk of trading with an agent who has superior information. In order to assure from this risk, the traders demand a recompense from the block trader. This recompense nicely describes the negative price effect.

Now, crossing networks come into play. They collect buy and sell orders and allocate the stocks at a price that is derived from a reference market. The advantage is that the price is executed at the current price without the negative price effect.[39] Taking the size of the blocks into consideration, the block traders are tempted to manipulate the price of the reference market. The random closing rules are designed to discourage this manipulation behavior. Since the closing time is uncertain, manipulation is getting more costly because more buy or sell orders have to be submitted (Harris 2003).

- Agent inactivity

  The case of agent inactivity is another common instance of a closing rule. The message exchange process is terminated if no more messages are placed. On an abstract level, it can be assumed that the absence of new messages is reasoned by the fact that the institution has attained a situation in which the messages converge of to the real preferences of the society. This implies that every agent has had the opportunity to release an updated message. Principally, all agents can bid up to their valuations – if necessary. If all agents forfeit the chance to revise their messages, apparently no agent can improve his situation by placing another message.

  Note that agent inactivity can be coupled with a scheduled closing rule. In this case, the closing time is scheduled in advance. Different to pure scheduled closing rules the mes-

[36] In the finance literature professional traders are usually called institutional traders. This refers to the fact that these institutions, e.g. banks or insurance companies, are not trading for their own account, but (merely) conduits for someone else, e.g. retail customers. To avoid misunderstanding between institutions – understood as the set of rules – and institutions – understood as some sort of companies –, the term "professional traders" is used in the following.

[37] Note that a unanimous definition of a block is missing.

[38] Theoretically, there are many plausible explanations for this negative effect existing (see for example (Burdett and O'Hara 1987; Holthausen, Leftwich et al. 1987; Ball and Finn 1989).

[39] The disadvantage is that only a fraction of the entire block is executed. This market imbalance stems from the fact that the crossing price does not reflect demand and supply situation and hence cannot attain a market clearing.)

sage exchange process is automatically extended on receiving another message. The process is finally terminated when no further messages are posted.

Example 2.1-19: Agent inactivity closing rules

Auction Theory offers a comprehensive pool of examples for agent inactivity closing rules. For example, the perhaps most common auction format, the English auction, is often dubbed by the phrase "*going, going, ..., gone*". This phrase literally depicts the closing rule: The message exchange period stops after the closing has passed and no new messages are transmitted for some minutes.
Furthermore, the example of the English auction also confirms the convergence hypothesis. The agent with the highest valuation eventually clinches the deal. Under the strong assumptions of the IPV model, the optimal strategy is in deed "*bid up to your valuation*".[40]
In summary, the IPV model imposes a strict corset on the economic environment.

- Agent activity
  According to the agent activity closing-rule, the message exchange process is terminated once a pre-specified activity such as bid submission has occurred. For example, if a new bid is submitted that allows execution with a previously issued offer, the transaction is initiated. This example is taken from the continuous double auction, where allocation and price determination is performed whenever it is possible.

Example 2.1-20: Agent inactivity closing rules

The single unit Dutch auction is presumably the easiest agent-inactivity closing rule. Once an agent accepts the current price the auction closes.

2.1.3.5 Institution Description

Bringing the pieces of a trading institution together, each agent has the right to send some sort of messages to other agents. The messages are complying with a language, which specifies the nature and the content. Furthermore, the institution also regulates the sequencing of the message transfer, i.e. the agents do not have the right to place a message at any time. After the message exchange process ceases the institution constitutes the allocation of goods and the transfers for all agents depending on the previous message flow. Subsequently the allocation and transfer payments are enforced, which occurs in the microeconomic system framework immediately and for certain.

Figure 3 illustrates the resources allocation process. Opening and closing rules confine the message exchange process. Throughout this "communication process" the rules can change. Again, opening and closing rules delimit each phase with similar rules. What constitutes the resource allocation process is the processing of messages into choices and payments.

For example, the institution of an English auction the agents or better bidders have the right to place bids which contain a price. Bids can be placed at any time, only if their associated price is higher than the previous highest bid. The auction stops bidding for some minutes. The standing highest bid receives the auctioned item for the offered price. All other agents obtain nothing. Formally, the rights an agent has under an institutional setting are described by

[40] In the absence of common value components, externalities, … the optimal strategy in an English auction is characterized by "bid up to your valuation". Even under the strong assumptions of the IPV-model, the English auction is bothered by a multiplicity problem. However, strategies other than "bid up to your valuation" fail the test of trembling-hand perfection. (See for example (Wolfstetter 1999))

$I^i = \left(M^i, h^i(m), t^i(m), g^i(t_0, t, T)\right)$. The totality of all individual rights represents the microeconomic institution. That is, institution *I* is defined as $I = \left(I^1,...,I^N\right)$ (Smith 1982).

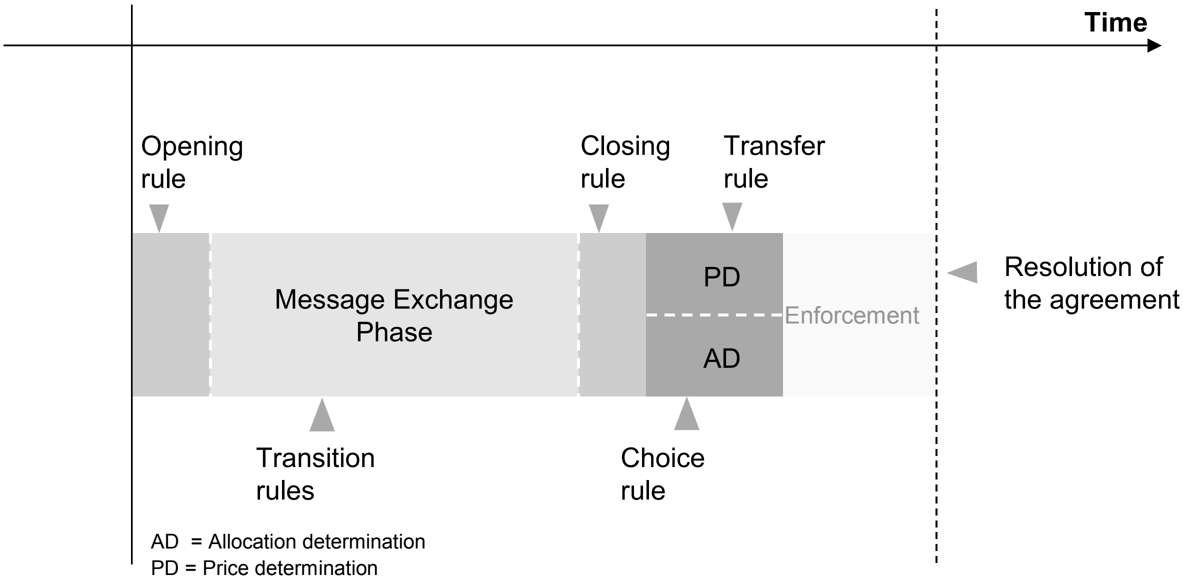

Figure 3: Stylized Resource Allocation Process

2.1.4 Microeconomic System

Now, the microeconomic system, managing the resource allocation process, can be defined as consisting of the economic environment e and the corresponding institution I. A microeconomic system is thus defined as $S = (e, I)$. Broadly speaking, a microeconomic system must contain information about the actors, particularly their preferences, about the resource or item that has to be allocated and the protocol of negotiating.[41]

By means of the microeconomic system the term *market* can be defined. This is, however, not that easy and unambiguous as the notion of the term market has changed. Traditionally the market was defined as the meeting point of demand and supply, which are balanced through the price mechanism. As such, the microeconomic system $S = (e, I)$ denotes a market. The economic environment determines demand and supply situation of a market, where the institution price brings them into balance (Henderson and Quandt 1980; Richter and Furubotn 1997). Hence, the institution in the traditional sense is rather unspecific: *"Although economists claim to study the working of the market, in modern economic theory the market itself has an even more shadowy role than the firm. [...] In the modern textbook, the analysis deals with the determination of market prices, but discussion of the market itself has entirely disappeared"* (Coase 1988, 7). As such, it is the price that attains the balance of demand and supply. Emphasizing the price-based coordination, the market embodies the price system, which is essentially an institution.

New institutional Economics has refined this unspecific institution description to the aforementioned definition. Apparently, the institution of a market is defined by a language, adjustment process, choice and transfer rule. In the market context, the transfer rule specifies the

[41] Note that a macroeconomic system usually comprises of actors that represent all agents of an economy or sector.

price an agent has to pay. Despite the deviations in the meaning of the institutions the market can still be defined as microeconomic system.[42]

Definition 7: Market

The market is a microeconomic system consisting of an economic environment and the price system as institution.

Remark 2.1-3: Some confusion with the term market

The use of the term market is sometimes confusing, as it is frequently used as an abstract aggregation of totality of bilateral relationships in a certain product (i.e. aggregation of goods and services). For example, the term *financial markets* refers to the aggregation of bilateral relationships without specifying the price system any closer. As the term *market* is an aggregate determinant, it can be arbitrarily often partitioned, where every sub-partition is again a *market*. Sometimes the market is partitioned concerning different institutions among the total market. Nonetheless all uses of the term have in common that they always refer to a microeconomic system.

2.1.5 Agent Behavior

The agent behavior constitutes a middle layer between the motivations of individual agents embedded in their local environment, the feasible actions confined by the institution and the resulting outcomes: Agents form their messages along the communication process based on their individual circumstances. It becomes obvious that *agent behavior* reduces in this context to *messaging behavior*. The messaging is, however, limited by the institutional rules. This middle layer is accordingly important to express that "institutions matter".
There are two major ways to describe the agent behavior (Reiter 1977):

(1) Static Description – Outcome Behavior
The static description of the microeconomic system is merely concerned with the final choices that determine the outcome (Smith 1982). Accordingly, the communication process takes place in a single step. This single step can be interpreted in two ways. Firstly, it can literally mean that the agents are only allowed to submit a one-shot message. Secondly, it can also mean that iterative communication is admissible but only the final message profile is of concern. In both cases the final message profile is converted into outcomes. Hence, the static description of the microeconomic system is depicted as outcome behavior; only the final allocation-determining message profile is relevant not how this profile evolved over time.
The outcome behavior of agent i, represented by a function $m_i = \beta_i\left(e^i \middle| I\right)$, determines the basis for the allocation.

Example 2.1-21: Outcome behavior

For example, in a "First-Price-Sealed-Bid auction" the institution prescribes the agents to post a single bid, which is sealed. The choice rule assigns the item to the agent who placed the highest bid. The price the winning agent has to pay is his actual bid, while all the other agents do not have pay anything. Furthermore, suppose the environment is described by

[42] Every market is a microeconomic system, whereas the reverse is not true.

an IPV-setting.[43] In this case, the only real choice the agents have is to select their bid (Milgrom 1989). Depending on their circumstances, they probably will bid a price lower than their valuation.[44] This so-called shading behavior accounts for the fact that the winner has to pay his bid. If an agent bids up to his valuation and finally wins the auction, his (quasi-linear) utility, valuation less the price, is zero. Accordingly, the agents can improve their situation by bidding less than their valuation (Wolfstetter 1995).
Suppose the institutional rules are slightly modified in a way that the price the winning agent has to pay is the bid of the second-highest agent leaving all other rules unchanged.[45] Then, the agents no longer have an incentive to shade. All what the agents can influence by their bid is the possibility to win the auction. The price, on the other hand, lies outside their control since it is calculated by the bid of someone else. Bid shading decreases the probability to win, without lowering the price.[46]

In summary, these two examples illustrate that the agent behavior is strongly affected by the underlying institutional rules and of course by the local environment.

(2) Dynamic Description – Response Behavior
The dynamic description of the microeconomic system is concerned with the process of exchanging messages among the participating agents. As such, it can explain, how the system approaches the *allocation determining* final message profile (Smith 1982). The communication process is modeled as an iterative exchange of messages among the participating agents. The agents can submit a message drawn out of the language at time *t*. Agent *i* submits a feasible message m_i at time *t* depending on his information set which consists of

- the private information e_i agent *i* holds (local environment)
- the information gathered along the communication process prior to time t

The latter (sub-) set of information is a little bit catchy to record. If there are more than three agents participating communication can be distinguished into two groups (Van Zandt 1999). Firstly, the messages are *broadcasted* to every agent, i.e. all agents receive the same pieces of information along the communication process. Secondly, the communication can be *targeted*, meaning that the messages are only posted to a specific group of recipients.

In traditional literature (Hurwicz 1973; Reiter 1977; Smith 1982) it is assumed the messages are broadcasted to all agents. Having assumed broadcasted communication, the response behavior of i-th agent at time t can be generically described by the equation $m_i(t) = f_i(m(t-1) \mid e_i, I)$. Function f_i marks an individual decision rule of agent *i*. The concrete appearance of this decision rule is part of a behavioral theory. The information

[43] The IPV model is the easiest formulation of an economic environment. The preferences of the participating agents are totally independent of each other. Recall Example 2.1-2: "Independent Private Value Model".

[44] As previously mentioned this implicit assumption – although logically plausible – already imposes a behavioral theory on the individual agent.

[45] In auction theory this format was designed by Nobel Laureate William Vickrey who also gave his name to the Vickrey auction (Vickrey 1961).

[46] The intuition is straightforward. Suppose agent i has the highest valuation. Further suppose the agent bid less than his valuation. In the case he wins the auction despite his shading, he still has to pay the price of the second highest bidder. However, there is also the case that the agent is not winning the auction due to his shading behavior. In this case, the agent cannot draw utility from the auction.

set the agents have at time t to form their decision is described by their local environment e_i, their set of feasible actions – limited by the institutional rules *I* –, and the messages received so far along the market process *m(t-1)*. The messages sent at time t are at this time not publicly posted, and are thus not part of the information set.
Economic theory has ever been busy with theorizing how individuals behave in economic situations. For example, the common assumption of utility maximization is simply a theory, and not a general, natural law.
The process is initiated at the starting time t=0 by an exogenous message profile. Subsequently, the previously mentioned transition process commences. At terminal time T, determined by the closing rule, the allocation is computed.
One popular closing rule is worthwhile to mention here since it may elucidate the coherence between the dynamic and static description of the response behavior. The particular closing rule of a simple exchange institution prescribes a closing of the message exchange process when no new message has been posted for some time. In other words, this means that the prevailing message profile converges to a stationary profile $\overline{m}$. A message profile $\overline{m} = (\overline{m_1},...,\overline{m_N})$ is said to be stationary if $\overline{m_i} = f_i(\overline{m}|e_i, I)$ for all i (Reiter 1977). In effect, stationary messages are converted into outcomes by the means of the allocation function. Considering only stationary message profiles yields the static description of the microeconomic system.

Example 2.1-22: Response Behavior

For example, in an "English auction" the institution regulates that the agents can place as many public bids as they want. Only bids toppling the previous highest bid are permitted. The auction closes when no bids have been submitted for a while. Subsequently, the auction is resolved by awarding the standing highest bid with the item for the bidden price. In this case the agents receive additional information about the individual preferences, since the agents can notice at what price the agents drop out of the bidding process. The institutional rules determine the minimum increment the newly introduced bid must exceed the standing highest bid. Now, the agents generate their bids by taking the standing highest bid adding the minimum increment if their valuation exceeds the standing highest bid. The iterative nature of the English auction entails that the agents successively "bid up to their valuation" before they drop out of the auction. The last standing highest bid wins the auction.

2.1.6 System Performance

Institutions are introduced to attain a desired set of objectives. The objectives pertain to the outcome that results from agent interaction along the message exchange process. Clearly, the institutions are not intended to attain these goals at random but rather frequently. In other words, the institution must set the right incentives such that agents behave in a certain way, that the (game-theoretic) equilibrium corresponds with an outcome, i.e. allocation and prices that satisfy the desired set of goals. Setting the right incentives is not easy as they are dependent on the economic environment.

In this context the notion of the term mechanism can be introduced that combines the institution and the economic environment. Broadly speaking, a mechanism describes the procedure by which the agents can realize an allocation. In game-theoretic terms the mechanism determines the rules of a game. Once this mechanism is set up, the agents submit their corresponding (equilibrium) messages (i.e. strategies) and receive their allocation share. Apparently, mechanisms are mappings from preferences, and each agent's information or beliefs about other agents, into allocations (Smith 2003b). Mechanisms create thus the connection between the economic environment via the messages (agent behavior) and the outcome dependent on the institutions.[47]

A mechanism $\mathcal{M}$ specifies the available messages and the rules how to resolve it via choice and transfer rules: For any message profile m =(m_1, m_2, …,m_n) the mechanism $\mathcal{M}$ computes the resulting allocation and transfers as an equilibrium solution.

Definition 8: Mechanism

A mechanism $\mathcal{M}$ is a pair *(M, y_M)* where M is the message space (language) and y_M the resulting choices and transfers.

Mechanisms thus create the relationship between the institution and the economic environment on the one hand and the outcome on the other hand. The system performance now measures the outcomes with respect to the economic environment. The outcome refers to the distribution of resources and the corresponding transfers, which is determined by $y^{SCF}(\theta) = \left(h^1(\theta), h^2(\theta), ..., h^n(\theta), ..., t^1(\theta), t^2(\theta), ..., t^n(\theta)\right)$. This function $y^{SCF}(\theta)$ is in literature termed *social choice function*. Note that the social choice function calculates the outcome as a function of the preferences and not as a function of the messages. As Figure 2 proposes, comparing the actual outcome with the social choice function yields the assessment of the goodness of the applied mechanism. In other words, there is generally an evaluation function, $U(X,\theta)$, which *"tells the designer how to value particular outcomes"* (Ledyard 1993, 127) with respect to the environment. Purely allocation-oriented measures may, however, ignore that mechanism itself can create frictions or so-called transaction costs are defined as the costs of running an microeconomic system (Arrow 1969). Transaction costs occur on a transaction, i.e. on the exchange of resources; as such they diminish the benefits from trade. A reduction of those frictional costs would consequently increases the individual gains drawn from trade and thus social welfare (Coase 1937). A performance measure should ideally not only take allocations but also the mechanisms into consideration. Apparently, transaction costs are such a comprehensive performance measure. To make transaction costs more manageable, they are split into coordination and motivation costs (Milgrom and Roberts 1992).[48]:

- Coordination costs arise from the need to determine the allocation and transfer payments and other details of the transaction, such as bringing buyers and sellers together. This means coordination costs comprise both allocation as well as mechanism-oriented aspects. For example, the transaction costs for a buyer are the price he has to pay for a good and the time he spent searching for a corresponding partner.
- Motivation costs are associated with *informational incompleteness and asymmetries* and *imperfect commitment*. Informational incompleteness and asymmetries refer to situations where the participating agents do not have all relevant information. Due to the lack of this relevant information they cannot determine whether the terms of the agreement are mutually acceptable. The agreement can – although beneficial for all participating agents – fail, as the agents may fear to be shortchanged. Alternatively, the agents can make costly protections against shortchanging, which basically are transaction costs. Imperfect commit-

47 The way a resource allocation mechanism works is not independent of the domain, which is represented by the economic environment. A resource allocation mechanism yields different outcomes when applied on a different class of environments. As such, the study of mechanisms *"must be made with reference to the class of environments to be covered"* (Hurwicz 1959) and in the light of some performance characteristics.

48 Dahlman summarized transaction costs as search and information costs, bargaining and decision costs, policing and enforcement costs (Dahlman 1979).

ment refers to the inability of the participating agents of binding themselves to their announcements. This inability stems from the fact that the agents once they announced either a threat or a promise, would like to renounce. For example, a supplier make a large investment in order to accommodate the specific wishes of a manufacturer. The contract between the supplier and manufacturer defines the prices the manufacturer has to pay. After the supplier has made his investment, the manufacturer may want to renegotiate the contract. As the investments are basically sunk costs, the manufacturer can force lower prices and other concessions. Prior protection against opportunistic behavior is costly, constituting also transaction costs.

As Milgrom and Roberts note is the transaction cost approach appealing, but not applicable to all problems of economic institutions (Milgrom and Roberts 1992). The primary criticism here is not associated with the concept of transaction costs, but with the desiderata that institutions should be designed such that those transaction costs are minimized.[49] For example, why should a seller design an institution that minimizes the transaction costs of the system, consisting of the seller and buyers? Instead the seller presumably cares for only those costs he personally has to bear.

Group	*Criterion*	*pertains to*
Efficiency	Allocative efficiency	Allocation
	Informational efficiency	Mechanism
Optimality	Revenue maximization	Allocation
Solution	Equilibrium and convergence	Mechanism
	Number of iterations	Mechanism
	Stability	Allocation
Feasibility	Allocative feasibility	Allocation
	Budget balance	Allocation
	Informational feasibility	Mechanism
	Incentive feasibility	Mechanism
Fairness	Pareto-satisfactoriness	Allocation
	Institutional fairness	Mechanism
Tractability	Simplicity	Mechanism
	Computational tractability	Mechanism

Table 1: Objective Categories

The transaction costs approach cannot constitute the overall goal. Instead the general evaluation function $U(X,\theta)$ can comprise various objectives or desiderata. The following discussing attempts to describe the most commonly desiderata for the evaluation function used in literature. The goals are classified into six groups according to their scope as Table 1 illustrates.

The first column describes the general category of goals; its sub-goals are further shown in the second column. The last column exhibits whether the goal pertains to the mechanism or to the resulting allocation.

2.1.6.1 Efficiency

In general efficiency denotes the capacity to produce desired results with a minimum expenditure of energy, time, or resources (Merriam-Webster 2002).

[49] In fact, there are more limitations of the transaction cost approach (see for example Milgrom and Roberts 1992).

Principally, the following two criteria can be defined:

- Allocative Efficiency
- Informational efficiency

Allocative efficiency is a very old and well-defined concept in Economics. Traditional welfare theory provides measures and criteria to evaluate and compare different allocations in micro-economic systems. There are several efficiency criteria, but most of those are fairly restrictive and bear some problems in their general applicability. The most common efficiency criterion is that of Pareto-efficiency. Pareto efficient resource allocation denotes an allocation, for which no other allocation exists, that makes at least one agent better off without making at least one agent worse off.
Pareto-efficiency is often mistakenly listed as a mechanism property. However, Pareto-efficiency refers to the imputed allocation and not to the mechanism. Pareto efficiency can be defined in an ex-post and ex-ante sense. Ex-ante efficiency takes preferences over *expected* allocations in consideration, whilst ex-post analyzes preferences over *realized* allocations.
A mechanism that maximizes the sum of individual utilities (i.e. the sum of surpluses conditional on the given information set) is called efficient. This efficiency concept commonly used in mechanism and auction theory corresponds with Pareto-efficiency only when utility is transferable among the agents.

Remark 2.1-4: Efficiency and Common Values

In the case of the pure common value model (see Example 2.1-3) the issue of efficiency becomes trivial, as any outcome that assigns the resources with the probability 1 to an agent is efficient. This is intuitive since all agents have the same (common) valuation (McLean and Postlewaite 2003).

Informational efficiency pertains to the issue of decentralization of information and to the limited information processing capacity of the agents (Hurwicz 1972; Hurwicz 1973). In order to explain the notion of informational efficiency, it is convenient to discuss the effect of different environments on the informational efficiency if the same mechanism is applied. Subsequently, the concept can be used to compare different mechanisms:
The informational burden a mechanism creates is dependent on the underlying environment: If information is fully decentralized, as it is the case in an informationally decentralized environment, a mechanism causes a higher informational burden as if information would be fully centralized. The intuition for this lower burden of a fully centralized environment is straightforward: The informational burden is lessened, since no information must be transmitted tothe mechanism. Furthermore, the agent decision problem[50] is per definition resolved at no costs. As the mechanism knows all local environments, the *valuation problem*, i.e. the computation of the preferences and the *bidding problem*, i.e. the computation of the best strategy dependent on the preferences, vanish. In decentralized environments this agent decision problem and the corresponding deliberation costs naturally become more severe as the information processing capacity of the agents is limited.

This instructive example shows that the *informational burden* can be defined on the basis of *communication and deliberation costs*. Those costs are here used as a broad concept and refer to all tasks connected with communication and information processing. That means they comprise all costs that are related with tasks such as "communicating", "observing", and "computing" to name a few.

[50] Generally the agent decision problem is separable into a valuation and a bidding problem (Parkes 2001).

Apparently, not only the underlying environment but also the applied mechanism determines the amount of informational efficiency. Given the same environment, there exist a variety of mechanisms that achieve the same outcome (i.e. Pareto efficient allocation). However, those mechanisms can be ordered based on their informational efficiency. The objective of a mechanism designer should be "design a mechanism that (1) attains a desired allocation, and, (2) is informationally efficient".
Searching for a mechanism that is efficient with respect to all components of communication and deliberation costs appears to be extremely difficult. In literature those costs are frequently measured in terms of the size of the message space M.[51] Recall that the message space or language denotes the messages available to the agents. A larger message size[52] therefore implies higher communication and deliberation costs: It is harder for the agent to conceive the meaning of the message and also to identify what action to be taken as a reaction of the message. Now, the objective of the mechanism designer can be refined to "design a mechanism that attains a desired allocation with a minimal message space size".
However, since long messages can be expressed by a sequence of small messages from small message spaces, this measure appears to be meaningless if no further restrictions are introduced.[53] The restrictions may basically pertain to the adjustment process rules or choice rules. For example, one restriction could require that only the last message sent by each agent are taken into consideration (Mount and Reiter 1974; Van Zandt 1999; Hurwicz and Marschak 2001).
Recently, the newly developing scientific branch of computational mechanism design renews the idea of informational efficiency. The underlying assumption is that the communication requirements may themselves constitute a 'bottleneck' that prevents efficiency (Gomber, Schmidt et al. 2000; Nisan and Segal 2003).

2.1.6.2 Optimality

The objective of optimality commonly refers to the maximization of the revenues a selling agent can earn in a mechanism. An optimal mechanism is the one, which maximizes the total revenue. In the single unit case under the assumptions of the IPV, efficiency corresponds with optimal auctions (Milgrom 1989). However, in more complex environments (e.g. multi unit cases) this does not necessarily hold. When resources are complementarities, that is the valuation for resource a and b together in a bundle exceeds the valuations of its parts $v_a + v_b < v_{a+b}$ (i.e. informational externalities) it is possible that there is a trade-off between efficiency and optimality.

Example 2.1-23: Trade-Off between optimality and efficiency

Assume there are two resources a and b and two buying agents competing against each other. Agent I values resource a 10 € and b 7 €, whereas agent II values a 8 € and b 12 €. An efficient mechanism awards a to I and b to II, as this combination maximizes the sum of valuations. The corresponding revenue the seller can get is 15 € which is the sum of the rejected bids. The seller could raise his revenue by selling both resources as a package to agent II. The revenue would amount to 17 € being the highest rejected bid. Apparently, there is a trade-off between efficiency and optimality (Jehiel and Moldovanu 2003).

[51] See for example Mount and Reiter (Mount and Reiter 1974).
[52] Hurwicz proposes the dimension of Euclidian spaces as a measure of size (Hurwicz 1959). For an extension to topological spaces see (Mount and Reiter 1974).
[53] Mount and Reiter note in their footnote that *"certain additional restrictions are need to avoid anomalies arising from the fact that arbitrary amounts of information can be encoded in a single real number"* (Mount and Reiter 1974, 165).

2.1.6.3 Solution

The solution criteria investigate the properties of the allocation such as occurrence likelihood or stability. The criteria comprise the following:

- Equilibrium and Convergence
- Number of iterations
- Stability and the "core"

In *equilibrium* no agent would find it in his interest to unilaterally change his behavior. In other words, equilibrium denotes a state where no agent wishes to depart from. For example, if the mechanism proposes an allocation based on the received offers, the agents may have the chance to adjust their offers to the new information.[54] If the mechanism proposes an allocation such that each agent would agree to choose its part, the mechanism attained equilibrium (Varian 1992; Wellman and Wurman 1998). Such a situation is highly desirable if the allocation itself meets certain criteria such as allocative efficiency. There are many (game-theoretic) equilibrium concepts discussed in literature.[55] Standard equilibrium concepts that play a role in this book are the following three:

- Nash Equilibrium
  As in the above description, a Nash equilibrium is characterized by the fact that all agents cannot increase their utility by unilaterally changing their behavior.
- Bayesian-Nash Equilibrium
  A strategy profile m is in Bayesian-Nash equilibrium if for all agents the expected utility over all types derived from the chosen strategy is greater than those derived from any other strategy.
- Dominant Strategy Equilibrium
  A dominant strategy m^* maximizes the utility of agent regardless what strategies the other agents play. Hence, a dominant strategy equilibrium is an equilibrium in which all agents play their dominant strategy.

The existence of an equilibrium given a certain mechanism is applied in a specified economic environment is necessary but not sufficient that this equilibrium state is really achieved. The requirement of convergence simply states that the mechanism approaches an equilibrium allocation over time.

Mechanisms are often iterative. That means they accept messages on each round and announces a provisional winning allocation. The mechanism stops when equilibrium is reached. The *number of iterations* confines the rounds necessary to approach equilibrium. Malinvaud formulated a desideratum that the mechanism yields a feasible solution within a finite number of iterations (Hurwicz 1973). Accordingly, the mechanism should not only converge to an existing equilibrium but also in an acceptable amount of time. Malinvaud, for example, shows that some adjustment processes fail to attain a feasible allocation if the process is interrupted after a finite number of iterations. In this tradition the number of iterations are sometimes termed Malinvaud's criteria (Hurwicz 1969).

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54 Using game-theoretic reasoning, the mechanism must not take place in iterations. The process can also occur as calculations in the head of the agents. An agent can predict the equilibrium, and also that the opponents predict it, and so on. If all agents predict it right that particular (Nash) equilibrium will occur (Fudenberg and Tirole 2000).

55 For a comprehensive overview see Fudenberg and Tirole (Fudenberg and Tirole 1983).

Stability or being in the core requires that all agents cannot increase their individual utility by not participating. If the resulting allocation is unacceptable to some group (coalition) of agents since they can increase the utility for the members of this group, it is unstable. Such instable allocations are dominated. The set of all undominated allocations originates the core. If a solution is in the core it is automatically Pareto-efficient; though the converse is not true. The concept of the core comes from coalitional game theory and provides a useful tool for mechanism design, as it demonstrates whether a mechanism evolves: If the economic environment has an empty core, no such mechanism would emerge (Telser 1994; Nyshadham and Raghavan 2001; Roth 2002).

Remark 2.1-5: Individual Rationality and Stability

The constraint that the mechanism is individual rational requires the solution to be stable for the coalition size of 1. This implies that the agent is not worse off than initially. The utility after participating in the mechanism must be higher than before. Otherwise the agent would decide not to take part in the mechanism. This individual rationality constraint is thus sometimes termed participation constraint (Wurman 1999; Fudenberg and Tirole 2000).

2.1.6.4 Feasibility

Feasibility criteria deal with the question whether a mechanism or an allocation is technically implementable. An allocation is only feasible if it does not distribute more (either transfer payments or resources) than is available. Mechanism-oriented feasibility is concerned with the question whether some outcome, given by the social choice function can be implemented, with respect to information and incentives. As such, the message space and the outcome function are analyzed whether they can achieve the desired outcome.

Feasibility objectives are the following:

- Allocative feasibility
- Budget balance
- Informational feasibility
- Incentival feasibility (incentive compatibility)

Before the quality of an allocation is analyzed, it is important to know whether the allocation is *allocative feasible*. In other words, allocative feasibility requires that the allocated resources are actually available. In exchange environments allocative feasibility is fairly easy to keep track of: The mechanism simply cannot assign more resource than the initial endowment. However, if production is possible the interdependence between inputs and outputs can be difficult to monitor: for example, if agent i can produce X only if it gets Y and X and Y are allocated by the same mechanism (Wellman and Wurman 1998).

Furthermore, *budget balance* is concerned whether the mechanism requires transfer payments from outside the system. A mechanism is said to be budget balanced if the amount of transfers sum up to 0 over all agents $\sum_{i=1}^{N} t^i = 0$. In this case the mechanism 'merely' redistributes the payments among the agents. Neither funds are removed from the system nor is the system subsidized from outside. Budget balance is a nice property since the resource allocation can be performed at no costs. In case the transfers result in a surplus $\sum_{i=1}^{N} t^i < 0$ funds are taken away from the system and given to some outsider. Returning the surplus to the system would exacerbate the incentival impact of the mechanism. In the case the mechanism runs a deficit $\sum_{i=1}^{N} t^i > 0$ the mechanism must be subsidized by some outside source and is thus not per-se feasible. In both cases the allocative efficiency of the resource allocation is distorted: Deficits must be financed by some sort of tax, which creates new distortions. Surpluses must be given away also leading to distortions (Parkes 2001; Jackson 2002a).

Informational feasibility imposes a lower bound on the minimal size of the message space. If the information carrying capacity represented by the message space size is insufficient, the mechanism cannot implement a specified goal. For example, if the language of a mechanism allows only for single dimensional bids, e.g. price, the communication of a production set describable by a number of real parameters is impossible. Accordingly, a mechanism, which requires production sets as inputs is not feasible (cf. chapter 2.2.1.2).

"A mechanism that is informationally feasible may be criticized on grounds of incompatibility with "natural" incentives (Hurwicz 1972**,** 320). Incentive feasibility or more often used incentive compatibility refers to the validity of the messages the agents place. It is said a mechanism is incentive compatible if the agents report their preferences truthfully. Agents may have an incentive to untruthfully report their preferences in order to increase their individual utility. Recall the public goods example (Example 2.1-12). If the report (message) is not only used to determine whether the project is realized but also taken as a basis for payments, the agents can increase their utility by understating their true valuation: In case the project is undertaken agent i reduces his corresponding payment by the shaded report. This misrepresentation of the agent's valuation is individually optimal but for the society it is not since it creates an allocative distortion.
Accordingly, incentive compatibility imposes an important requirement on mechanisms. The mechanism must direct the behavior of the agents to honestly reveal their preferences by setting adequate incentives. Designing mechanisms is thus often reduced to incentive engineering.

2.1.6.5 Fairness

Fairness can refer to either the allocation or to the mechanism. Note that fairness with respect to the allocation does not demand for equal shares for all agents. It rather demands that the chances for all agents are regardless of the initial endowment equal. Fairness concerning the mechanism requires equal institutional rights. The group of fairness objectives thus comprehends two criteria:

- Pareto satisfactoriness
- Institutional fairness

From a social welfare point of view, a Pareto-efficient allocation can be non-satisfactory. That means a very imbalanced distribution of resource is not desirable although it suffices Pareto-efficiency. In this context Hurwicz introduced the criterion of *Pareto-satisfactoriness* (Hurwicz 1973). Accordingly, Pareto-satisfactoriness terms a mechanism that attains a Pareto-efficient allocation as equilibrium. This property is called *non-wasteful*. Furthermore, Pareto-satisfactoriness demands that this equilibrium can be obtained by redistributions. This so-called *unbiasedness* requires the mechanism to equalize the chances of the agents independent of their initial endowment. Lastly, Pareto-satisfactoriness also postulates the mechanism to be essentially single-valued. That means the mechanism should not yield multiple equally good equilibria.

A mechanism is said to be *institutionally fair* if the institutional rules do not favor one or more groups. Fairness thus means uniform opportunities, rights, and obligations along the adjustment process (Ströbel and Weinhardt 2003). In other words, a fair mechanism *"[...] should treat all participants without discrimination in a fair and equitable manner"* (Atkin 2003**,** 72). Hence, a key aspect of fairness is the degree to which all messages are handled in the same way by the mechanism.
Sometimes the goal of fairness is relaxed in order to attain another goal. This more or less sloppy statement may debase the importance of fairness. It can make sense to privilege some agent groups in order to set incentives for a desired behavior.

Example 2.1-24: Fairness

In financial markets the group of market makers receives privileges concerning the information feedback. Different to all the other participants the market makers can see the orderbook, which reflects complete information about all previously sent messages. In exchange market makers have to set a quote at any time, which means simultaneous offers to sell and buy. In other words, the market maker provides the corresponding market side regardless of all other agents. This institutional rule remedies the impact of temporary imbalances concerning immediacy, while the privilege allows the market makers to refinance their expenses (O´Hara 1997).

2.1.6.6 Tractability

Tractability is associated with complexity. The complexity can stem from two sides. Firstly, the agents have to determine their strategy. Simplicity refers to the strategic complexity that agents have to solve in order to compute and play equilibrium strategies. Secondly, the mechanism has to solve the allocation problem, which can also become very complex.

- Simplicity
- Computational tractability

Simplicity refers to the comprehensibility of the institutional rules. In case the rules are too complex, the agents have problems to form their strategy. For example, an inexperienced bidder can have serious problems to determine his optimal strategy in a Vickrey auction.[56] Experiments have demonstrated that bidders either understate or even overbid their true valuation. Although the Vickrey auction has nice theoretical properties it is inapplicable in real settings. The institutional rules should thus be simple. Some authors recommend that straightforward bidding (or sometimes called myopic best response (Wurman 1999; Parkes 2001)) should be possible (Ausubel and Milgrom 2002). Straightforward bidding denotes a simple strategy, which simply advises to bid up to ones valuation and then drop out of the market. Accordingly, straightforward bidding does not require any information outside the local environment. The bidders must not try to infer their rivals' strategies to make up their bid.

Computational tractability considers the complexity of computing the outcome of a mechanism from agent strategies (Kalagnanam and Parkes 2003). With the size of the message space the allocation problem can become very demanding. Computational constraints may delimit the design of choice and transfer rules.

[56] A Vickrey auction is a single-sided sealed bid auction. Any bidder submits one single price bid in a sealed envelope; the bidder with the highest bid receives the item for the price of the second highest bid.

Example 2.1-25: Computational tractability

The determination of the winner becomes computationally intractable when (1) many resources are sold at a time that can be complements to each other and (2) on can bid on any conceivable combination of resources. For k resources there are 2^k-1 conceivable packages to bid on. When the choice rule demands the resources to be allocated efficiently, the computation becomes intractable (NP-hard) (Gomber, Schmidt et al. 1998; Schmidt 1999). Unfortunately, approximations entail a loss of desired properties such as allocative efficiency. Solving the tension between computational and game-theoretic properties is the main challenge of computational mechanism design (Parkes 2001).

2.1.6.7 Concluding Remarks on System Performance

Dependent on the intention the mechanism designer wants to achieve, the mechanism must satisfy a set of goals. However, as previously noted, the goals are sometimes conflicting each other, so that the designer has to accept compromises.
Generally, the first two categories efficiency and optimality qualify for objective functions the mechanism designer wants to achieve while the remaining categories principally are constraints upon the objective function. In other words, the mechanisms are intended to either maximize total utility or revenue (Krishna and Perry 1998). The remaining criteria usually impose constraints on the maximization problem.

2.2 Mechanism Theory

In the previous chapter the concepts of a market have been identified and structured. Accordingly, a market – understood as microeconomic system – consists of an environment and a price-oriented institution. A market, furthermore, produces allocations of resources and corresponding prices as outcomes through the competitive agent interaction. The framework denotes, which concepts are dependent on one another. For example, the framework states that the environment affects the outcome but not vice versa. As such, the microeconomic system framework grants the researcher a comprehensive overview over the shadowy concept of the market, the used elements, and their relationships.
The framework, however, does not reveal how exactly the used concepts affect other concepts. In other words, while the relationship among the concepts is shown the underlying effects are not specified. For example, it is known that the economic environment has an effect on agent behavior and thus on the outcome. It is, however, not clarified how the environment exactly influences agent behavior. What is needed for fully understanding the working of markets is a variety of economic models that provide insights between the interplay of the concepts. Economic models impose for tractability reasons more or less strict restrictions on the concepts: for example, models assume the structure of preferences to follow a simplified pattern (e.g. independent private values). By means of these restrictions the degree of the problem complexity can be tremendously reduced – an isolation of specific effects becomes possible. Accordingly, restricting the model to few key variables whose interactions are examined in depth provides clear conclusions. These conclusions are, however, very sensitive to the underlying assumptions and the applied equilibrium concept. The sensitiveness does not diminish the value of models, taking into account that the real value of models lies in developing intuition (McAfee and McMillan 1996).

From an institutional economic point of view, markets are frequently modeled as mechanisms. The nice thing about mechanisms is that they connect the economic environment and institutions with agent behavior, which results in the outcome. Accentuating the notion of mechanisms the following theory streams are called mechanism theory. Mechanism theory can be classified under one of the two headings, information or incentives:

- Incentives
  Samuelson first raised incentive issues in a context with public goods. Recall the library example (Example 2.1-12), where the agents have to report their valuations in order to decide whether the project is realized, and, if so, how it is financed. In such a setting the agents have an incentive to misrepresent their valuation to lower their share of support (Hurwicz 1998). This example, however, does not only address incentive but also informational problems. Since the provider of the public good, say the government, cannot watch the agents' behavior, the agents have a range for misrepresenting their behavior.
- Information
  Basically, the importance of information for mechanisms undisputed. The mechanism requires information – that is initially dispersed among the agents – from the agents in order to attain the specified desiderata, i.e. allocative efficiency. Informational mechanism design explores the informational requirements and processing capacities of mechanisms.

In the following those two theory streams are closed investigated. Incentival mechanism theory encompasses the game-theoretic treatment of mechanisms, which can be distinguished into mechanism design and auction theory. Informational mechanism design formalizes the mechanism as information processing system. As the attention is restricted to information, game-theoretic reasoning does not play a role.

2.2.1 Incentival Mechanism Theory

Before the description of the models is started, it is necessary to distinguish a mechanism from a game-theoretic point of view: broadly speaking any social process can be modeled as a game, where the institutions are the rules of a game.
Game theory specifies the rules of a game, a mechanism, by three components:

- the set of players
- the admissible moves at any given stage of the game
- the outcomes or consequences of the game dependent on the moves of the players, i.e. who wins and what.

A mechanism $\Gamma' = (N, M, y)$ is often used as a synonym for a *game form*. The terminology game form distinguishes it from a game, as the consequence of a messages vector m is an outcome rather than a vector of utility payoffs. That means a game also involves the message space, but instead of an outcome function it specifies so-called pay-off functions. Informally, the game shows the pay-off $u_i(m_1, m_2,\ldots,m_n)$ an agent realizes when he chooses strategy $m_1, m_2,\ldots,m_n$. Once the preferences of the individuals are specified, then a game form (or mechanism) induces a game $\Gamma = (N, M, u)$. Why is this distinction important at this stage? The answer is straightforward: By distinguishing between game-form and game the different goals of auction theory and mechanism design can be explained.

- Mechanism design
  In the theory of mechanism design institutions become the variable of the design problem. Mechanism design seeks to identify the institutional rules in order to attain a given objective or desiderata (cf. chapter 2.1.6 for economic objectives). Accordingly, mechanism design is devoted to the examination of different institutions. Different institutions correspond with different game-forms. Thus, the design of institutions is nothing more than changing the rules of the game, i.e. the game-form. If the preferences are assumed to be independent of the underlying rules (recall the Debreuian preference ordering) changes, in

the game-form are associated with changed outcome functions, and – as previously mentioned – induce a different game (Hurwicz 1987; Hurwicz 1998; Jackson 2002a).

- Auction theory
  The theory of auctions assumes the institutional rules, the game-form, to be a priori specified. Hence, each auction format determines a game of incomplete information among the bidding agent. For any auction format auction theory determines the resulting (Bayesian-Nash) equilibrium dependent on the (informational) environment[57]. This allows auction theory to derive conclusions about the outcomes of various auction formats. Auction theory is not the only theory analyzing the outcomes of specific institutions. For example, market microstructure theory also examines the impact of different trading venues on the market performance for financial markets. Market microstructure theory is, however, much more diverse than auction theory and often omits game-theoretic reasoning and is thus not investigated in more detail.

2.2.1.1 Mechanism Design

The theory of mechanism design[58] provides a theoretical toolbox for designing institutions with a particular emphasis on incentives (Maskin and Sjöström 2002). Basically, the problem of designing a mechanism, i.e. game form, is to implement a mechanism (M, y) such that the equilibrium outcome satisfies the social choice function y^{SCF}. Here the problem arises that the agents may have an incentive to misrepresent their preferences: *"The basic design problem can be stated simply. The "gaming" behavior that could undermine price discovery, and thereby efficiency, is the strategy called »hiding in the grass«*" (Wilson 2001, par. 6). Even abstracting from communication costs, the mechanism designer may attempt to elicit the true preferences. But if the agents know the outcome rule they improve their situation by simply report false preferences. Ideally, the task of the mechanism designer is to devise a mechanism such that (1) the agents announce their true preferences and that (2) the "right" allocation is chosen. The critical design question is accordingly whether there exists such a mechanism that implements a specific social choice function (Maskin 1999).

Some authors distinguish implementation theory from mechanism design by referring to the multiplicity problem: Mechanism design literature merely focuses on the question, whether a specified outcome can be attained as an equilibrium of some mechanism. This also implies that it ignores other equilibria than the desired. Implementation theory also accounts for those undesired, multiple outcomes, by requiring that all equilibrium outcomes satisfy the desired properties (Jackson 2001). In situations, where mechanism design theory comes to a negative result, i.e. no mechanism can attain a given social choice function as an equilibrium, the impossibility is strict. However, in situations, where mechanism design comes to a positive result, in a way that there exists a mechanism that can implement a given objective in equilibrium, the possibility should be handled with care. The reason is that there might exist more equilibria, which do not satisfy the demanded objectives (Jackson 2001). Implementation theory is, however, aggravated by its natural devotion to highly abstract mechanisms *"with little or no concerns for practical application"* (Palfrey 2001, 2274). The degree of abstraction hinges on the objective of implementation theory: Usually mechanisms are constructed in a way that they apply to arbitrary social choice functions. For example, an equilibrium concept, say a Bayesian-Nash, equilibrium, is selected and analyzed under which conditions a social

[57] The term informational environment is taken from auction theory (Krishna 2002). In our terminology the informational environment refers to the preference structure (cf. chapter 2.1.2.2).

[58] "Mechanism design in general, in the spirit laid out in Hurwicz (1973) has become a recognized subject in the theoretical literature, and even boasts a specialized journal, the Review of Economic Design"(Roth 2002).

choice function is implementable. Thereby, the domain restrictions upon the environment should be as minimal as possible. In other words, a single game form is identified that implements all arbitrary social choice functions in equilibrium (assumed the specified equilibrium concept). In order to do so, the mechanism must be of abstract nature.
In the following, the mechanism design literature is reviewed as it provides more practical insights what can and cannot be achieved by the mechanism designer. Mechanism design is supposed to bridge the gap between theoretic microeconomic implications and practical applicability.[59]

The results of mechanism design theory are easier to understand if one has a thorough understanding about the exogenous and endogenous variables of the mechanism design problem. Usually, mechanism design takes the environment e, the set of outcomes X, the behavior m, the (quasi-linear) utility function and the distribution functions as given. Now, the mechanism designer has to choose a mechanism *(M, y)* such that the utility of the society is maximized. However, the problem is hardly tractable as the message space M can be extremely huge. A very valuable shortcut has been developed to restrict to a certain set of mechanisms. The shortcut, known as the revelation principle[60], relies on game-theoretic reasoning on behavior and states that for any equilibrium of any (indirect) mechanism there exists an equivalent incentive compatible direct mechanism that attains the same outcome.

Remark 2.2-1: Revelation Principle

For the understanding of the revelation principle the notion of direct mechanisms and incentive compatibility are essential.

- A *direct mechanism* is defined as mechanism, where the message space M is the type space of the agents Θ. The agents may only announce claims about their true preference. Those announcements can but must not be truthful. Note that a direct mechanism also represents a social choice function.
- An *incentive-compatible* direct mechanism is a mechanism, where the agents truthfully report their preferences, which are private information. Incentive compatibility accordingly implies that the agents put their selfishness behind. Truthful reporting the preferences can either be a dominant strategy or equilibrium of a mechanism. If truthful announcement is a dominant strategy, the utility drawn out of truth telling is as least as good as any other arbitrary strategy. This – so-called *strategy proofness* – is a quite strong requirement: regardless of the other agents' strategies, truth telling is always the most profitable strategy (Jackson 2002a). Dominant strategies coincide with the removal of game-theoretic reasoning; agents need not to form conjectures about the other agents' reactions.[61] Naturally, theorists strive for an implementation of social choice functions in dominant strategies. However, implementation in dominant strategies imposes a very strong demand on the design problem and is accordingly not always possible. A weaker formulation of incentive compatibility requires truth telling as equilibrium behavior.

59 As such, mechanism design founds the basis for a computerized mechanism design, a fruitful application area for electronic markets.

60 The revelation principle was initially developed by the works of Gibbard, Myerson, and others (Gibbard 1973; Myerson 1982). See (Myerson 1989) for a survey on mechanism design literature.

61 This truth telling property extends the mechanism beyond those, where only "honest men" are taking part.

As previously mentioned, the revelation principle says that for any mechanism there exits an equivalent incentive-compatible direct mechanism that implements the same social choice function.

The underlying intuition of the revelation principle is as follows. Suppose the microeconomic system can be totally simulated in the laboratory. This simulation comprises the strategies of the participating agents, the choice, transfer and adjustment process rules of a complex (indirect) mechanism. The simulated mechanism will compute the agent's optimal strategy faithfully based on the preferences. For an agent, it is an optimal strategy to truthfully report his preferences to the new (simulated) direct mechanism, because the program optimizes the agent's strategy faithfully based upon this report. Hence, it does not make sense to lie to the simulator (Matthews 1995). Evidently, this new direct incentive-compatible mechanism implements the same social choice function as the indirect mechanism.

This shortcut allows – without loss of the designer's objective – restricting one's attention to direct incentive compatible mechanisms.

With the device of the revelation principle mechanism design can derive a number of impossibility theorems that reveal the set of properties that cannot be attained by any mechanism under a specific environment (Sen 1999). The reasoning is now straightforward, if no direct mechanism exists, which satisfy some properties, there is no mechanism (including iterative and other indirect mechanisms) that satisfies these set of properties.

2.2.1.1.1 Impossibility results

In the following the most discussed impossibility theorems are summarized. Those theorems state for which combination of properties no mechanism does exist. Table 2 sketches the impossible combinations of properties dependent on the preference domain[62], i.e. the restrictions on possible orderings of the alternatives, and the used equilibrium concept.

Theorem	*Environment*		*Performance*	
	Preference Domain	*Resources*	*Equilibrium Concept*	*Impossible*
Gibbard-Satterthwaite	Rich	Discrete set of Commodities	Dominant	non-dictatorial
Hurwicz-Green-Laffont	Quasi-linear	Single units of the same resource	Dominant	Allocative efficient and Budget Balanced
Myerson-Sattterthwaite	Quasi-linear	Single units of the same resource	Bayesian-Nash	Allocative efficient, Budget Balanced, Individual rational
Green-Laffont	Quasi-linear	Single units of the same resource	Coalition-proof	Allocative efficient

Table 2: Impossibility Results (Parkes 2001)

As the impossibility theorems demonstrate the feasibility of mechanisms satisfying some properties, they are important for design. In the following, the details of the impossibility theorems are outlined.

- Gibbard-Satterthwaite Theorem
  The Gibbard-Satterthwaite theorem reveals that it is impossible to implement a non-dictatorial social choice function in dominant strategies, if the preferences are sufficiently

62 For a detailed formulization of preference domains see Dasgupta et. al. (Dasgupta, Hammond et al. 1979).

rich[63] (Gibbard 1973; Satterthwaite 1975). A dictatorial social choice function denotes those social choice functions that are dependent on the utility of a single agent, i.e. the dictator. Changes in the individual utilities other than the dictator do not influence the social choice function. Unfortunately, the theorem states that it is impossible to implement a truthful non-dictatorial social choice function in dominant strategies if there are more than three agents and the preference domain is rich. A rich preference domain simply requires that all strict orderings must be possible (Maskin and Sjöström 2002). If the preference domain is restricted this strong impossibility theorem no longer holds.

- Hurwicz-Green-Laffont Theorem
  Parkes points in his dissertation at the – as he calls it – "Hurwicz Impossibility Theorem" (Parkes 2001). Basically the theorem states that it is impossible to implement an incentive compatible mechanism in dominant strategies that is allocative efficient and budget-balanced when the preferences are quasi-linear and single units of the same good are allocated. It can be shown that only the so-called Groves mechanisms are strategy-proof, i.e. incentive compatible in dominant strategies. However, no Groves mechanism achieves budget balance in this restricted environment (Green and Laffont 1977; Jackson 2002a).
- Myerson-Satterthwaite Theorem
  The Myerson-Satterthwaite theorem extends the results of the Hurwicz-Green-Laffont theorem to Bayesian implementation problems. Accordingly, truth telling is no longer required to be a dominant strategy but Bayesian-Nash equilibrium behavior. Bayesian incentive compatible demands that truthful reporting is a Bayesian-Nash equilibrium. Any deviation from truth telling reduces the expected utility of any agent. Even with this relaxed (less strict) equilibrium concept, the Hurwicz-Green-Laffont impossibility holds if additionally individual rationality is also required (Myerson and Satterthwaite 1983; Fudenberg and Tirole 2000). In summary, it is impossible to achieve all three properties allocative efficiency, individual rationality and budget balance in markets with quasi-linear agent preferences as a Bayesian-Nash equilibrium (Parkes 2001).
- Green-Laffont Theorem
  Another impossibility theorem from Green and Laffont reveals that there does not exist a strategy-proof mechanism that is allocative efficient and simultaneously robust to manipulations by coalitions. This impossibility still occurs in environments where agents have quasi-linear preferences (Green and Laffont 1979; Parkes 2001).

2.2.1.1.2 Possibility results

Mechanism design not only provides impossibility but also possibility results. Those possibility results must, however, be used with great care. As previously mentioned, those possibility results demonstrate what is principally possible. Due to the chance of other (bad) equilibria it is not guaranteed that the mechanisms always provide those desirable properties. Possibility results can be distinguished into two groups optimality and efficiency theorems. Optimality theorem(s) seek to identify mechanisms that maximize the revenue a selling agent receives, whereas efficiency tries to find mechanisms that maximize total utility of the society.

<u>*Optimality Theorem*</u>

In his salient paper, Myerson developed an approach to derive a revenue maximizing mechanism (Myerson 1981). Basically, he transformed the mechanism design problem to an optimization problem. His objective is to construct a choice rule that maximizes the expected revenue under three additional constraints. The first constraint, *allocative feasibility* requires that resources can only be allocated if they do exist. The second constraint, *incentive compatibil-*

[63] Reny points at the similarity between the Gibbard-Satterthwaite theorem and Arrow's celebrated impossibility theorem in a voting setting (Reny 2001).

ity, demands agents to truthfully announce their true preferences. The third constraint, *individual rationality,* presupposes the expected utility of participation to be higher than non-participation.
Myerson subsequently developed conditions on the choice and corresponding transfer rules without explicitly formulating them. Moreover, Myerson derived an optimal auction for the single-item case. Overall, optimal auctions are exclusively a theoretical construct without practical application (Wolfstetter 1999). Satterthwaite characterizes this claim in a more detailed way: *"optimal mechanism depends critically on the agents and mechanism designer sharing a common knowledge prior of the ex ante distribution of each other's preferences. Common knowledge among the agents who participate in the mechanism is a strong assumption; for this common knowledge to extend to the mechanism designer is arguably untenable*" (Satterthwaite 2001). Thus, the description of optimal mechanisms ends here with the reference to Bulow and Roberts for further depiction (Bulow and Roberts 1989).

Efficiency Theorems
The Gibbard-Satterthwaite theorem projects a dismal chance for mechanism design: Only dictatorial social choice functions are strategy proof and together efficient. Nonetheless, the negative results of the Gibbard-Satterthwaite theorem can be easily circumvent by either restricting the preference domains or by using a less stringent equilibrium concept. The most important results are presented in Table 3. Similar to Table 2, Table 3 demonstrates which properties a mechanism can attain under a specific environment.

- Groves Mechanism
  If only quasi-linear preferences are permitted there exists a class of mechanisms that are allocative efficient, and for which truth telling is a dominant strategy (Groves 1973).
  Those mechanisms usually called Groves-mechanisms are characterized by an efficient choice rule: $h^*(\hat{\theta}) = \arg\max_{h \in X} \sum_i v_i(h, \hat{\theta}_i)$
  and a transfer rule for the i-th agent
  $$t_i(\hat{\theta}) = \sum_{j \neq i} v_j(h^*(\hat{\theta}_i, \theta_{-i}), \theta_j) + q_i(\hat{\theta}_{-i})$$
  Note that the transfers depend on two components:
  The first term is sum of the valuation for all agents $j \neq i$, where agent i announces some value $\hat{\theta}_i$ and all other agents are faithfully reporting their preference. This component of the transfers accounts for the effects agent i places on the society by his announcement of his preferences. Those externalities are internalized, as the effects posed on the other agents are incorporated in the transfer function. This way, the society goals can be reconciled with the individual goals.
  The second term q_i is an arbitrary function, which depends on all but agent i's preferences. Thus, there exist a number of mechanisms that belong to the class of Groves-mechanisms.

  If the preferences are quasi-linear, the Groves mechanisms are the only class of mechanisms for which allocative efficiency and strategy proofness holds. Accordingly, one can restrict one attention to those class of mechanisms (Green and Laffont 1977). Holmstrom additionally shows that further restricting of the preference domain does not sway this result; the class of Groves-mechanisms remains the only class, which attains those properties (Holmstrom 1979).[64] Nonetheless, Groves mechanisms have also undesirable properties as they usually do not balance budget.

- VCG Mechanism

  One version of the Groves scheme is the so-called VCG (Vickrey-Clarke-Groves), pivotal or Clarke mechanism. What makes the VCG mechanism powerful in mechanism design are the nice properties associated with it. The VCG mechanism denotes a special Groves mechanism where the arbitrary part of the transfer schedule is specified as $q_i(\hat{\theta}_i) = -\max_{h \in H} \sum_{j \neq i} v_j(h, \theta_j)$.

  The total transfers amounts to

  $$t_i(\hat{\theta}) = \sum_{j \neq i} v_j(h^*(\hat{\theta}_i, \theta_{-i}), \theta_j) - \max_{h \in H} \sum_{j \neq i} v_j(h, \theta_j).$$

  As the transfers are always negative (i.e. the agents have to pay), the mechanism is always feasible. Furthermore, the interpretation of the transfers is instructive (Jackson 2002a): if agent i's presence does not make a difference in the maximizing problem (viz. agent i is not part of the optimal allocation), the transfers are zero. Otherwise i's presence is pivotal, as the social welfare, i.e. the sum of all agents, is affected by the participation of agent i. The transfers exactly reflect the loss in valuation of the other agents, which is incurred by the participation of agent i. Accordingly, the VCG mechanism incorporates the marginal impact on the other valuations by the announcement of $\hat{\theta}_i$ into the transfer function internalizing this external effect. At the bottom-line the individual agent is thus forced to consider also social welfare when making his choice. Altogether, the VCG mechanism is the only mechanism that achieves allocative efficiency, individual rationality and is also feasible, as the transfers – although they do not balance – are negative.[65]

- AGV Mechanism

  The AGV mechanism basically represents the "expected Groves" mechanism. d'Aspremont and Gerard-Varet, and independently Arrow show that one can weaken the requirement of dominant strategy incentive compatible to Bayesian strategy incentive compatible as long as the agents have probabilistic beliefs over the type distribution (d'Aspremont and Gérard-Varet 1979; Jackson 2002a). The choice rule is exactly the same as for the Groves mechanism. Only the transfer rule differs in a way that not the actual valuations are used but their expected value. That is:

  $$t_i(\hat{\theta}) = E_{\theta_{-i}}\left[\sum_{j \neq i} v_j(h^*(\hat{\theta}_i, \theta_{-i}), \theta_j)\right] + q_i(\hat{\theta}_{-i})$$

  Again, the second term q_i denotes an arbitrary function independent of agent i's valuation. The first term reflects the expected value of the other valuations, provided that agent i announces some arbitrary valuation $\hat{\theta}_i$, and all other agents correctly report theirs.

  Comparable with the Groves mechanism the AGV mechanism can achieve an allocation efficient and, different than the Groves mechanisms, one can construct the q_i in such a way that budget is balanced (Arrow 1979; d'Aspremont and Gérard-Varet 1979). Following Krishna and Perry's instructive presentation (Krishna and Perry 1998), function q_i is given by

  $$q_i = \left(\frac{1}{I-1}\right) \sum_{j \neq i} SW_{-j}(\hat{\theta}_j),$$

[64] This holds when the domain is smoothly connected. For the notion of smoothly connectedness see Holmstrom (Holmstrom 1979).

[65] Only in the special case Groves and Loeb showed that the VCG balance budget if the valuations are quadratic (Groves and Loeb 1975).

where SW denotes the “expected social welfare” or in the terminology used here the expected sum of all $j \neq i$ individual valuations when the i-th agent is reporting $\hat{\theta}_i$. That is

$$SW_{-i}\left(\hat{\theta}_i\right) = E_{\theta-i}\left[\sum_{j \neq i} v_j(h^*(\hat{\theta}_i, \theta_{-i}), \theta_j)\right]$$

The AGV mechanism thus internalizes the “expected externalities” that arise with agent i’s announcement of $\hat{\theta}_i$. In this case, the budget balances: however the mechanism does not satisfy individual rationality (Krishna and Perry 1998).[66] Recalling Myerson-Satterthwaite’s impossibility theorem this is not astonishing, as it rules out all three properties allocative efficiency, budget balance, and individual rationality (see Table 2).

- GVA mechanism
  The Generalized Vickrey Auction[67] was developed by Nobel Laureate William Vickrey (Vickrey 1961) and denotes an application of the VCG mechanism to combinatorial (resource) allocation problems, henceforth CAP. Actually, the VCG mechanism is implemented by a sealed bid combinatorial auction.
  CAP can be easily formulated as follows (Parkes 2001; de Vries and Vohra 2003). Suppose there are n agents and $K \in H$ resources that are to be allocated. The agents can report a valuation for every subset S of H. CAP is thus concerned with the computation of the allocative efficient allocation, i.e. the maximization of the sum of individual valuations:

$$S^* = arg \max_{S=(S_1, S_2, \ldots, S_n)} \sum_i v_i(S, \theta_i)$$
$$s.t. \quad S_i \cap S_j = 0, \quad \forall i, j$$

  Note that the constraint of this simple maximization problem is assuring a feasible allocation, in a way that a resource is only allocated once and each agent receives only a single subset S_i.
  The GVA transfers reduces to $t_i(\hat{\theta}) = \sum_{j \neq i} v_j(S^*_{-i}, \theta_j) - \sum_{j \neq i} v_j(S_j^*, \theta_j)$,

  where S^*_{-i} denotes the “second best allocation”, i.e. best allocation without the i-th agent being present (Parkes 2001). The intuition of the VCG mechanism remains the same; the transfers equal the marginal effect on the valuations of the other agent that agent i induces by his participation.
  Even in the combinatorial setting, the GVA attains allocative efficiency, strategy proofness, and individual rationality. The GVA mechanism does not balance budget, but at least, it generates a surplus. In auction settings this surplus is not considered harmful as the transfers are given to the seller.
- GL mechanism
  The Groves-Ledyard (GL) mechanism assumes quasi-linear and quadratic preferences. Quadratic preferences basically reflect the public nature of the resource (Groves and Ledyard 1977). In such a setting, Groves and Ledyard developed a choice and transfer scheme such that truth telling is a Nash equilibrium. The resulting allocation is efficient and, moreover, individual rationality is assured.

[66] A nice presentation of the proofs is given by Parkes (Parkes 2001).
[67] Note that the distinction into mechanisms and auctions is dropped at this point.

Mechanism	Environment		Performance	
	Preference Domains	Resources	Equilibrium Concept	Possible
Groves	Quasi-linear	Exchange	Dominant	Allocative efficient and (Budget Balanced or Individual rational)
AGV	Quasi-linear	Exchange	Bayesian-Nash	Allocative efficient and Budget Balanced
VCG	Quasi-linear	Exchange	Dominant	Allocative efficient and individual rational
GVA	Quasi-linear	Combinatorial	Dominant	Allocative efficient, Budget Balanced* and individual rational
GL*	Quasi-linear and Quadratic	Exchange	Nash	Allocative efficient, and Individual rational

Table 3: Possibility Results concerning Efficiency (cf. Parkes 2001)

2.2.1.2 Auction Theory

Auctions have a long tradition as trading mechanisms. For example, Herodotus reports about auctions in Babylon 500 B.C. Even the entire Roman Empire was sold by an auction after the Pretorian Guard had killed the Emperor Pertinax (Wolfstetter 1995; Krishna 2002).
Likewise have Economists extensively been devoted to the study of auctions. The devotion stems from the fact that the study of auctions and their respective properties builds understand of dynamic price formation in markets. Since the late 1970s the numbers of works have literally been exploded. Milgrom writes in his book that in 1978 the entire theory boiled down to seven main theorems (Milgrom 2004). In the meantime the theory has grown so largely that nobody would start counting the theorems.

Hitherto it was implicitly assumed that auctions are mechanisms. This is not completely correct, as auctions are mechanisms that are both universal and anonymous. The property of *universality* refers to the characteristic that an auction can be used to sell any good. *Anonymity* states that the identity of the bidder does not play any role in the determination of the winner and the corresponding price. Mechanisms are neither universal nor anonymous. As mechanisms are dependent on the distribution of the buyer’s valuation, they are not universal, as the buyer’s valuation corresponds to certain goods, not for any arbitrary good. Furthermore, mechanisms can treat different buyers differently, such that anonymity does not apply (Krishna 2002). Despite these subtle differences, mechanisms can – as aforementioned – specify an auction. As such, traditional auction theory is largely based on mechanism design theory. When auctions are analyzed, it is necessary to state (1) the demand condition and (2) the number of competing sellers.

Demand Condition

The case of singleton demand – where buyers have valuation for a single unit of a good only – is the most thoroughly studied category in auction theory. This is quite natural, as singleton demand removes lots of complexities. Suppose for a moment that the analysis is not associated with one but with multiple items. Then, there are many more possible allocations. Hence the computation of the bidding strategies will become more complex. Furthermore, the restriction to singleton demand eliminates the tension between efficiency and revenue maximization (Milgrom 2004). While for single unit cases efficiency corresponds to revenue maximization, this does not hold for multiple unit cases (see Example 2.1-23).

Number of Competing Sellers

Moreover, the number of competing sellers in an auction is of importance. In case there is only one seller and multiple buyers, the competitive bidding procedure only takes place for one side.[68] In a double-sided auction the sellers are also engaging competitive bidding activities in order to make the deal. Most of the studies in auction theory analyzes single-sided auction – as such it is not astonishing that double-sided auctions are *"not nearly as well understood"* (Kagel 1995, 501) as single-sided auctions.

2.2.1.2.1 Single-Sided Auctions

As aforementioned, single-sided auctions have received the most attention. Typically, it is distinguished into single- and multiple-unit auctions.

2.2.1.2.1.1 Single-Unit Auctions

In the treatment of single-unit auctions usually four common auction formats[69] are analyzed under different preference relations.

- English Auction
  The English auction is the oldest and *"perhaps the most prevalent auction format"* (Krishna 2002, 2). Central to the English auction is the auctioneer, who conducts the bidding process. More precisely, the auctioneer calls out a (low) price and increases that price incrementally as long as there are more bidders interested.[70] When the second last bidder refuses to stay in the bidding process, the last bidder receives the item. Obviously, the price the winner has to pay equals the second highest bid (if necessary the price is one increment higher to beat the second highest bid). The dominant strategy of the English auction under private value settings can thus be headlined as *"pay up to your valuation"*[71].
- Vickrey Auction
  The Vickrey auction is a sealed bid auction. The bidders submit one single bid in a sealed envelope to the auctioneer. Finally, the bidder who submitted the highest bid is awarded with the item at the price of the second highest bid. It can be shown that truthfully bidding is a dominant strategy.[72] Thus, the English and the Vickrey auction are dubbed strategically equivalent, as their strategies are alike.
- First-Price-Sealed-Bid
  In the First-Price-Sealed-Bid auction, the bidders submit one single bid in a sealed envelope. The bidder who has submitted the highest bid receives the item to the price equal to his bid..
- Dutch Auction
  In the Dutch auction, the auctioneer calls out a price and lowers this price incrementally as long as no bidder is willing to accept it. Once a bidder accepts the pealed price this bidder wins the auction and has to pay his bid. It becomes clear that the strategies in the First-Price-Sealed-Bid and in the Dutch auction are alike. Basically in both cases, the bidder has to define a price he is willing to accept (Milgrom 1989). This price will be below his valuation in order to draw positive utility from the auction.[73] Bidding below the own valuation is termed *shading*.

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68 Note that so-called reverse-auctions, where one buyer is facing many sellers, are theoretically equivalent to original auctions with one seller facing many buyers.

69 Actually the four auction formats represent classes of auctions.

70 A similar format of the English auction requires from the bidders the open outcry of the bids.

71 Note that the English auction is bothered by multiplicity problems. However, those alternative equilibria are not trembling-hand perfect and will thus be neglected in the following.

72 For an individual agent truthfully reporting the singleton preference is a dominant strategy, as underbidding reduces only the probability of winning while overbidding creates the risk of running a loss.

73 In case the buyer bids his valuation and receives the item to exactly his price, his quasi-linear utility is zero.

As aforementioned, each auction format determines a game of incomplete information among the bidders. Auction theory, hence, proceeds by calculating an equilibrium of any of those games with a solution concept as strong as possible (usually dominant strategies of Bayesian-Nash). The relative performance of an auction format can be obtained by comparing the equilibrium outcomes with other auction formats in terms of efficiency or revenue.

Typically, many assumptions are imposed in order to make this mathematically tractable. For example, the structural property of the individual preference relations is extremely important (recall chapter 2.1.2.2.1). The easiest way is to assume that all agents have private values that are statistically independent.
Due to its nice properties the symmetric independent private value (SIPV) model has become the benchmark model in auction theory. In essence, the SIPV model makes a number of assumptions: Firstly, independent private values, secondly symmetric[74] and risk neutral[75] bidders.

Using this model it can be shown that the revenue is for all four auction formats the same. This is the celebrated revenue equivalence theorem proposed by Vickrey (Vickrey 1961). Within the SIPV model auction design would become irrelevant, as all auctions achieve the same outcome. By employing the envelope theorem the revenue equivalence theorem can be even further generalized in a way that all auction formats that are allocative efficient attains the same revenue.[76] This is a quite powerful theorem, as it is not confined to the four common auction formats. For instance, the theoretical construct of a third-price auction - which is analogous to the Vickrey auction, but differs in the fact that the winner pays the price of the third-highest bid – yields the same revenue as the four common auction forms (Krishna 2002).[77] In laboratory experiments tests of revenue equivalence among different auction forms repeatedly fail (Kagel 1995). Even the proposed strategic equivalence among the First-Price-Sealed-Bid and the Dutch auction does not hold (Coppinger, Smith et al. 1980; Kagel 1995).

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74 Symmetry demands that the bidders are indistinguishable. Stated differently, symmetry requires the valuations of the bidders to be drawn from the same distribution.

75 Note that risk neutrality corresponds with quasi-linear utility functions.

76 Payoff equivalence can be shown as follows: Basically any agent tries to maximize its utility. As utility is uncertain, the agent tries to maximize the expected utility. In an auction, the expected utility of that agent depends on the payments (transfers) that he has to pay and on the probability of winning. That is

$\max U = \pi (v - t)$
where π denotes the probability to win, v the own private value and t the payment.

By his bid β the agent can determine both the probability to win and the expected payments. In equilibrium the agent can exactly see how his bid β^* maps into the probability to win and the expected payment (π^*, t^*).
Apparently, the bidder sets his bid β^* such that the expected utility is maximized. The maximum value function U^* denotes the expected utilities for all optimal equilibrium bids dependent on the private value v. For this maximum value function U^* the envelope theorem applies. Basically the envelope theorem establishes a relationship between any optimal bid and the value function. By differentiating the maximum value function $U^* = \pi^*(v - t^*)$ by v one obtains $U^{*\prime} = \pi^*$. Integrating this expression yields the expected utility dependent on the private valuation v: $U^* = U(0) + \int_{s=0}^{v} \pi^* ds$. If auctions where the lowest type of bidders always lose and pays 0 are compared, then the expected utility is zero. If furthermore the choice rules are for all bidders alike (π), then the bidders expected payoffs and payments are the same (Myerson 1981; Milgrom 1989). For auctions that are efficient the revenues are the same (Milgrom 2004).

77 The third-price auction is a purely theoretical construct, as it exposes the seller to unnecessary risk (Wolfstetter 1999).

The *"amazing result"* (Wolfstetter 1995) of revenue equivalences among all efficient auction formats is however not robust. Once the SIPV model is left, the theorem does not hold any more. Auction theory has thoroughly studied the effects when one or more assumptions are dropped. As this book is not entirely devoted to auction theory, it eventually must fail to survey all relevant extensions and variations.[78] Instead few, selective samples of the extensions are presented to get a feeling about the theory.

- Removing Risk Neutrality
  When risk-neutrality is removed, it does not change the optimal strategy of an English auction. It is still optimal to bid up to ones valuation. For the Dutch auction it is however less profitable for bidders to shade their bids below their valuation, since it decreases the probability of winning. The more risk-averse the bidders are, the more reluctant they become to shade. While the dominant strategy in the English auction does not change, the Dutch auction yields higher revenues, as the agents are bidding more aggressively (Wolfstetter 1995).
- Removing Symmetry
  When symmetry is removed, only the bidding behavior of the Vickrey auction is unaffected. Truthful revelation of the valuation still remains a weakly dominating strategy. Removing symmetry changes the bidding behavior of First-Price-Sealed-Bid auction. Unfortunately, a closed form expression of the bidding strategy is not available making comparisons extremely difficult. While no general ranking in revenues can be obtained, it can be stated that the First-Price-Sealed-Bid auction is not necessarily allocative efficient. Weak bidders[79] tend to bid more aggressively as they face – broadly speaking – fiercer competition. Suppose the case that the valuations of the weak and the stronger bidders are very close together, but the strong bidder has a slightly higher valuation than the weak. In such a situation it can happen that the weak bidder wins the First-Price-Sealed-Bid auction since he bids more aggressive. However, this also implies that the allocation is inefficient (Krishna 2002).
- Introducing *"Numbers uncertainty"*
  "Numbers uncertainty" addresses the uncertainty that is introduced if the auctioneer does not reveal the number of participating agents. Now number uncertainty has no effect on the bidding strategies in the English and the Vickrey auction. It has, however, an effect on the bidding strategy in a First-Price-Sealed-Bid auction when the bidders are risk-averse. In such a case the bidders tend to bid even more aggressively. As such, *"numbers uncertainty"* favors the First-Price-Sealed-Bid auction (McAfee and McMillan 1987a).
- Introducing *"Pure Common Values"*
  Now the assumption of private values is being dropped. The value of an item is for all bidders the same but unknown. Each buyer receives an unbiased estimate about the potential common value. As the bidding strategy rises with the estimate, the most optimistic bidder is awarded with the item. However, this also means that the average winning estimate exceeds the value of the item (Wolfstetter 1995). Apparently, the agents must adjust their strategy facing this adverse selection bias called winner's curse by bidding below one's estimate. Apparently, the strategy *"bid up to your valuation"* is no longer a dominant strategy for English auctions.

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[78] Interested readers in auction theory are referenced to the fundamental works of Krishna (Krishna 2002) and Milgrom (Milgrom 2004). Both books provide a good overview over state-of-the-art auction theory. Furthermore, they provide the proofs to most of their propositions that may help to conceive the strengths and weaknesses thereof.

[79] For weak bidders the valuations are "stochastically lower" than those of the strong bidders. That is, the distribution of the weak bidder's valuation is dominated by the distribution of strong bidder's valuation in terms of the reverse hazard rates.

As these selective samples have shown, the results of the specific auction formats vary when the assumptions of the environment are changed. In other words, auctions are extremely context-sensitive.

2.2.1.2.1.2 Multi-Unit Auctions

When multiple units are for sale, new questions and accordingly new problems arise (Milgrom 2004).

Those problems typically concerns:

- Matching Problem
  In the case of singleton demand the matching problem determining who gets what item was trivial, as any agent is interested in the same single good. This becomes more complex when multiple items are present.
- Market Power
  In the single unit case market power was meaningless, but when multiple units are available large bidders can try to manipulate the price. For instance, bidders can reduce their final price they have to pay, by reducing demand.
- Absence of Competitive Prices
  Auctions are usually installed to determine competitive prices. When the items for sale are not substitutes market clearing prices may not exist.
- Complexity of Bidding Strategies
  Especially in case the items for sale are complementarities the optimal bidding strategies are difficult to obtain. Simulations have thus adopted very simple – far from optimal – strategies

Facing those additional problems, it becomes clear that many results of the single-unit case cannot be transferred to multi-unit auctions. For simplicity it is only referred to auctions with identical units. When multiple units are for sale, there exist at least two ways to sell the items: the items can be sold within the scope of a single or multiple auctions.

Multiple auctions can in turn occur simultaneously or sequentially. In the case simultaneous case, the bidders have to observe many auctions and if necessary place multiple bids in several auctions. This can be very expensive, as observation and the deliberation before placing bids are associated with costs. In sequential auctions, the items are sold one after the other. In theory, under the assumption of interdependent values with affiliation Milgrom and Weber have predicted the prices to drift upwards, as more items have been sold (Milgrom and Weber 2000 cited by Krishna (2002)). This stands in contrast to the real world, where prices tend to drop downwards (Ashenfelter 1989). Although few explanations have been attempted the *"declining price anomaly"* still remains a puzzle (McAfee and Vincent 1993; Bernhardt and Scoones 1994; Jeitschko 1999; Krishna 2002).

In a *single auction* the items are sold all at a time. Comparable with single-unit auctions it is possible to employ either sealed or open bids. Beside the prices the auction format also defines the quantity of items that is assigned to an agent.
Traditionally three sealed bid auction formats for sale are of particular interest.

- Vickrey Auction
  In his salient paper *"Counterspeculation, auctions, and competitive sealed tenders"* Vickrey already proposed the multi-unit version of the Vickrey auction (Vickrey 1961). Basi-

cally, a bidder who wins k units pays the k highest losing bids of the other agents. In other words, each bidder pays an amount equal to the externality he exerts on the other bidders (Krishna 2002). The Vickrey auction thus corresponds to the Vickrey-Clarke-Groves mechanism discussed in chapter 2.2.1.1.2. The Vickrey auction is only rarely applied in reality.[80] This corresponds with the insights gained from laboratory experiments. The Vickrey auction is considered suspicious because of its high complexity. This complexity bears the danger that the bidders do not perceive the optimal strategy. This is exactly what is being observed in laboratory experiments where bidders overbid their true valuation (Kagel, Harstad et al. 1987; Kagel and Levin 2001) In common value settings the Vickrey auction is anyway considered to loose its dominant-strategy property.

- Uniform-price auction
  In the uniform auction all item are sold at the uniform market-clearing price. It was the belief of famous economists that it is possible to transfer the properties of the Vickrey auction to the uniform auction. They argued that the agents have the dominant strategy to reveal their true demand. However, Ausubel and Cramton have shown that an agent can be better off to reduce demand in order to lower the uniform price (Ausubel and Cramton 1996).
- "Pay as you bid" auction
  In the case of *"pay as you bid"* auctions each bidder has to pay that price that he bids on the winning bids. *"Pay as you bid"* auctions are especially vulnerable to demand reduction. Furthermore, this auction format is dangerous for uninformed agents, as the utility depends on the beliefs.

Accordingly, none of the three auction types are optimal. The Vickrey Auction is on the one hand superior, as it is immune against demand reduction. It is, however, too complex to be of any help in the field. Both the uniform as the *"pay as you bid"* auction have some defects; a general revenue ranking has not yet been found (Bikhchandani and Huang 1993; Binmore and Swierzbinski 2000).

Due to these shortcomings of sealed bid auctions, economists have attempted to derive iterative open or dynamic auction formats. For example, the so-called Ausubel auction is intended to implement the same social choice function as the Vickrey auction (Ausubel 2003). Although laboratory experiments for the Ausubel auction have rendered promising results (Kagel, Kinross et al. 2004), it still lacks empirical evidence, as the Ausubel auction is not yet realized in the field. Beside the Ausubel auction the multi-unit versions of the English and Dutch auctions are also heavily discussed.

The description of multi-unit auctions may have illustrated that currently the basic auction formats are analyzed with respect to their revenue and efficiency. Apparently, also multi-unit auctions are impeded by context sensitivity. Unlike single-unit auctions the multi-unit auction research is not as mature.

2.2.1.2.2 Double-Sided Auctions

Double-sided auctions or shortly double auctions are those auctions where competitive bidding takes places on both sides. In comparison to traditional single-sided auctions, double auctions have received much less attention by modern economic theory. For double auctions, where many buyers and many sellers compete against each other, it is difficult to game-

[80] Further reasons for not using the Vickrey auction in the field can be found for example at Rothkopf, Teisberg et. al. (Rothkopf, Teisberg et al. 1990).

theoretically model the strategic behavior of buyers and sellers (McAfee and McMillan 1987b).

Thus, theoretical models typically focus on the very simple two sided institutions, where agents engage directly in bargaining over the terms of exchange. The k-double auction is thereby the simplest form of a double auction. In essence buyers and sellers submit their bids in a sealed envelope to the auctioneer. The auctioneer forms from the individual bids demand and supply schedules and determines the prices where demand and supply are balanced. Using a given parameter $k \in [0, 1]$ a market clearing price $p = (1-k)a + kb$ is chosen from the interval [a, b] confining the range of all possible market clearing prices. Buyers with bids higher than this market-clearing price will then trade to those sellers, who submitted lower bids than the clearing price (Satterthwaite and Williams 2002).

The k-double auction was initially introduced by Chaterjee and Samuelson (Chatterjee and Samuelson 1983). Originally, they consider a bilateral-monopoly single unit-case with private values that are independently drawn from known uniform distributions (Friedman 1991). In essence they find linear Bayesian Nash equilibrium bidding strategies, which can miss mutually beneficially trades with a positive probability. These inefficiencies can be explained by the fact that both the buyers and sellers have an incentive to misrepresent their true preferences. In this context, Myerson and Satterthwaite show that in environments with incomplete information some of those ex-post inefficiencies are inevitable (cf. chapter 2.2.1.1.1) (Myerson and Satterthwaite 1983). However, Rustichini, Satterthwaite, and Williams demonstrate that these efficiency losses decrease, as the numbers of buyers and sellers increase.[81] This rise in efficiency occurs because each agent's strategy converges rapidly towards truthful reporting – in other words the agents become price-takers (Rustichini, Satterthwaite et al. 1994).[82] Accordingly, the increase of agents induces a price taking behavior and thus increases the efficiency of the double auction.[83] Wilson (1985) introduces the many-buyer/many-seller double auction model as a game of incomplete information. He also comes to the conclusion that double auctions are *incentive efficient* in large markets with strategic traders (Wilson 1985).

When values are private, it can be summarized that under quite general distributional assumptions that double auction equilibria – *if existent* – are nearly efficient, if the number of the participating agents is *"sufficiently large"* (Fudenberg, Mobius et al. 2003; Gjerstad 2003). The existence of equilibria has long been an open question. Recently some contributions have been provided that prove the existence of double auction equilibria in certain environments (Fudenberg, Mobius et al. 2003; Reny and Perry 2003). Apparently, the outcome of a double auction exists and is *"approximately"* efficient when sufficiently large number of agents participate.

Accordingly, it is not astonishing that the double auction has been praised for its strong price discovery capability. Moreover, the double auction has even been claimed to substitute for human-rationality. For example, Gode and Sunder introduced the *"zero-intelligence"* (ZI) robots that are governed by random choice and constrained only by a budget constraint. In their simulation they show that the market forces coordinate the agents towards the efficient

81 Rustichini, Satterthwaite, and Williams established a $1/n^2$ rate of convergence towards efficiency, where n is the equal number of buyers and sellers (Reny and Perry 2003).

82 Satterthwaite and Williams demonstrate that agent behavior converges to price-taking behavior at a rate of $1/n$, where the where n is the equal number of buyers and sellers (Reny and Perry 2003)

83 Since the early work of Vernon Smith (Smith 1962), experimental economists have demonstrated that double auctions with sufficiently large numbers of buyers and sellers converge reliably to competitive equilibrium (Smith 1982; Gjerstad 2003).

competitive equilibrium (Gode and Sunder 1993). It is, however, highly unlikely that these results can be transferred to human agents, as humans are more complex than ZI robots in their information processing capabilities (Brewer, Huang et al. 2002).

In summary, the theoretical research concerned with double auctions is currently in its infancy. It is well known that the double auction converges efficiency if the number of buyers is sufficiently large. It is, however, not completely understood why this is the case. Furthermore, as any other auction, the double auction is also context sensitive – though extensive work is missing.

2.2.2 Informational Mechanism Theory

In line with the prevailing tradition, informational mechanism design interest was focused on allocative efficiency and informationally decentralized decision-making. Allocation and informational efficiency are *"two highly desired properties for an economic mechanism"* (Tian 2004**,** 79) as the resources are non-wastefully allocated with minimal cost of operation. Both properties point at some more or less obvious information aspects:

Intuitively, it appears to be natural that *allocative efficiency* in general requires the availability of some information to obtain optimal outcomes. Allocative efficiency in general is not restricted to a particular mechanism but applies to *any* mechanism. The following example demonstrates that certain information is necessary to determine the efficient allocation.

Example 2.2-1: A simple mechanism[84] (Hurwicz 1972; Hurwicz 1998)

Suppose there is one commodity Y, which is currently produced by two producers 1 and 2. The maximum aggregate output of the two producers $Y = Y_1 + Y_2$ denote the optimal outcome. The producers' production functions are given as follows:

$$y_1 = \alpha_1 a_1 + \beta a_2 - \frac{a_1^2}{2}$$

$$y_2 = \alpha_2 a_2 - \frac{a_2^2}{2}$$

Note, that a_i denotes producers i' activity level. The term βa_2 denotes the negative external effect (caused for example by pollution) agent 1 suffers. By standard economic procedure one obtains the optimal activity levels a_i*

84 A mechanism is here interpreted as a "verification scenario". Hurwicz defines a verification scenario as a procedure in which each participant verifies that the adjustment process has reached a stationary point. Recall that an adjustment process was viewed as a message exchange process. As such it can be formalized by a number of difference equations representing the response behavior of the agents. That is response behavior of the i-th agent was defined as:

$$f_i(m(t-1) \mid e_i, I) \quad = \quad m_i(t) \quad = \quad m_i(t-1) + l_i(m(t-1) \mid e_i, I)$$

The (informationally decentralized) adjustment process is in equilibrium when a stationary message profile $\overline{m_i} = f_i(\overline{m} | e_i, I)$ has been reached. This is the case when for all agents $l_i(\overline{m} \mid e_i, I) = 0$. Now the notion of a verification scenario may become clear. Each agent knows his local environment e_i and his equilibrium function l_i. For any "candidate message profile" m_0, all agents verify whether the condition $l_i(m_0 \mid e_i, I) = 0$ is verified (Hurwicz 1998).

In other words, a verification scenario is defined as an omniscient oracle that proves the participating agents that the proposed allocation is optimal (Nisan and Segal 2003).

$$a_1^* = \alpha_1$$
$$a_2^* = \alpha_2 + \beta$$

In the absence externalities, it suffices having knowledge about α_1 and α_2 in order to calculate the optimal activity levels. However, if externalities were prevalent but the impact β was unknown, no mechanism could assure optimality. That means in the presence of externalities an efficient mechanism also requires knowledge about the externality beside knowledge about α_1 and α_2.

This little example[85] shows that any mechanism requires some information in order to guarantee allocative efficiency. If this critical information were not available, no mechanism can attain allocative efficiency.

Information is, however, not freely accessible but embedded in the agents' local environments (i.e. preferences, endowment, and technology). The mechanism simply utilizes the dispersed information concerning the local environments to obtain a plan where the resources should optimally flow by communication and computation. For example, an agent expresses his desire for a certain resource by an offer to buy the resource for a certain price. Subsequently, he communicates this offer to another agent. The receiving agent computes, whether he should accept the offer. The computation takes his local environment into consideration. If the computation yields that the offer is unacceptable, he submits a refusal or a counteroffer to that agent.

This illustration marks the informational point of view, which regards the resource allocation mechanism as a *"gigantic information processing system"* (Hurwicz 1997). Now *informational efficiency* comes into play, as it requires the mechanism, i.e. the information processing system, to have minimal informational cost of operation or in other words the least cost of communication (Nisan and Segal 2003). Among the mechanisms that realize the same outcome, the least costly one is the most desirable mechanism. Cost of communication denotes an umbrella term and reflects all *"efforts the organization's members have to make as they carry out the mechanism"* (Hurwicz and Marschak 2001). Those communication efforts – sometimes called the informational burden – could be quantified by measures that are labeled *"communication"*, *"computation"*, *"observation"*, and so forth. Those measure are, however, tightly intertwined as the following example will show:

Remark 2.2-2: Informational burden

In order to calculate the allocative efficient allocation in a combinatorial auction, e.g. in a GVA, the auctioneer requires full information about the agents' preferences. The burden of such information requirements primarily reflects the centralized determination of the allocation and transfer combinations (winner determination problem). If the combinatorial auction had in contrast being exerted by an iterative format – as it is motivated by several authors (cf. Parkes 2001; Ausubel and Milgrom 2002) – the allocation-price combinations would be obtained through an informationally decentralized process, in which the central computational burden is sidestepped by transferring it from the central auctioneer to the participating agents (Nisan and Segal 2003). Nonetheless the informational burden is in both cases taking all costs into consideration almost alike.

[85] One could also interpret this production problem as a resource allocation problem. In this case, Y denotes total utility of the society and a_i the amount of units assigned to agent i.

Searching for a mechanism that is efficient with respect to all measures would be cumbersome, if possible taking the demonstrated interdependencies among the costs into account. Economic literature thus introduces a measure for the communication effort. More specifically, it concentrates on the informational size of the message space M. The richer the information-carrying capacity of messages, the harder the computational burden for the agents becomes. This burden primarily reflects the agents' difficulties to identify the messages that are being announced to them or to decide how to react (Mount and Reiter 1974; Hurwicz and Marschak 2001). The informational size is basically an indirect way to restrict the kind and the amount of information exchanged. Frequently, the informational size is operationalized by the dimensionality of the message space (Mount and Reiter 1974).[86] That is the number of real variables that need to be communicated to solve the allocation problem efficiently. A mechanism that realizes the same allocation as another but has a smaller dimension of the message space is said to be informationally more efficient.

Example 2.2-2: Informational size

Example 1:
In our production example (Example 2.2-1), in the absence of externalities minimally two variables, α_1 and α_2, need to be announced in order to ensure allocative efficiency. At least a message space of dimension three is required if externalities are present. Beside the technological parameters also the strength of the externality β is essential to attain efficiency.
Example 2:
The (Walrasian) competitive mechanism only requires price vectors to be communicated and the allocation. A mechanism that attains the same allocation as the competitive mechanism but requires the revelation of full preference sets is less informational efficient.

The main achievement of the informational mechanism design literature is the *"formulization of Hayek's idea"*(Nisan 2000) that the competitive mechanism achieves for all convex environments an efficient allocation at minimal informational costs (Hurwicz 2003). That implies that there does not exist a mechanism for this class of environments that also achieves optimal coordination but uses a smaller informational size of the mechanism space than the competitive mechanism. In the absence of convexity (externalities) there may not exist a mechanism with a finite-dimensional message space that guarantees allocative efficiency. More complex message spaces are required to achieve optimality (Calsamiglia 1977).

The exploration of the message space size has direct impact on mechanism design. As informational mechanism design does not take incentival issues into account, the minimal message space size marks the lower bound for the incentive-oriented designer. Smaller message spaces cannot guarantee allocative efficiency and are thus inappropriate. On the other hand, the powerful instrument of incentive-oriented mechanism design, the revelation principle, is once again reconsidered: Two mechanisms, say a direct revelation mechanism and an indirect one, implement the same social choice function. From an incentival perspective, both mechanisms are equivalent. However, from an informational point of view the indirect mechanism can incur much less information costs (Groves and Ledyard 1977; Hurwicz and Marschak 2001; Sertel and Koray 2003).

[86] Recent research has been focusing on the concept of informational size from a Computer Science perspective. For an overview see for example Nisan (Nisan 2000).

2.3 Chapter Summary

The term *market* is often used but rarely fully understood. Neoclassical theory starts its analysis with the determination of the market prices – without giving an interpretation of the market itself. The reason why the *market* is not further observed follows straightforwardly from its properties: Markets are institutions through which exchange of resources is facilitated. As such, the market reduces transaction costs. In the so-called Coasean world free of transaction costs the market has no really function. As such, the neoclassical models regard institutions as allocatively neutral (Coase 1988).

A Coasean transaction-cost-free world is, however, not realistic by any means. From an institutional point of view, the market is defined as a microeconomic system. The microeconomic system framework aims at the identification and structuring of the main concepts that are used in the market context. Basically the microeconomic system consists of an economic environment and an institution.

- Economic environment
  The economic environment summarizes all factors that affect demand and supply. More precisely, the economic environment comprises the agents, the agents' characteristics, the resources, the resources' characteristics, and the endowment.
- Institutions
  Institutions are rules that make agent behavior more predictable. In the market context, the institutions comprises a language through which the agents can express their strategies via messages, a choice rule that determines *who gets what*, a transfer rule that computes the corresponding prices and adjustment process rules, which regulate the process of exchanging messages.

Institutions are principally issued in order to attain a set of goals or desiderata, i.e. allocative efficiency or revenue maximization. The institutions alone are just rules delimiting the decentralized resource allocation process among the agents. What determines the allocation and the prices, and thereby the set of goals, is the agent behavior. Agents behave spontaneously triggered by needs and desires within the scope of the institution. Needs and desires are expressed by messages to buy or to sell. More abstractly the outcome of an institution, i.e. the allocation and prices, is determined by agent behavior, which is in turn influenced by the economic environment and the institution. Apparently, for analyzing institutions it is necessary to include a behavior assumptions. By means of a *mechanism*, the outcome of a given institution and economic environment can be computed by assuming rational behavior.

Hitherto, the description of the market as a microeconomic system framework was rather static. The used concepts and their general relationships are revealed. What is missing is an understanding how markets work. What is the impact on the outcome if one institutional rule is changed or added? What is the impact of an institution if it is applied to a different environment? What is the institution that maximizes revenue? The static microeconomic system framework certainly cannot answer questions like that.

Models are needed that explain the exact transmission channel of one concept on another. Basically models are abstracting from the reality by making assumptions. Within the limited scope of the model effects can be studied, equilibria can be tested, and impossibilities can be detected etc. Models that are concerned with mechanisms can be classified as either interested in information or incentives.

Informational mechanism theory is mainly concerned with the convergence properties and complexity of the microeconomic systems involved. Mechanisms that require a smaller informational size of the message space but achieve the same allocation are preferred. These mechanisms require less computation since they are informationally more efficient. Obviously higher informational efficiency corresponds with lower transaction costs. While the work on informational mechanism theory continued and still continues, "*the issue of incentives began to creep in as well, as it became clear that any system for making decisions or allocation resources might be open to some manipulation by its participants*" (Jackson 2003). Broadly speaking classical mechanism design strives for developing incentive schemes, i.e. mechanisms, such that an intended social choice function, i.e. outcome, is realized. The main contribution of mechanism design is to verify whether there exists any mechanism that can implement a particular outcome as equilibrium. Another important strand of mechanism design theory is concerned with the design of optimal or efficient mechanisms in different environments. These so-called possibility theorems may, however, be taken with a pinch of salt, as the results are often plagued by multiple equilibria. While the mechanism itself is the variable in the mechanism design, auction theory treats the mechanism as given. As such, auction theory shows the effect of the incentive scheme on individual bidding strategies. This way it is possible to compute utility and revenues in equilibrium. Auction theory can thus reveal valuable information about good bidding strategies and the impact of auction formats on revenue and efficiency.

With these two components of theory at hand, framework and models, firstly, characterize the market as a microeconomic system for resource allocation and secondly gives insights about the effects markets have in coordinating resources.

3 Electronic Market System Framework

> *"But what happens when the friction becomes the machine?"* (DeLong and Froomkin 2000, 18)

In the previous chapter the *market* was abstractly characterized as microeconomic system. The microeconomic system framework provides a well-defined basis for analysis. Relying on this framework, mechanism theory has established itself as a rather mature discipline. When *electronic markets* are analyzed it stands to reason that electronic markets are nothing more than markets. As such, the research papers that can be found about electronic markets often address exactly the same questions as mechanism theory. For example, the newly emerging field of computational mechanism design strives for developing algorithms that implement or approximate the mechanisms from classical mechanism design theory in polynomial time (Parkes 2001).

The microeconomic system framework and the corresponding theories are indeed an appropriate model for an electronic market, if it is reflected that transaction costs can arise in carrying out the market process. These transaction costs can be substantial such that they may swamp the theoretical benefits of the institutions (McMillan 1994). Apparently, when electronic markets are regarded as mechanism, it is implicitly assumed that the provision of the institution and the conduct of the resource allocation process come for free and without incurring additional transaction costs. In the last chapter Stigler (Stigler 1972, 12) was cited, who criticizes the strange neoclassical model world without transaction costs. For explaining electronic markets, it is also strange to assume provision and conduct of the institutions for free.

Thus, electronic markets are not just *"growing like weeds"* they need intensive care (Roth 2002). Different to non-electronic markets it is impossible for electronic markets to spontaneously evolve. A computer-system as a facility for trading is necessary for an electronic market to emerge. Thus, there must be *someone* who is willing to provide this facility. As this provision is associated with costs, this *someone* must recoup his expenditures. Apparently, the assumption of free provision is no longer tenable.

Different to the transition from the neoclassical to the new institutional approach it is not necessary to introduce a new paradigm for including those aspects associated with electronic markets. On the contrary, the discussed theories still apply to electronic markets. The effects predicted by mechanism theory are naturally becoming blurred as other – previously not observed – effects may also emerge. Principally, the microeconomic system framework can be extended such that the aspects of electronic markets can be fully covered. It is the goal of this chapter to illustrate a comprehensive overview over electronic markets by adopting the viewpoint of new institutional economics. Basically the framework relaxes some implicit assumptions on the key concepts economic environment and makes them explicit in concepts.

The relaxation is necessary since those assumptions substantially diminish the general applicability of theory in practice. For example, the celebrated Electronic Market Hypothesis (EMH) predicts a shift from firm-bound coordination to (electronic) market coordination because IT as a catalyst lowers transaction costs of electronic market significantly (Malone, Yates et al. 1987; Kauffman and Walden 2001). This prediction of the EMH assumes, however, the market to be a resource allocation mechanism, which does not itself create transaction costs. In practice, providing and operating electronic markets is rather an entrepreneurial activity. As such, the entrepreneur will require the market participants to discharge fees, which are – transaction costs. Apparently, the EMH overestimated the impetus of the shift, because other factors were not included. This does not mean that the model of the EMH is incorrect, but it does mean that models must be handled with care.

The development of the electronic market system framework, thus, serves as a common ground to investigate the limits of a model: It may illustrate which concepts a model is using. Likewise does the framework point out, which concepts are not explicitly specified. When models are applied to practical problems the electronic market system framework may help to point at weaknesses. The identification will, furthermore, play a crucial role, as it reveals the action space (or parameters) for designing electronic markets. Lastly, the framework is also intended to incite the development of new models, which take different aspects of the electronic market realm into (formal) considerations.

The objective of this chapter is to extend the microeconomic system framework to electronic markets. By extending the prevalent framework, it is intended to assure compatibility with existing theory. As the extensions cover a wide range of different aspects, it is not possible to provide a closed formal description of all concepts. Different than the microeconomic system framework the electronic market system framework is not the formal definition of a generalized model. The real world is too complex to squeeze it in one general model. This may explain why this chapter does not contain a part *"models"*. There does not exist a coherent theory of electronic markets. This does not mean that there are no models at all – only the existing models differ from each other. The description of the framework thus includes at some points remarks that briefly explain models that deal with the proposed extensions of the framework.

The chapter is divided into five parts. In the first part (chapter 3.1) the microeconomic system framework is extended. Mainly the environment and in particular the institution require several amendments. The electronic market is, however, still regarded as a coordination mechanism. Chapter 3.2 introduces the entrepreneurial view on electronic markets. Electronic markets are (formal) organizations that strive for profit-maximization or at least cost-coverage. This point of view opens up a totally new perspective on electronic markets – a service view. Chapter 3.3 elaborates on the organizational view in a way that markets firm are no longer regarded as a monopolist but as a firm in competition. Chapter 3.4 summarizes all three views on electronic markets – the institutional, organizational and the industry view in one framework – which basically is the electronic market system framework. Chapter 3.5 concludes with a chapter summary.

3.1 The Institutional View on Electronic Markets

In the microeconomic system framework it was assumed that there exists a resource allocation mechanism. The existence can be postulated without problems because the provision and conduct of the mechanism comes for free. Stated differently, in absence of transaction costs for carrying out the resource allocation process, the resource allocation mechanism is free of charge. This simplification among others allows the isolation of the mechanism design problem. Apparently, by means of assumptions, the mechanism design problem becomes mathematically tractable. Comprising, the microeconomic system framework is exclusively devoted to the analysis and design of mechanisms in different environments.

In this simplified model world there is presumably no place for electronic markets. Since the conduct of the resource allocation process creates no transaction costs, an electronic market reduces to the underlying microeconomic system described above (cf. chapter 2.1.4). Regarding the electronic market as microeconomic system is, however, only meaningful when the mechanism design problem is focused. But even then it is highly problematic to analyze electronic markets without paying attention to transaction costs. Markets are conducted electronically *because* they incur less transaction costs in carrying out the resource allocation process (Bakos 1991; Bakos 1998). When analyzing electronic markets it is, hence, essential to include those transaction costs into consideration.

The introduction of the transaction costs has, however, major ramifications. Firstly, the medium through which the allocation process is conducted affects the allocation problem and must be included in the adapted framework. Secondly, installment, operation and maintenance of the medium create costs that must be subsequently recouped. Apparently, providing a medium for conducting the allocation process is an entrepreneurial task. The entrepreneur overtakes the risk of investing in the medium, in expectation of subsequent revenues. Hence, incurring costs are charged from the participating agents who actually benefit from the medium. Altogether the microeconomic system must be extended with respect to (at least) two aspects: an entrepreneur is needed and the institution must also allow payments from the agents to the entrepreneur. Those two points have another crucial consequence: the allocation mechanism is no longer for free. The entrepreneur must decide, for which environment to provide electronic markets. Apparently, the free lunch assumption of the microeconomic system framework is no longer tenable.

This brief depiction already pinpoints the fact that the microeconomic system framework sketches a very restrictive view upon markets. Not the definition of markets – being a microeconomic system $S = (e, I)$ – is restrictive but the underlying assumptions. On the one hand, those assumptions help to isolate the implementation problem and make it formally tractable, on the other hand they abstract from the real world such that an application to more realistic settings is impossible. This trade-off between applicability and tractability is, however, immanent.

For the analysis of electronic markets it is intended to provide a modified framework Electronic Market System framework (henceforth EMS) that is devoted to *"real world"* aspects at the expense of rigor tractability. In other words, the EMS framework introduces the concept of an electronic market, which constitutes a microeconomic system but modifies the assumptions in a way that the electronic market can reflect its counterpart in the real world. More precisely, an electronic market amounts to a modified microeconomic system $S^{EM} = (e', I^{EM})$, where the modification pertains to the concepts of the economic environment and institution and their assumptions.

Definition 9: Electronic Market

An Electronic Market is a market that uses information systems for communication.

In summary, the EMS framework strives for depicting the electronic market in a way that real world phenomena can be analyzed. This is actually achieved by relaxing the assumptions of the microeconomic system framework imposed on the components economic environment and institution. This extension to the EMS framework comes, however, in expense of a closed formal model.

3.1.1 Economic Environment

The microeconomic system framework has a clear understanding of the economic environment. This understanding can, however, be characterized as being static, and fully rational. Static nature refers to the fact that the economic environment is a-priori fixed and not changing.[87] Furthermore, the economic environment assumes – in microeconomic tradition – the agents to behave rational. This implies that the agents act such that their utility is maximized, where utility is defined over the allocation of resources alone.

Both basic assumptions thwart the central intuition of the EMS, which emphasizes realistic environments, which are characterized by dynamism and irrationality. For example, electronic markets exert their strengths especially in highly dynamic settings. Conducting the market process over electronic media is much faster than over traditional non-electronic markets. Apparently, they bear the potential to accommodate the demands of highly dynamic environments. The participating agents can immediately react on changes in demand and supply for a resource by accessing the electronic market. Different than ordinary non-electronic markets this can be done within seconds. Moreover, the EMS seeks to systematize arguments that could also play an important role in the utility formation of the agents.

Furthermore, the EMS introduces a third central extension, which basically pertains to the presence of an entrepreneur willing to conduct the allocation process. While there was no need to include an actor, who performs the allocation process in the microeconomic system framework, the EMS simply requires it. The position of entrepreneur is crucial, as the existence of an electronic market hinges upon the entrepreneur. With the introduction of the entrepreneur also aspects that were previously exogenously given (e.g. the resources for allocation) will now depend on the entrepreneur's decision. As such, it moves aspects from the economic environment towards the institution.

Those three amendments affect the economic environment, as will be demonstrated along this sub-chapter. Nonetheless, the basic structure of the economic environment can be held upright despite the amendments. Consequently, the economic environment pertaining to electronic markets still consists of agents, resources and their characteristics.

3.1.1.1 Agents

The microeconomic system framework characterizes agents by their participation in the mechanism for trading reasons, e.g. buyers and sellers exclusively. Those agents can naturally differ in their preferences, size, and endowment. For example, intermediaries may naturally represent agents possessing a large endowment. It is, however, not required by definition that agents must participate for trading reasons. Principally, the mechanism designer could also actively take part in the resource allocation process. In the microeconomic system framework, this is simply ruled out by assumption.

This ruling out can be best understood if the tasks of the mechanism designer in the microeconomic system framework are closer observed. Basically, the mechanism designer is a fictitious planner, who performs beside the designing task also administrative jobs such as conduct and enforcement to ensure the market process. Since the framework implicitly assumes that the messaging occurs immediately without any interruption, and, the allocation as well as

[87] Basically Vernon Smith already addressed this point in his description of the microeconomic system framework. He suggested that preferences could change over time. Nonetheless, this suggestion was hardly incorporated in the framework (Smith 1982).

the corresponding transfers[88] are computed regardless of the time at once conduct is no issue. Likewise is enforcement irrelevant, as it is assumed that allocation and transfer payments take places immediately without any risk. Lastly, the mechanism designer develops a mechanism such that a given social choice function is implemented. Apparently, the mechanism designer is hypothetical, as the associated tasks are defined away from self-interested acting of the mechanism designer. If those restrictive assumptions are relaxed the mechanism designer may eventually materialize as a player. Remark 3.1-1 and Remark 3.1-2 demonstrate two examples where the mechanism designer appears as an actor being part of the economic environment.

Remark 3.1-1: The Mechanism Designer as Interactive Designer

Example 2.1-1 already raises the question, why the mechanism designer is not actively engaging in the process (Jackson 2001). The standard implementation problem assumes that the designer or social planner respectively designs the mechanism, i.e. message space and choice and transfer rules which maps the messages into allocations and payments. Once this mechanism is set up, the agents submit their corresponding (equilibrium) messages and receive their allocation share. However, in case the agents submit out-of-equilibrium messages the mechanism will attain highly undesirable allocations. Since the mechanism designer is not taking part in the process, there is no chance to mend this endemic defect.

If the mechanism designer is, on the contrary, capable of changing the mechanism interactively along the process, those bad outcomes can be ruled out: In the *theory of interactive implementation* the mechanism designer is a player, who wants to maximize his utility function. The social choice function is thereby representing the mechanism designer's utility function. The resource allocation process is now characterized as a two-staged process. In the first stage the agents simultaneously convey their messages to the mechanism designer. Subsequently, in the second stage the planner reacts upon the message profile by selecting a mechanism that maximizes his expected utility. By the inclusion of a utility-maximizing designer as a player those undesirable (out-of-equilibrium) outcomes becomes impossible (Baliga, Corchon et al. 1997).

Remark 3.1-2: Mechanism Designer as Supervisor

The mechanism designer acting as a supervisor becomes a player, if he can revoke his guarantee to enforce the trade. For example, if the seller bribes the mechanism designer, the buyer makes a payment, which the colluding buyer and mechanism designer divide among them. Taking a one-shot game into account, this collusive behavior may make sense, in repeated games, however, not. The defrauded agent will presumably absent the market process; it is advisable not to participate in the resource allocation process, as the utility is negative with a positive probability (Celik 2003).

In the electronic market system framework a *real* entrepreneur replaces the *hypothetical* mechanism designer. This entrepreneur is subsequently called market firm.

Definition 10: Market Firm

The market firm is the business unit, which designs the institution, conducts the bidding process and enforces the resulting allocation and prices.

[88] Determining the allocation and transfers is regularly called the winner determination problem.

Different to the microeconomic system framework the electronic market system framework drops the (hidden) assumptions of immediate and correct conduct as well as certain enforcement. Relaxing these assumptions the market firm receives tasks that are not per definition immediately solved without any risk. Apparently, the market firm becomes an actor being part of the economic environment.

3.1.1.2 Characteristics of the Agents

In chapter 2.1.2.2 the characteristics of the agents were described as the agents' decision-making behavior. In the microeconomic framework the agents are supposed to act in the mechanism such that their utility drawn from the resource allocation is maximized. The utility is expressed by two factors: risk attitude and by preferences over resources (see 2.1.2.2). The utility formulization thereby implicitly assumes the following:

(1) preferences are only dependent on resources,
(2) social factors are absent,
(3) preferences are stable,
(4) agents are present from the outset of the resource allocation process.

Assumption (1) suggests that preferences of the agents are only dependent on resources. This, however, widely ignores that taking part in a mechanism may also affect utility.

Assumption (2) claims that social aspects do not play a role in the decision-making behavior. Apparently, the social life of the agent such as friendships or other relationships also affect the decision-making behavior.

Assumption (3) sketches a static character of the microeconomic framework, since preferences are not changing over time. It is rather obvious that the extension towards an EMS framework must drop this assumption.

Assumption (4) rules out any dynamic elements in the microeconomic system. Agents are present from the beginning of the resource allocation process. When the factor time is introduced agents may enter the resource allocation process late.

In summary, assumption (1) and (2) prevent that agents can have other arguments in their utility function than the pure resource allocation. Assumption (3) and (4) impose a static character of the resource allocation process. In the following the assumptions will be subsequently dropped.

3.1.1.2.1 Preferences over Mechanisms

The microeconomic system framework models the preferences as a function of the consequences, i.e. allocation and payment, of a mechanism. The consequences are further defined in terms of the outcomes. This, in turn, implies that preferences are not affected by events and activities associated with the participation in a mechanism. The difference between those two sources of utility might be confusing. Thus, two examples are given to pinpoint those two sources in more detail:

Example 3.1-3:Upstairs markets

Recall the block-trading example from Example 2.1-18. Block-traders favor crossing networks to usual continuous trading systems (cf. Pagano 1989). The conclusion that this epitomizes the fact that agents value the usage of mechanism differently, depends solely on the mechanism is simply wrong. The reason why block-traders choose this mechanism is totally output-driven. Due to the detrimental effect of continuous double auction, they do not use it. Accordingly, the classical mechanism theory model is sufficient to mirror this step.

Example 3.1-4: C2C Internet auction

A different example is reported about a famous Internet auction-house. Within bidding frenzies such overbidding can occasionally reach ridiculous heights. For instance, a computer cable worth $9 available in any store was sold for $50 (Cohen. 1999). Unlike the previous example, utility cannot only be drawn through the consequences. The outcome of this mechanism is highly inefficient, as it results in a drastically negative utility for the buyer. Obviously, the winning agent derives utility not only from the allocation (which was negative) but also from the participation in the mechanism.

Accordingly, not only the allocation of resources but also the thrill in participating in the mechanism contributes to an individual utility. As noted, classical mechanism design theory implicitly ignores mechanism-oriented determinants, since the utility function only comprises outcomes as arguments. Or stated differently, it takes the mechanism as an exchange of *"meaningless messages"* (Glazer and Rubinstein 1998, 159). However, messages are not meaningless at all: Suppose for example, there are two agents, one buyer and one seller with corresponding reserve prices v_b and v_s, respectively. The designer wants to implement a social choice function, which attains that the good is transferred from the seller to the buyer as long as $v_b > v_s$. Mechanism Design theory suggests that "take-it-or-leave-it" would be appropriate in such a situation. This rational, down-to-earth view, does not account for the idiosyncratic factors concerning the mechanism. Participating in a mechanism can itself influence the individual utility. In this respect the interpretation of meaningless messages is incorrect. Rather are the messages, offers, counteroffers, or accepts. An offer may mean something totally different to different people. In our example the seller could set his take-it-or-leave-it price at slightly less than the buyer's reservation price v_b. This offer could – although it leaves some value on the table for the buyer – insult the buyer. Because of these emotions the buyer opts for the "leave it" option, which leaves him with zero utility. Accordingly, *"ignoring mechanism-related motives may yield misleading results."* (Glazer and Rubinstein 1998, 159)

Remark 3.1-5: Implementation with agents that have preferences over the mechanism

The idea of preferences over mechanisms is not completely new in mechanism theory. In the Glazer and Rubinstein model, for example, preferences are also dependent on the mechanism. Basically, they sketch a voting scenario where the agents provide recommendations as messages. As an innovation, the model prescribes that the agents are concerned about how their recommendations end up in the final decision: apparently, agents wish to see their recommendations be reflected by the implemented social choice function. This introduces a feedback between the mechanism and the equilibrium behavior of the agents. Interestingly, Glazer and Rubinstein demonstrate that implementation becomes possible by the introduction of preferences over the mechanism that were previously impossible (Glazer and Rubinstein 1998; Jackson 2001). From an implementation theory point of view, modeling preferences over the mechanism will become an interesting issue.[89]

[89] Nonetheless, the author is not aware of any other model than the presented Glazer-Rubinstein model that also incorporates a feedback between equilibrium behavior and mechanism.

As a conclusion, the EMS framework also incorporates preferences over mechanisms in its description of the economic environment. Since the mechanism itself can exert positive or negative impact on individual utility, it must be made explicit.

3.1.1.2.2 Embeddedness

One of the most persistent issues within economic sociology has been the criticism concerning the modeling strategies of human behavior. Traditionally economics proceeds from *"the notion of homo economicus acting in a world with full information, independent decision making, polypolistic competition, transitivity, and fixed preferences"* (Beckert 2003, 769). Sociologists commonly agree that the observed economic decision making in the real world does not match with these assumptions. Accordingly, sociologists have come up with a rival approach that may explain economic processes. It was Granovetter who revitalized the embeddedness approach, which has over the last fifteen years served as the crucial counter-concept used by economic sociologists (Granovetter 1985; Beckert 2003).

"The revival of economic sociology in North America has catapulted Mark Granovetter's 1985 article into prominence as its programmatic text and the embeddedness approach as its primary framework (Swedberg 1991). Consciously departing from the old economic sociology of Talcott Parsons and his colleagues, the proximate theoretical inspiration of the embeddedness approach is Karl Polanyi's work, especially his collaborative book Trade and Market in the Early Empires: »The human economy [...] is embedded and enmeshed in institutions, economic and noneconomic« (Polanyi, Arensberg et al. 1957, 250)" (Lie 1997, 349).

Basically the key assumption of the embeddedness approach is that social networks – resting upon friendship, trusts or goodwill – sustain economic actions. Economic actions such as negotiating or trading are embedded in networks of interpersonal relations. Four kinds of embeddedness are usually distinguished: cognitive, cultural, structural, and political embeddedness (Dequech 2003).

- Cognitive embeddedness basically refers to the concept of bounded rationality, as it addresses the limitations of *economic reasoning* due to the structures of mental processes (Zukin and DiMaggio 1990; Dequech 2003). Hence, decision making of an agent depends on (or is embedded in) his mental processes.
- Structural embeddedness refers to the social relations that are essential to the market process. Any agent is involved in network of relations. Clearly, this so-called relational embeddedness affects the behavior of the agents but is not the issue of this type of embeddedness. What is meant by structural embeddedness addresses the aspect that not only the personal relations matter, but also the structure of the aggregated network of relations. In other words, the relationship between economic agents cannot be validly decomposed into multiple atomistic bilateral relationships, as the overall network of social relationships influences the agents' behavior (Granovetter 1985; Simsek, Lubatkin et al. 2003). Granovetter summarizes structural embeddedness as the *"contextualization of (economic) exchange in patterns of ongoing interpersonal relations"* (Granovetter 1985; Dacin, Ventresca et al. 1999, 319).
- Economic actions are not only embedded in the network of ties but also in the political and legal framework of the country. Political embeddedness refers to the political context and the manner in which economic institions and decisions are shaped. Also the political and legal framework of the economy is designed embedded in a social environment. Both the political and the legal frameworks also sustain economic action (Jacobson, Lenway et al. 1993).

- Cultural embeddedness is concerned with the shared collective understandings of the society in shaping economic strategies and goals. As culture – understood as a system of believes, values, and symbols – provides the categories and thus the meanings in order to engage in economic actions, it affects individual behavior (Beckert 2003). Thus, cultural embeddedness as part of the economic environment stresses a constitutive form of culture.[90]

Overall, embeddedness emphasizes the fact that the agents are indissolubly connected with their social surrounding. Their decisions take also place within and with respect to this social surrounding. Apparently, embeddedness is not a rival theory to the prevailing economic theory. On the contrary, *"embeddedness arguments take economic activity seriously but look beyond the rhetoric of intentionality and efficiency and make a strong commitment towards understanding relational aspects of organizations"* (Dacin, Ventresca et al. 1999**,** 320-321). This allows the integration of the concept of embeddedness into the electronic market system framework as an additional external variable, which affects agent behavior and consequently the outcome of an electronic market (Beckert 2003). This may surprise on the first view as embeddedness was often cited as a rival theory. Nonetheless embeddedness cannot constitute a rival approach at all, as it does currently not provide a theory, which can explain the formation of strategy. Embeddedness thus argues on a different conceptual level, being part of the economic environment (Beckert 2003).

3.1.1.2.3 Instable Preferences

The founder of the microeconomic system framework already hinted at the possibility that preferences can change (Smith 1982). The microeconomic system framework principally is capable of modeling those learning processes. However, classical mechanism theory literature abstains from incorporating changes in preferences. As electronic markets are inherently associated with dynamic environments, it is essential to incorporate changes in preferences. Altering preferences can happen either on a short or on a long scale, i.e. during the messaging process or between different resource allocation processes:

Changing preferences during the messaging process

If it is assumed that the resources are not remaining the same during the messaging process, preferences concerning the modified resource characteristics can also fluctuate. For example, perishable goods such as flowers are gradually fading and, hence, loosing value for the agents. Even the risk of loosing value suffices to value a resource at a later time less than the same resource at an earlier time, i.e. the preference for immediate preferences are higher valued than delayed preferences. In those cases preferences can be conceived as a function of time.

In many cases preferences are assumed to decrease over time. Preference discounting has been coined to reflect uncertainty or anticipated decreases in the preferences of delayed consumption.[91] In this context factors that may induce preference discounting on a short scale are for instance changes in the probability or, alternatively, changes in the preference function. As time passes by, the probability that future consequences occur naturally changes.[92] Also the

[90] Culture will also play a role in the depiction of institutions. Under the term "social norms" aspects of culture will also be discussed. Different to the constitutive form of culture the section about "social norm" emphasizes a regulatory form. Regulatory form points at the changed level of analysis. Culture does not give meaning to the concepts but constrain the agents' behavior. As such "social norms" are enlisted in the chapter about institutions (Dequech 2003).

[91] Elsewhere, discounting is also used to reflect the assumption that agents have care less about future utility than about current utility.

[92] This bears the problem that the common discounted utility model representation has no explicit mean to account for changes in probability. Frederick thus concludes that in the case of changing probabilities,

preference function can change over time if the individual value for some resources change. As before, the benefit that can be drawn out of consuming resources depends on levels of recent consumption: Water is being valued higher when thirsty (Frederick 1999; Frederick, Loewenstein et al. 2002).[93]

Beside those economic arguments also other disciplines contribute to explaining changing preferences. For example, in social psychology, two major theories have been emerged to explain changing preferences during the messaging process[94]:

- *Dissonance theory* asserts that agents try to minimize cognitive dissonances (Festinger 1957; Bowles 1998). Cognitive dissonances term a state of psychological discomfort aroused by conflicting preferences[95]. During the messaging process the agents are supposed to submit messages, e.g. offers. Selecting one offer out of the variety of possible offers can create a dissonance, since choosing an offer forfeits attractive features of another. This state of cognitive dissonances is resolved by valuing the non-selected offer less attractive and the selected more attractive than before (Akerlof and Dickens 1982; Bendersky and Curhan 2003).
- Alternatively, *self-perception theory* assumes that the agents are unsure about their preferences. Based upon their own behavior the agents infer – comparable with a neutral observer – their preferences. This means the agents make a choice during the messaging process and take this choice subsequently as a kind of evidence concerning their preferences: If an agent submitted a specific message he must appreciate it (Bem 1967; Bendersky and Curhan 2003).

Those preference changes during the messaging process are difficult to capture. These phenomena are an exception to standard preference theory. As there are only few approaches in economic theory that can cope with these intra-mechanism preference changes, this issue is at this point not further elaborated.

<u>*Changing preferences between different resource allocation processes*</u>
The inter-mechanism change of preferences reflects the changes in preferences mostly on the long scale. It can either refer to mechanism-oriented or allocation-oriented preferences[96]. The change of *allocation-oriented* preferences is straightforward to explain. Firstly, as before, the preference may change if one or more resources are allocated to an agent. Then, satisfied de-

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the probabilities of future events and those for current consequences must be separately represented (Frederick 1999).

93 In this context, Rachlin argues that diminishing marginal utility is derivative of time preference. That is marginal utility diminishes because consumption of the marginal unit must be increasingly delayed. For example the first apple is valued more than the tenth as consumption of the tenth apple is delayed. Thus, Rachlin concludes that satiation alone cannot explain diminishing marginal utility because consumption could be sufficiently postponed to avoid satiation, with no loss in value if the discount rate was zero. Nonetheless as Matthews pointed out that this argument cannot account for all forms of diminishing marginal utility. The standard example is that the second teaspoon of sugar may improve the taste of a glass of iced tea less than the first teaspoon, although it does not delay its consumption (Rachlin 1992; Frederick 1999).

94 Here, only preferences concerning allocations are observed, as the emphasis is on changes during the participation in a specified mechanism. Note that preferences over mechanisms are relevant before the mechanism is selected.

95 Dissonance theory usually takes conflicting beliefs, attitudes or action as a reason for cognitive dissonance (Festinger 1957). At this point the psychological term is translated into the economic language.

96 For simplification reasons preferences without explanation are treated as preferences over allocation, whereas mechanism-oriented preferences are shown separately.

mand reduces the need for a resource and thus reducing the residual demand.[97] Secondly, a resource may be valued less than before due to the time elapsed. This devaluation can be reasoned by various reasons: perishable resources, expired contracts, a positive time preference rate, etc. Again, allocation-oriented preferences are time-dependent.

Remark 3.1-6: Dynamic Mechanism Design

Dynamic mechanism design accounts for the changing preferences by distinguishing two cases of time-dependent preferences (1) constant types (2) changing types of the agents. In (1) the type of the agents remains the same, only the allocation at time t is discounted. In (2) the characteristics of an agent, represented by its type is altering. Interestingly, dynamic mechanism design demonstrates that in a more period setting with changing preferences where the agents can commit intertemporally, the optimal dynamic allocation equals the replica of the optimal static allocations over all periods. This would suggest that a static formulization is sufficient. However, if renegotiation among the resources is possible dynamic mechanism design does not boil down to the static one (Dewatripont 1989; Fudenberg and Tirole 2000). An introduction about the discussion of dynamic mechanism design can be found at (Baron and Besanko 1984; Fudenberg and Tirole 2000; Ishiguro 2003).

Instable – in particular time-dependent – preferences will have an impact on the resource allocation process. For example, when analyzing the revenue maximizing mechanism for electronic markets, the dynamic nature of the environment is an important factor that needs to be considered. The previous discussion about the agents' preferences is envisioned to discover current shortcomings of the problem formulation. As aforementioned, there are only few research papers dedicated to the dynamics of the environment (for example Gallien 2002), but currently there is hardly anything known about the robustness of static mechanism design results in dynamic settings.
Nonetheless, as previously mentioned the EMS framework simply requires a certain degree of dynamic environment. As such, the inclusion of changing preferences – either on a short or long scale – is necessary to accommodate this dynamism.

3.1.1.2.4 Dynamic Arrival

Commonly, mechanism theory assumes that all agents are taking part in the resource allocation process from the beginning of the process. As such, those models are static in a way that they ignore the process through which bidders arrive to the market (Gallien 2002). Dynamic arrival relaxes the assumption of idle agents that are waiting for the market to start. Instead agents may arrive stochastically (Wang 1996).

3.1.1.3 Characteristics of the Resources

The microeconomic system framework usually assumes the available resources to be ex ante specified. That means the goods or services that are being allocated are finitely defined beforehand. Equivalently, there already exists a set of preferences over these resources. Since those preferences are exogenously given, they belong to the environment. This approach is rather convenient, as it avoids the need to formalize a *theory of commodities*.[98]

97 For instance, Wang models a multi-period model with conditional preferences (Wang 2003).

98 The development of a theory of commodities is heavily impeded by the fact that there are many ways to slice any resource into commodities. For example it is possible to sell spectrum licenses as a single item or as a bundle. This brief example may hint at the varieties how resources can be aggregated, decomposed, etc. However, a clear superior treatment of how to select the resources, which will be traded, has not yet developed (Wellman 1996).

In the EMS framework, the resources are not exogenously given. On the contrary the market firm can not only select the traded resources but also design it.[99] The market firm designs the resource by imposing (institutional) rules upon the appearance of the traded resources. By designing the resources, which amounts to a definition of the trading objects[100], the market firm can achieve two main objectives. Firstly, the market firm can standardize the trading objects in order to assure a basic quality of the traded goods. Secondly, the definition also gives the market firm a tool at hand to choose potential participant groups.

As a matter of fact, elements, which were part of the economic environment within the microeconomic system framework, are part of the institution with the EMS framework. Assuming the trading object to be ex ante defined, the set of preferences previously belonged undoubtedly to the economic environment of the microeconomic system framework. Now, allowing the market firm to specify the trading object makes this unambiguous assignment to the environment difficult, since the preferences are no longer exogenous. In other words, there is a – theoretical – dilemma since preferences over resources are one the one hand exogenous but also endogenous. More precisely, preferences over resources are per definition exogenous, as the market firm cannot alter the participating agents' taste by varying the trading object. On the other hand, preferences over resources obviously depend on the resources. As the market firm can design the resources, preferences over resources become endogenous (Postlewaite 2001).

This contradiction is more of a technical issue and can be mended by a different modeling of the preferences: Preferences are in Debreu's tradition expressed a function of the consumed resources. In his "new" approach of consumer theory Lancaster modeled preference to be dependent on the consumed physical characteristics of the resource (Lancaster 1966b). Lancaster argues that agents do not directly draw utility out of a good, but from its characteristics (or attributes)[101]. For example, the good "notebook computer" is defined by a bundle of its attributes such as weight, battery life, and computing power. In the figurative sense those attributes are taken as inputs into a production process, which converts the attributes into a kind of basic goods. For instance, the basic good, notebook model, is obtained by its attribute combinations "low weight", "long battery life", and "high computing power". The level of utility imputed by these attributes coherently differs from agent to agent. A business traveler, for example, may value low weight of the notebook more than its computational power, whereas a student appreciates more computational power than low weight.

In a Lancastrian utility function the attributes to meet some kind of needs are the primitive. Resources are no longer modeled as self-contained atomic unit but as a combination of attributes. Two goods that share the same attributes in the same proportions are deemed identical. What makes the Lancastrian approach attractive for the electronic market system framework is the fact that the preferences are exogenously given and constant. This flexibility is incurred with no additional drawbacks as any traditional utility function can be mapped into a Lancastrian utility function (Postlewaite 2001).[102] The exogenous nature of preferences over attrib-

[99] The notion of design may be surprising, as electronic markets are not necessarily producing the resources that are traded. Actually, so-called "biased hubs", i.e. producers, who are concurrently operating a market as a distribution channel, fall under this category. In these cases the term *design* in fact refers to a production process. But these biased hubs only characterize the minority of market firms. In most of the cases a neutral hub – viz. the market firm is neutral intermediary – can effectively design the trading object.

[100] The definition will be given in chapter 3.1.2.3.4.

[101] Lancaster adopts the term characteristics, as its connotation is neutral (Lancaster 1966a).

[102] Note that the mapping in turn is dependent on social factors (Postlewaite 1998; Postlewaite 2001).

utes entails that a newly introduced transaction object merely means nothing more than the compilation of the attributes in a different ratio than before. Apparently, the Lancastrian formulization allows the separation between trading object definition and the physical characteristics. While the compilation of the attributes is part of the institution, the preferences determined by the attributes are still part of the economic environment.

3.1.1.4 Endowment

The microeconomic system framework thoroughly defined the endowment of the agents consisting of resource and technological endowment. Resource endowment refers to the number of resources that are lying idle in storage. Technological endowment, on the other hand, refers to the technology with which new resources can be produced. As the economic environment of the EMS framework is a dynamic one, resource and technological endowments are consequently subject to change over time.

The central change in the EMS framework does, however, not pertain to the endowment of the agents engaged in trade, but to the endowment of the market firm. In particular, the medium through which the resource allocation process is conducted is dependent on the market firm's resource and technological endowment. Stated differently, the market firm's endowment refers to the hard- and software endowment combined with specific knowledge and skills (e.g. software engineering skills). Apparently, the market firm's endowment imposes natural limits upon the design of electronic markets. Note that the market firm's endowment – determining the market firm's potential to build electronic markets – is exogenously given and thus part of the economic environment. In contrast to the potential, the realization of the electronic market – the information system as medium – is designable by the market firm. Being endogenous the information system does not belong to the economic environment. Being consistent with the EMS framework, it must be part of the institution (as *institution-substitute*).

3.1.1.5 Environment Description

The economic environment description of the EMS framework can be best given when compared with the economic environment of the microeconomic systems framework (see Figure 4). The economic environment of the latter framework consists of the set of agents participating in the market, the resources to be allocated, their characteristics and the endowment of the agents. The microeconomic system framework imposes, however, (implicit) assumptions upon the environment. Those assumptions allow isolating the mechanism design problem. In essence, the assumptions sketch a static world without transaction costs for carrying out the mechanism.

The EMS framework basically adopts the same description of economic environment as the microeconomic system framework. However, it relaxes critical assumptions such that the counterpart in the real world can be explained. For example, the absence of transaction costs for carrying out the mechanism can no longer maintained. Relaxing this assumption, however, entails that new concepts must be introduced. For instance, the market firm as the business unit that operates the electronic market is introduced. Another assumption sketching a static environment is changed in favor of a dynamic environment.

The introduction of the market firm has also major ramifications on the boundaries of the economic environment. In the microeconomic system framework, it was assumed that there exist some resources for allocation. Apparently, this existence assumption simplifies the system – rather are the resources for allocation resulting from a decision of the market firm. As such, the market firm can define the resources that are traded. Previously exogenous factors are now under direct control of the market firm. In other words, parts of the economic environment are actually shifting to the institution. However, note that not the resources itself move to the institution – they still remain part of the economic environment. What shifts to the institution are rules about the facts in the economic environment (e.g. the resources) (Holtmann and Neumann 2003).

In summary, Figure 4 sketches the differences between the economic environment of the microeconomic system framework and of the EMS framework. There are two major amendments needed: the relaxation of assumptions and the endogenization of exogenous factors.

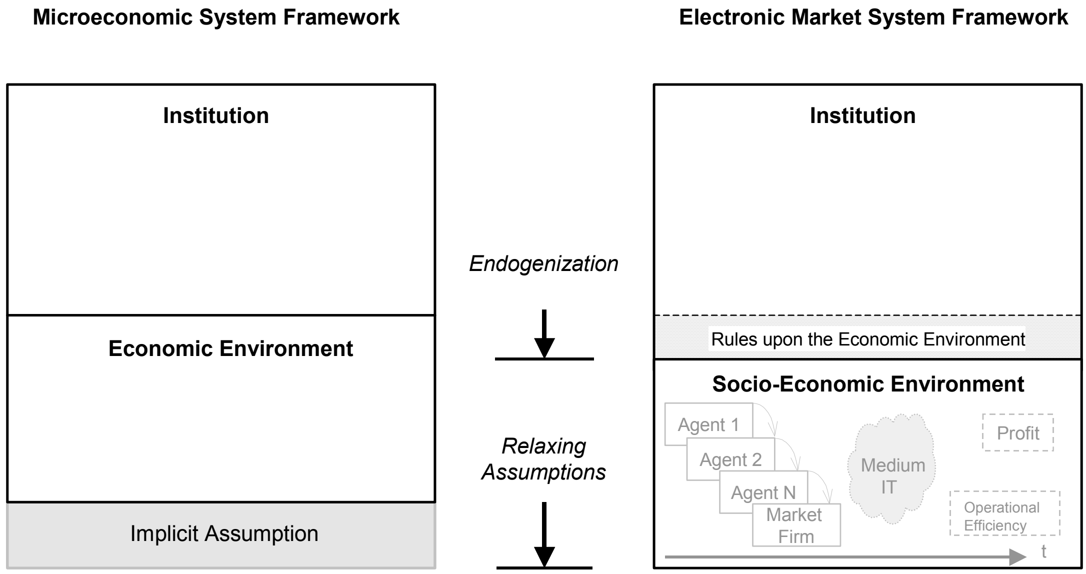

Figure 4: Economic Environment of the EMS Framework

3.1.2 Institutions

The microeconomic system framework defined the institution as consisting of four elements language, process adjustment, choice and transfer rule. The assumption of *no transaction costs in carrying out the mechanism* also implies that (1) conduct of the resource allocation process occurs failure-free, free of charge and immediate, (2) enforcement of the outcomes (i.e. payment of the transfers and exchange of the resource) takes places immediately without risk and without additional costs such as transportation. If those assumptions are imposed the institution definition is complete in a sense that all essential rules for trading are defined.

As aforementioned, these assumptions allow the isolation of the mechanism design problem, but cannot be held upright in the EMS context. Recall that otherwise the existence of *electronic* markets cannot be explained at all. When relaxing the assumption of no transaction costs for carrying out the mechanism, the institutions do not cover all aspects relevant for electronic markets (Menard 2001; Holtmann and Neumann 2003; Weinhardt, Holtmann et al. 2003).

With the relaxation of the transaction cost assumption, a market firm was necessary that is willing to assume the entrepreneurial risk of running an electronic market. The introduction of the market firm also demands for new institutional rules that reflect the decisions of the market firm: As the (electronic) market is no longer a free lunch, the market firm can decide over the resources for which an electronic market is provided and who may participate. Additionally, the market firm can issue fee schedule through which the market firm recoup the investments in the trading venue. Since enforcement is no longer immediate and certain, the market firm must think of an effective enforcement machinery. Furthermore, the choice of the information system also imposes rules upon the agents when trading, which can be considered as institution-substitutes. Comprising, there are a number of institutional rules that are not covered by the definition of the microeconomic system framework.

The modified institution definition of the EMS framework must hence comprise rules for trading, rules for the running the business, and rules imposed by the used medium (Neumann, Holtmann et al. 2002a; Weinhardt, Holtmann et al. 2003). There is, however, another important type of institutional rules, which is – different to the aforementioned rules – only indirectly influenceable by the market firm, namely social norms. Social norms are rules that have spontaneously developed by the social interaction among the individual agents of a society.

Apparently, the definition of institutions given by the microeconomic system framework is not comprehensive enough. As such, the EMS framework broadens the concept of institution to reflect electronic markets. But before the extensions are given (in 3.1.2.3), it is necessary to review the notion of institution. Since the analyses of institutions are located on different levels, it is helpful to introduce those them (subchapters 3.1.2.1 and 3.1.2.2).

3.1.2.1 Classification of Institutions

The importance institutions have in the coordination process can be best understood, when the fundamental economic problem of society is reflected. In his critique Hayek argues that the efficient allocation of resources is not *the* economic problem, but the communication of dispersed knowledge about the agents' characteristics (Hayek 1945). Due to the natural dispersion of knowledge, coordination of individuals appears to be difficult. Coordination – understood as the act of working together harmoniously – requires information about the other agents, either by communicating or by sensing. An efficient coordination requires that the interacting agents quickly economize on information. Economizing on information often means that only few pieces of information (signals) are sufficient to recognize complex pattern of information in the behavior of the other agent. This is only possible if those few signals, e.g. an action, follow a predictable recognizable *order*.

In abstract terms *"order means that various elements in a system remain in a recognizable and predictable interrelationship"* (Kasper 2002**,** 35). As an example for order refer to steps of a staircase, which represent the elements of the system staircase. As they are arranged in equal height, they are in an order, which is recognizable and predictable. Essentially, the degree of order determines the effectiveness of actions: For instance, walking down a staircase with equally high steps is easier to get down than one with varying step heights (Kasper 2002).

If the signals are in this context interpreted as actions, order refers to a recognizable sequence of actions that is obeyed by all agents. In a specialized economy the effectiveness of actions depend on some order or consistency in the behavior of other agents. For example, a manufacturer only produces a good, if he can expect money from a consumer for this good. In social life, some order or consistency always must prevail: Without order, i.e. chaos, individual actions are difficult to pursue, as the actions rely on certain predicted behavior of the other agents. When this behavior is chaotic, the effectiveness of individual action tends to be low: Hayek describes this as follows: *"Living as members of society and dependent for the satisfaction of most of our needs on various forms of co-operation with others, we depend for the effective pursuit of our aims clearly on the correspondence of the expectations concerning the actions of others on which our plans are based with that they will really do"*(Hayek 1973, 36).

Hence, order becomes manifest in rules of human conduct whose violation usually entails some sort of sanctions, e.g. fines (North 1991a). Those rules of human conduct are defined as institutions. In the words of Douglass North, *"Institutions are humanly devised constraints that structure political, economic, and social interaction"* (North 1991a**,** 1). They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct) and formal rules (constitutions, laws, property rights"), and the enforcement characteristics of both.

If institutions are meaningful, they delimit the set of possible outcomes without making one particular outcome certain to evolve (Kasper 2002). At least institutions confine individual behavior to a specific pattern, which can also reduce transaction costs. For example, the institution can ban opportunistic behavior; transactions intended to aggravate such a behavior are then no longer necessary, which results in lower transaction costs. At the bottom line the quality of institutions are defining the overall transaction costs of an economy.

The range of all possible humanly devised rules is naturally very large. A solid analysis and understanding of institutions is fundamental for grasping the essence of electronic markets. Institutions can be classified according to two criteria *origin of the institution* and their *enforcement* (see Table 4).

		Origin of Institutions	
		Spontaneous Evolution	Planned Design
Enforcement	Formal Institutions Planned Feedback	Example A professional code of conduct, which is enforced by an administered authority.	Example Legal code, which is enforced by authority, e.g. constitution or trading rules as market institution.
	Informal Institutions Spontaneous Feedback	Examples Customs, usuances and manner, which are enforced by social feedback.	Example Legal code, which is enforced by spontaneous feedback mechanisms, e.g. electronic markets with reputation mechanisms.

Table 4: Institutional Matrix (cf. North 1987)

The criteria origin of institution raises the question how institution or – in the terminology of Hayek – order can be created (Hayek 1967; Hayek 1973). According to Hayek, there are in general two ways of coordination human behavior. Coordinating human behavior requires the ordering of interdependent action:

- Spontaneous Evolution of institutions
  Institutions or order can arise spontaneously. Institutions are formed as a result of a cultural-evolutionary process on the basis, which institution can solve best the coordination problem (Foss 1996). Apparently, it is a social process that let institutions evolve. Agents believe that they "ought to keep to" institutions based on their moral beliefs. However, there is no super-ordinate, independent concept that would provide a rational foundation of these beliefs. Rather are those beliefs also result of the same process of evolution as the institutions itself (Hayek 1967; Hayek 1973; Sugden 1989).

Comprising, order arises spontaneously. Those institutions reflect patterns of behavior that are self-sustaining. Evolution means that those patterns guided by the institutions replicate themselves successfully (Elster 1989; Sugden 1989).

- Planned Design of institutions
  Institutions or order can also be consciously imposed. A planner or designer can come up with a pattern of behavior and implement it from top down. In most of the times designed institutions are written down. The rationale for this is that those imposed institutions are not endogenous constructs that have evolved other time, but exogenous and must be taught to the agents of a society (Kasper 2002).
  Comprising, order can be imposed by a planner or designer. The institutions reflect patterns of behavior, the designer deemed to be adequate.

The question arises, what genesis of institutions is more desirable, spontaneity or design? Philosopher Sir Karl Popper empirically observed that *"only a minority of social institutions are consciously designed while the vast majority have just 'grown' as the undesigned results of human actions"* (Popper 1964, 65). As Popper understood conscious design of institutions as the delimitation of freedom, he argued against such a *"social engineering"*. Nonetheless can the design of institutions result in a decrease in the transaction costs. Electronic markets have emerged because of their ability to reduce transaction costs by the provision of consciously designed institutions. As electronic markets implement institutional rules, they require written rules. Either those written rules are reflecting the institutions that have evolved over time in non-electronic markets or they are consciously designed. As the latter can refurbish traditional institutions and thus reduce transaction costs, they have a greater potential. Furthermore is it doubtful, whether a translation of institutions prevalent in non-electronic markets to electronic markets is possible at all. Consider that all institutional rules are dispersed in the minds of the participating agents; institution descriptions are thus without design impossible. Throughout this book electronic markets pertain to planned or designed institutions.

Institutions are only effective if they are somehow safeguarded. Comparable with the origin of institutions enforcement can be performed either by spontaneous feedback of the society or by planned enforcement. These two forms of enforcement are usually addressed by the distinction into formal and informal institutions.

- Formal institutions
  According to North (North 1990) formal institutions are usually written down, e.g. constitution. As such, those written rules form the basis for enforcement. All violations or misdemeanors are enforced by authority according to written – planned – sanctions, which are also part of the formal institution. Authority is not limited to the government but could stand for an arbitrary organization as well.
- Informal institutions
  Informal institutions are usually not written or at most partially. The crucial point is that enforcement is not specified in advance. Instead spontaneous feedback of the society "punishes" the violators.

Electronic markets embody both formal and informal institutions. Electronic markets with inherent formal institutions are those with planned enforcement, i.e. based on written rules. Electronic markets with inherent informal institutions are – following the abovementioned line of argumentation – also written, however, they differ in terms of the enforcement. Instead of planned enforcement, sanctioning depends on spontaneous feedback by the other agents. This important issue of enforcement will be discussed in more detail in chapter 3.1.2.3.6.

Combining those two criteria, origin and enforcement, with two dimensions each yields the 2 × 2 matrix depicted in Table 4. Accordingly, electronic markets essentially belong to designed institutions. Note that spontaneous evolving electronic markets are impossible, as they minimally need an electronic infrastructure: The mere translation of the *"spontaneous developed"* institutions from non-electronic markets into electronic markets is basically a design process. Changes in the institution can also not evolve without a designed adaptation of the infrastructure. Depending on their enforcement electronic markets can be either formal or informal. In summary, as electronic markets must be designed, institutions – without further explanation – are in the sequel of this book referred to intentionally designed or planned institutions.

3.1.2.2 Analysis Levels

Institutional rules in general govern interactions of a society at many different levels, in the family, school, workplace, region or country. Those rules of different levels are closely interweaved. That means one set of rules determines how the other set of rules can either be initially defined or later on be changed. This interweavement of rules is often called *nested* (Ostrom 1998). Nested rules usually exhibit two basic characteristics:

(1) Change Consistency
Changes in a set of rules that confine the actions of agents at one level must comply with the higher-level set of rules.
(2) Stability of higher-level rules
As changes in the higher-level rules affect the succeeding sets, such changes are more difficult and costly to implement. Hence, their variability is naturally not as high as lower-level rules.

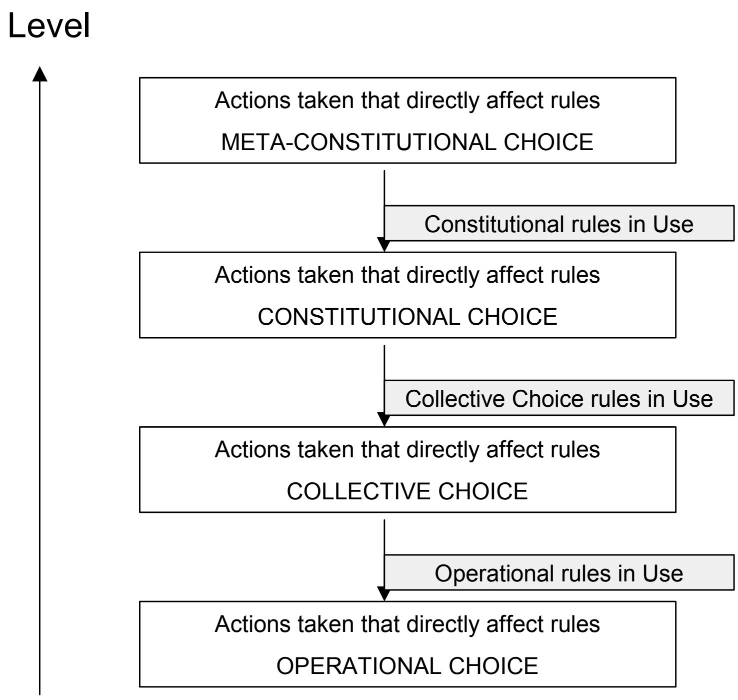

Figure 5: Linkages among Rules and Level of Analysis

In general, three levels of rules can be identified that delimit the set of individual actions, determining agent behavior, and also the outcomes obtained (Kiser and Ostrom 1982; Ostrom 1998). Beginning from the lower level, *operational rules* affect routine day-to-day decisions. That is operational rules specify what the permissible actions are and how they are enforced.

Collective choice rules govern the formulation and change of operational rules. Hence, they define who can formulate or change operational rules and how they can be formulated or changed. By this indirect link over operational rules on agents' behavior, the outcome can be influenced. *Constitutional rules* regulate how collective choice rules can be constructed, which in turn affect the operational rules.

Figure 5 may clarify the levels of analysis and rules. The white rectangles denote the level of analysis and the outcomes in terms of actions. Operational rules govern the individual decision making behavior, as they confine the set of actions. The analysis level of individual decision-making behavior is here denoted as operational choice. On a higher level, collective choice rules determine who is eligible and which specific operational rules can be defined. Collective choice rules are issued based on the constitutional rules. However, even the constitutional rules need a formulation. This formulation is result of a meta-constitutional choice process. This meta-constitutional level underlies all the other levels. Example 3.1-7 summarizes the nesting of rules by a concise example.

Example 3.1-7: Nested Rules

Stock trading is usually conducted over organized stock exchanges. The individual trading behavior of the traders is thereby limited by the trading rules. Normally, the way bids can be posted and how corresponding bids are matched against each other is stipulated by the trading rules. These trading rules – representing the operational rules – are put into operation by the organizing stock exchanges. However, the configuration of these rules is not totally free. Formal laws restrict the design of trading rules. Those laws reflect the value system of the society. For example, manipulation and other abuses are deemed harmful for the capital market as a whole. Accordingly, laws may impose restrictions on the conduct of trading. The trading rules must adequately incorporate these requirements. As such, collective choice rules govern the design of operational rules. The collective choice rules, e.g. laws, must again comply with the constitution of a country.

This excursus of nested rules makes it easier to pinpoint the level of analysis that is crucial for electronic markets. In the microeconomic framework defining the elements of an institution artificially confines the level of analysis. If the institution is extended one can be in danger of switching the levels. A different level of analysis, however, raises different questions. For example, the analysis of regulatory institutions (Sertel and Koray 2003) refers to collective choice rules. As such, it affects questions concerning competition policy, access to networks, ban of narcotics or firearms trades, and so forth (Laffont and Tirole 1991; Laffont and Tirole 1999; Levine and Smith 2000; Nickerson and Phillips 2003).

The analysis pursued here aims at the question of how institutions of the electronic market - understood as operational rules – affect the outcome? What can the market firm do to make his trading venue more attractive? As collective choice and constitutional rules tend to be stable, it can be straightforwardly assumed that they are exogenously given and fixed and hence part of the environment. The market firm's problem is to define the trading rules of his market within this legal framework, enfolded by collective choice and constitutional rules. According extending the institutional rules widens the scope of analysis without switching the levels.

3.1.2.3 Extended Institution

The EMS framework concentrates on the operational level of the analysis. Thus, only rules are regarded that directly affect the agent behavior. This also implies that the legal framework imposing rules on the rule-setting behavior of an electronic market is left out, being on a deeper level. The extensions of the EMS framework, consequently, affect only institutional rules that pertain to the same operational level. The institutional rules of an electronic market can stem from five sources (Holtmann, Neumann et al. 2003):

- Resource Allocation
  As the electronic market embodies a resource allocation process, the institutional rules defined by the microeconomic system framework also apply to electronic markets. To avoid misunderstandings between the institution definition of the microeconomic system framework and the extended institution of the electronic market, the former institution comprehending a language, choice, transfer and adjustment process rules is redefined as *trading rules*.
- Medium
  The medium that forms the trading venue imposes also institution-like rules – henceforth *media rules* – upon agent behavior.
- Market Firm
  The market firm is the central player in the EMS framework. In essence, the market firm can either define the resources that are being traded or restrict access. More importantly, the market firm must somehow earn money to cover the expenses that are associated with running the electronic market. The corresponding institutional rules are denoted as *trading object definition*, *participation rules*, and *business rules*.
- Social norms
  While the market firm needs to design the former rules, *social norms* evolve spontaneously. Extending the microeconomic system framework by social issues, it requires the inclusion of those norms.
- Enforcement
  Basically the EMS framework also accounts for the fact that agents may fail to comply with their obligations. The *enforcement machinery* comprises all rules that are associated with assuring the trade to occur as agreed upon.

In the following those rule-extensions are discussed in more detail.

3.1.2.3.1 Trading Object Definition

The microeconomic framework assumes that there *"[...] exists a list of commodities"* (Reiter 1977, 227). This assumption makes further considerations about the nature of commodities obsolete. Extending the microeconomic system framework to electronic markets requires a closer analysis of the resources that are allocated. In order to document the transition from the traditional to the electronic market view, the resources that are allocated are denoted as *trading object*. The market firm can decide what objects are traded over the electronic market. Apparently, the market firm does not invent some new physical object; instead is he providing a *"definition"* as trading object innovation. In other words, the market firm converts physical or immaterial resources into a tradable object.[103]

The trading object definition principally contains two types of rules. The first type is concerned with an immaterial description of object. As such, it specifies the characteristics an object must have, i.e. quality, age, etc., in order to qualify for trade. The second type of rules refers to the definition how the object is traded. For example, the size of the trading lot, i.e. the normal unit of trading, the settlement time and so forth, needs to be specified. Both rules together contain information about the object detached from the original object. What is really

[103] In finance this conversion of assets such as loans into securities that may be traded is dubbed securitization.

exchanged in the market process is the information about the object, not the object itself. Nonetheless, at the end of process the transfer of the (physical) objects is also processed.

The trading object definition is obviously part of the institution. By the possibility to define the trading object, the market firm has a powerful strategic instrument at hand to address or even to create a particular customer group. The trading object definition, thus, may answer the important question of *"How do you define your market?"* (Fennell and Allenby 2003b) that is subsequently being served. Clearly, there are many ways to define the trading object, which is essentially an information good. The market firm has principally four possibilities at hand:

- Describing existing resources
  The market firm can simply issue a description of an existing resource either physical (e.g. bushels of corn) or immaterial (stocks). This description standardizes the object, which is the prerequisite for double-sided markets, i.e. competition on the buyer and the seller side.
- (Re) Disassembling bundles
  Actually re- and disassembling of bundles also refers to describing existing resources. The clue is, however, to attain new trading objects by assembling new bundles or split bundles into components (Kalagnanam and Parkes 2003). Assembling bundles of resources can virtually be the value-added of an electronic market, as the agents may demand only the bundle, but not the single components. For example, trading financial portfolios in one venue reduces the risk that the agent only receives part of the financial portfolio, which has less desirable properties.
  Put it to an extreme, a special form of market firm – the so-called metamediary – aggregates bundles in the view of customer activities. Customer activities such as a car purchase can be extremely complex. When purchasing a car, the buyer may also be interested in insurance and financing. Offering all three goods in a bundle may satisfy the customer's needs along his activity (Sawhney 1999b; Neumann, Holtmann et al. 2002b). If all three goods are offered on separate electronic markets, the metamediary can offer them in a bundle.
- Generic trading object definition
  The market firm can also forgo the exact specification of the trading object. Instead the market firm can pass the definition over to the participating agents. In business-to-business electronic markets, the participating agents commonly conduct the trading object definition. This is especially the case if the resources are very heterogeneous (e.g. a machine). The agents can either contract out a need or advertise a selling position.
- Defining exotic objects
  Lastly the price of a market, which exhibits valuable information about the economic environment, can become the trading object: Those new exotic objects are often giving rise to so-called *speculative markets*. These markets are in a sense speculative as they allow the participants to place a bet on future prices by buying or selling today in the hope to even up the trade with a profit in the future. The (electronic) market aggregates all the dispersed private information among the agents into the price.[104] Most innovative product designs are entwined around this information aggregation property of decentralized resource

[104] Essentially everyone taking part in the market is invited to correct the current market price. Any trade shifts the current price closer to the conjectured future price. For example the current price for a share of stocks is worth € 10. Agent A believes the accurate price would be € 15. As such it is profitable for him to buy stocks for € 10. By his trade the current price goes up and is pushed closer to the conjectured price. As there are many agents with different beliefs the aggregated estimation of the stocks will eventually emerge. Accordingly, the incentive for the agents to reveal their private information lies in price system (Hayek 1945; Hanson 2003).

allocation mechanisms, e.g. double auctions. As the price reflects all bets on beliefs and internal knowledge, the aggregated information revealed by the price can be product. All what the market firm has to do is to pool the information into a common tradable resource (Hanson 1999). Those common tradable resources could be estimates concerning tomorrow's weather condition or future crime rates conditional on allowing hidden guns (see Example 3.1-8).

Example 3.1-8: Prediction Markets

Prediction markets are the prime example of innovative products. In these markets the value of the traded contracts depend on the future outcome. Accordingly, the price that will emerge yields an aggregated prediction about the outcome (Berg and Rietz 2003; Spann and Skiera 2003). Prediction markets are currently almost *"growing like weeds"*.

The Athletic Stock Exchange trades virtual shares of an athlete. The price of the shares solely depends on demand and supply situation. Dividends on the shares are paid in direct proportion to an athlete's performance in relation to the rest of the athletes on the exchange on a daily basis (Athletic Stock Market 2003). As such, the price of the shares reflect an aggregated forecast of the performance of athletes.

The Foresight Exchange Prediction Market enables agents to set bets on a range of events, from the voting out of Californian Governor Gray Davis by October to the cure of cancer by 2010 (Foresight Exchange Prediction Market 2003).

The Chicago Mercantile Exchange trades weather derivatives. Here, weather predictions are also formed. However, by means of weather derivatives industries whose production or sale is dependent on the weather can hedge their risk of unfavorable weather conditions. For example, agricultural firms can hedge their risk of bad harvest due to bad weather. In summary, prediction markets have the ability to form aggregate predictions. Those predictions or estimates can be used to hedge risks or to support decisions (Hanson 1999; Kambil and van Heck 2002).

In summary, the trading object definition denotes the institutional rules governing the admissible resources that can be traded over the electronic market. Not the object itself stands in the center of the market process, but the information about it: *"While the transfer of physical goods may remain the end result of a business transaction, the information that shapes the transaction [...] can now be separated and exchanged electronically"* (Wise and Morrison 2000, 89).

3.1.2.3.2 Participation Rules

The microeconomic system framework assumes the number of agents to be part of the economic environment. That means they are simply there. However, this is a quite unrealistic assumption. Rather can the market firm decide, which agents to participate in the electronic market. Restricting the access to the electronic market has two partially contradicting effects.

On the one hand, restricting access exerts a positive effect on the electronic market as uncertainty can be significantly lessened. Uncertainty can occur on both sides, either on the sell or buy side. The vendor of a resource runs a risk that the corresponding partner fails to meet his obligation to pay. Likewise is the buyer at risk that the vendor is not providing the resource. This so-called opportunistic default[105] can be diminished – though not eliminated[106] – by restricting the participants to confidential agents (DiMaggio and Louch 1998). For example,

[105] Opportunistic default is an inherent risk in any transaction the other party in an agreement will default.

[106] Elimination is only on the basis of the user selection not fully possible. At this point it is referred to the enforcement machinery, which will be addressed in chapter 3.1.2.3.6.

stock exchanges frequently admit only financial institutes for their trading arena. The degree of confidence can stem from many sources such as their assets, endowments or personal characteristics like past trading history. A related source of uncertainty is the quality of the exchanged resource. Now, the buyer is in danger that the vendor duly delivers the resource, but the resource is of inadequate quality. This defective performance is often a concern in business-to-business markets and may prevent firms from participating in electronic markets. Nonetheless, limited access can also alleviate this malpractice.

On the other hand, issuing participation rules also incurs negative effects. The negative effects stem also from restricting the number of agents. With the number of admitted agents is also the number of possible transaction possibilities[107] associated: The more agents are participating, the more likely it is that a corresponding offer at acceptable conditions exists. Pruning the number of potential participants accordingly decreases this probability. Similarly, auction design deems access to auctions as on of the issues *"that really matters"* (Klemperer 2002). As restricted access reduces the number of bidders, it also reduces the degree of competition. Less competition yields in lower allocative efficiency and also in lower revenues for the seller.

In summary, participation rules in general determine the number of participants, their characteristics and endowment, as well as the condition they facing entering the electronic market (Ostrom 1998).

3.1.2.3.3 Trading Rules

As previously mentioned, an electronic market embodies a resource allocation mechanism. As such, all the institutional rules that were defined throughout chapter 2.1.3 also apply to electronic markets. Any resource allocation process needs accordingly a) a language to express their preferences or the strategies concealing their preferences, respectively, b) a choice rule that computes the allocation, c) a transfer rule that specifies the corresponding prices, and, d) adjustment process rules that determines under what circumstances which messages can be submitted, modified or withdrawn.

Those four rules are enough to define a resource allocation process. However, such a process is simply a one-time allocation. At a specific time offers are collected and only *once* the allocation and corresponding prices as outcomes are determined. In other words, the resource allocation process only accounts for a single, unrepeated, and from the rest of the world uncoupled process: The current owner of the resource must sell (or keep the resource), and that the buyer of a resource keeps the resource throughout his life (Gârleanu and Pedersen 2003). In many situations, however, neither the sale decisions are exogenous nor are the buyers stuck together with the resource forever. Instead are sale decisions endogenous, they can depend for instance on the attainable price and on the alternatives. Furthermore, buyers can anticipate later resale, which changes the preferences (Haile 2003). For example, most financial securities are often turned over many times before they mature.

Apart from the theoretical assumption of one-time allocation, the electronic market can offer sale and subsequent resale possibilities right away. In fact, electronic markets can embody more than one resource allocation process.

[107] In financial literature, the number of transaction possibilities is subsumed under the concept of liquidity, which is introduced in chapter 3.1.3.

Example 3.1-9: Xetra trading rules - Stocks: An excerpt

The electronic market of the German Stock Exchange Xetra employs for their segment stocks the following trading rules as their skeleton. After the pre-trade phase, trading starts with a call double-auction in the morning. Subsequently commences the phase of continuous double auctions. The trading day ends with a closing call double-auction. During the day around noun the continuous double-auction is halted and another call double-auction is performed.

Example 3.1-9 epitomizes a trading structure that consists of many resource allocation processes that are arranged in a sequence. That is an electronic market embodies not only a single, but also multiple resource allocation processes in an array.

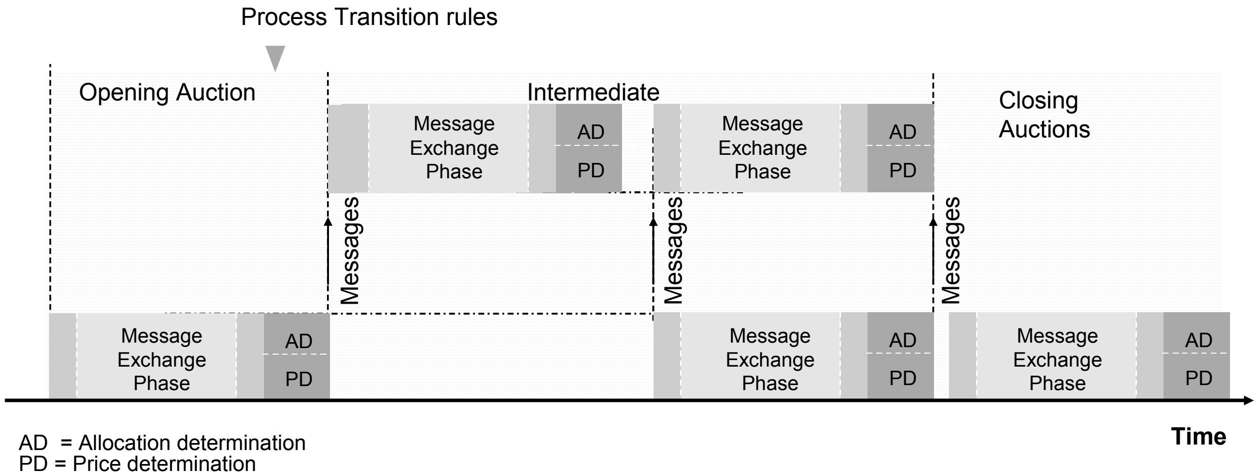

Figure 6: A stylized Electronic Market Process

Figure 6 illustrates the sequencing of four different resource allocation processes, where the single processes are symbolized by their anatomy[108]. Note that the two middle processes are not sequentially but simultaneous taking place. Nonetheless, the electronic market process defined as the array of resource allocation processes often consists of many more processes. For example, a continuous double auction allocates corresponding buy and sell offers right away. As the allocation and pricing closes the resource allocation process, a continuous double auction consists of several distinct resource allocation processes.
Apparently, electronic markets embody multiple resource allocation processes. This, however, creates the need for a fifth type of rules that was not covered by the microeconomic system framework, the process transition rules. The process transition rules basically state the conditions how the sequencing of different processes is governed. Accordingly, the process transition rules can be seen as an overlay over the remaining trading rules. As such, they determine how the opening and closing rules of a resource allocation process can be set. The main difference between process transition rules and the other trading rules is the scope. While process transition rules are concerned with inter-process issues the other trading rules govern the intra- process issues.
Comprising, the trading rules can be defined as follows:

[108] The anatomy of a resource allocation process can be looked up at Figure 3.

Definition 11: Trading Rules

The *trading rules* determine the languages, the choice and transfer rules, the adjustment process rules and process transition rules.

The introduction of an electronic market process as a composite of several resource allocation processes has two major ramifications.

- *Firstly,* the electronic markets are not independent one-shot events but embedded in an array of multiple resource allocation processes. That also means that the agents' strategies are not only dependent on the current allocation process but also on previous and future processes. Experiences that the agents gain along the process and expectations concerning upcoming processes can be used in the actual resource allocation process. Jehiel and Moldovanu nicely describe it as follows:

  "If the auction's allocation influences the equilibrium of an ensuing interaction, bidders will take this effect into account at the bidding stage. Thus, the channel of influence between auction and future interaction goes both ways: the auction's outcome through the resulting allocation of assets, and the future interaction influences the auction's outcome through the participants' expectations about their payoffs in various future constellations" (Jehiel and Moldovanu 2003, 281).

  There are several problems involved with the effect that previous and future processes have on the current process. The bidding strategy of the agents not only depends on the current process but also on the expectations what will happen in the post-process phase. Furthermore, the agents incorporate their previous experiences in their strategy formation. This may, however, entail that a process can have several equilibria with different allocations (Jehiel and Moldovanu 2003). Apparently, the outcomes of the processes are difficult to predict, making the design of trading rules extremely difficult. This may explain why endogenous sale decisions and resale motives have received only little attention in literature although both topics are important in practice (Gârleanu and Pedersen 2003).
- *Secondly*, the resource allocation processes are not arranged one at a time but simultaneous. That means it can happen that the same resource is offered in two different processes. This competition of mechanisms raises the complexity of the bidders' deliberation about the strategy. The reason stems from the fact that the bidder has to decide in which process to participate (Peters and Severinov 1997; Peters 1999). The theory of competing mechanisms that is tackling those problems is currently in its infancy.

In summary, extending the trading rules to cover an array of sequentially or simultaneously occurring resource allocation processes has two major effects on the bidding strategy. Firstly, previous and future processes will also affect actual bidding behavior. Secondly, participating agents have a choice among alternatives. Competition of mechanisms may also change the bidding strategy compared to one at a time mechanisms.

3.1.2.3.4 Media Rules

From an incentival point of view, a resource allocation process is expressed by a mechanism. The term mechanism appears to be apt, as "*it conveys the image of a device constraining and guiding the choices that individuals make"* (Kiser 1980, 1). Participants in the mechanism are shown what behavior is feasible and, furthermore, with which behavior of the other participating agents they most likely have to deal. From an informational point of view, a resource allocation process is considered as a huge information processing system. Information is transmitted, i.e. communicated, between the agents and processed by them through computations, which result in decisions (Hurwicz 1997). And exactly here is where the concept of media steps in. Basically, the media denotes the abstract platform through which information is transmitted and processed. The notion of media was introduced by Schmid and basically comprises three distinct components (Schmid 1997):

1. Channels
   A media naturally provides a system of connections between the agents that actually facilitates the transport of messages. Those connections denote a channel. A channel must hence be capable to firstly support the information to be transmitted and secondly to convey those over time and geographical distances. An example of a communication channel is face-to-face or the Internet.
2. Logic
   Channels are not sufficient for media, because a common logic between transmitter and receiver is necessary. Hence, media requires syntax that allows coding and decoding of messages. Beside the syntax successful communication requires semantics, such that transmitter and receiver can similarly interpret the language of the messages.
3. Processes
   Having pinpointed the channels and the language, a media also requires working rules to determine how process with coded information.[109]

In the words of Marschak it is a communication engineer, who is responsible for the media, as he constructs *"channels for the fast and reliable transmission of signals. He is therefore interested in devising appropriate codes which translates ordinary English into signals and signals into English*" (Marschak 1968, 10). Similar to Schmid's media concept Marschak identifies three components for communication a channel, translation logic, and a code for processing. With those three components the media, i.e. the infrastructure, that underlies the market process, can be adequately framed.[110] Different media impose different restrictions on the market process. For instance, an electronic media can process information, say bids, faster than a non-electronic market. Then, there is a direct link on the behavior, as the agents may place bids at an earlier time. This time advantage may open up the possibility for new superior strategies: Say an agent is interested in one good that is offered in two different auctions. Both auctions take place at the same time at different places. Non-electronic media thus makes a simultaneous bidding strategy infeasible, whereas electronic media permits such a strategy. In any strategy where time matters, e.g. arbitrage strategies, media rules – defined as the institutional rule imputed by the media[111] – are the binding institutional rules.

The concept of media is apparently a very abstract description of the underlying infrastructure. Media rules are those institutional rules derived from the used media. As such, media rules capture a variety of issues that can due to the space limitations not exhaustively be discussed. Five important issues that are frequently mentioned in literature are presented in the following.

<u>*Information carrying Capacity*</u>
Media rules further affect the agent behavior by the capacity limitations of the channel. Information carrying capacity of the channel governs to which extent messages can be sent to the receiver at a time, i.e. the bandwidth can be limited. Especially in peak loads limited bandwidth can become the crucial factor. Messages are then delayed although the trading

[109] As mentioned in Schmid the definition of processes also presupposes a system of roles (Schmid 1997).
[110] Schmid even extends the concept of media to all types of communities either at an operational or an interplant level (Schmid 1997; Klose and Lechner 1999).
[111] It is also possible to call the media institution-substitute.

rules prescribe an immediate matching. Basically the channel can be non-electronic or electronic. Electronic media have usually much higher capacities and can convey information much faster than non-electronic media. As such, the informational burden caused by the transmission can be reduced by the means of IT (Wrigley 1997).

Computational Capacity

Furthermore, media rules define which problems can be solved in what time. Thus, media rules have firstly a direct impact on the agent behavior via the processing time and secondly an indirect effect due to their impact on the trading rules. Media rules determine what choice and transfer algorithms are feasible.[112] Infeasibility refers to computation of the outcomes via complex choice and transfer functions that takes too long. Once more, electronic media naturally are superior to non-electronic media when it comes down to computational capacity.

Access

Media rules determine the way the electronic market can be accessed. Non-electronic markets can for instance be accessed by personally entering the physical trading pit or by telephone. The choice of the channel thus determines the reachability of the platform. By means of electronic media the electronic market can be accessed from distant places. The media rules dictates whether the agents must be physically or virtually present.

Interfaces

In electronic markets interfaces matter: By providing either programmatic, application or user interfaces agent behavior is affected. In case the electronic markets provides an application interface to ERP[113] systems the timing of the bid placement is different than would have been without the connection. The bids will be placed on occurrence of a particular event, say the inventory of a resource has fallen below a threshold. Without the technical coupling the processes can result in a totally different bid. Agent behavior is, moreover, affected by the graphical user interface (GUI). For example, media rules determine the ease of use, clarity and response speed of the GUI and thus the handling of the electronic market system. If the GUI is all but easy to use, i.e. usage requires effort, behavior can be changed in a way that it takes longer to place bids or that the electronic media is in an extreme case not used any more (Davis 1989). A programmatic interface such as API (Application Programming Interface) allows even the direct coupling with application for the automated conducting complex trading strategies.

Security

Media rules, moreover, also dictate the security of the used trading media. Insecure media are suspected to manipulation and opens up the doors to infringement and fraud. Hence the extent of trust will naturally fall if there is a security risk involved (Feldman 2000). Alternative media rules like encryption of the channels can alleviate security concerns. As such, the level of security – defined by the media rules – has a deep impact on the agent behavior.

Overall, it should be noted that the assumption that only the trading rules affect agent behavior is incorrect as the media rules can indeed have also a significant, even overriding, impact. Likewise are claims problematic that equal electronic with non-electronic markets: Media rules matter. Furthermore, there is a tight interdependence between media and trading rules: media rules dictate what trading rules can be implemented and trading rules in turn govern what media rules are being used. In the short run media rules may presumably dominate the

[112] Note that trading rules conversely affect media rules. As the intended trading rules determine what infrastructure is necessary to implement them.

[113] ERP is the abbreviation for enterprise resource planning systems (Klaus, Rosemann et al. 2000).

trading rules: if the infrastructure with its endemic media rules is just available, the trading rules have to maneuver within these confinements. In the long run this may not hold. Note that the design of media rules is clearly limited by technology given to the market firm.

3.1.2.3.5 Business Rules

Installing, operating and maintaining the infrastructure for trading requires to some extent substantial investments. The market firm – either profit-seeking or cost-covering – must recoup their investment through quid pro quo fees.

In this context, business rules represent the revenue model of the electronic market. As such, they are not originally rules that "*specify which actions are required, permitted or prohibited*" (Ostrom 1998, 73). As previously defined, the actions of the participating agents are governed by the trading rules and through its implementation by the media rules. Business rules do thus neither require, nor permit, nor prohibit any actions. Instead, they attach costs and revenues to the permissible actions. As the market process is nothing less than a communication process, the actions are submissions of messages. The sending and the processing of messages are associated with costs. Having assigned a cost to each message, summing the costs of a sequence of messages that finally leads to a transaction yields the communication costs of this transaction. Those costs denote primary planning determinants of the market firm. As these costs as well as the aforementioned set-up costs must be earned, the activities should be linked with the revenue model.

"Revenues are the 'bottom line' of a business model" (Alt and Zimmermann 2001, 6). Without adequate source of revenue no electronic market can sustain. For an electronic market there are several ways to generate income. Frequently charges depend on *"a combination of transaction-based fees and subscriptions with additional services being charged for separately"* (Segev, Gebauer et al. 1999, 144). Transaction-based fees increase the transaction costs that the participating agents occur since, their trading costs are consequently increased. Thus, business rules have significant impact on the agent behavior.[114]

Trading and business rules are highly intertwined. From the participating agent's point of view, fees denote explicit transaction costs, i.e. the direct costs associated with trading on a specific venue. Together with the implicit transaction costs, i.e. the costs incurred by the market process, they denote the total transaction costs of the participants. Implicit transaction costs naturally stem from the (informational and allocative) efficiency of the market process, which is attained by the trading rules, whilst explicit transaction costs stem from the entrepreneurial activity of the market firm, which is mirrored by the business rules. Participating agents thus gauge the advantageousness of an electronic market by the totality of trading and business rules[115] (cf. Pagano 1989).

Remark 3.1-10: Mechanism Design and Communication costs

Traditional literature on mechanism design widely assumes that communication in a mechanism is costless. An agent can send all possible messages at will. This also grants the possibility to arbitrarily misreport his private information. However, suppose sending messages that contain lies are associated with higher costs. The traditional example given

[114] There is no single right way for an e-marketplace to charge for its services, but there are many wrong ways. A full consideration of the possibilities should help companies avoid making expensive errors. (Kerrigan, Roegner et al. 2001).

[115] In chapter 3.1.3 a closed performance measure for gauging the combined effects of trading and business rules, namely transaction costs, is presented.

is the sharecropping relationship. The tenant has an incentive to understate his crop, in order to reduce the share that belongs to the landlord. However, this lied message is associated with costs, as the tenant has to store the crops at a secret place (Lacker and Weinberg 1989). In such an environment the assumption of costless communication is relaxed. Apparently, those communication costs have an appeasing effect on lying.

One can go even a step further by claiming communication to become an implementation tool, as incentive constraints on allocations can be relaxed. Suppose in a resource allocation mechanism there are two different agents A and B and a resource. Based on their preferences the resource should efficiently be assigned to agent B. Communicating a set of messages is for agent A (infinite) expensive, e.g. hiding the crops, and for agent B for free. If sending this set of messages is crucial for the allocation, agent B obtains the resource as intended. Agent A would have drawn higher utility out of the resource, but the high communication costs override the incentive constraints (Deneckere and Severinov 2002). Mechanism design becomes richer as the mechanism designer can screen the agents not only on the basis of preferences but also on the basis of their communication ability. At the bottom line certain allocation implementations can become possible only with the inclusion of communication costs.

Communication costs considerations are currently not linked with explicit fees imposed by the market firm. However, those fees could constitute a powerful instrument to attain desirable outcomes, as the market firm can directly affect the outcome via imposing levies on sending messages for particular agent groups.

Likewise are media and business rules interconnected: Media rules mirror how the market process is technically conducted. Apparently, the costs associated with transactions are via the technical platform dependent on the media rules. As these costs found the basis for the calculation of the fees, media rules impact the business rules. Conversely, business rules have also an impact on the media rules. Based on the target costing philosophy (Monden and Hamada 1991) the targeted costs – being element of the business rules – are established by a thorough design of the trading and media rules. For example, a market firm may wish to implement an electronic market where any transaction does not cost more than 1 Cent (Nagle and Holden 1995). This *target cost* has an impact on the design of the trading rules as complex choice rules, e.g. combinatorial auctions, may require a more powerful infrastructure. As business rules provokes technical confinements that impedes trading rule design, business rules indirectly impact trading rules.

Nonetheless, the discussion above shows that it is difficult to keep track of the level of analyses: Clearly, business rules together with the trading and media rules define the feasible actions of participating agents and therefore belong to the level of operational choice (recall chapter 3.1.2.2). However, the discussion about designing business and media rules focuses the collective choice level, as it addresses questions concerning how to design rules. These questions on the collective choice level are discussed in chapter 5.

In summary, business rules account for the entrepreneur's need to earn money out of the trading process, such that he can satisfy his expenses in the infrastructure. As the participating agents have to pay fees for sending specific messages, the business rules directly affect the degree of transaction costs.

3.1.2.3.6 Social Norms

Most rules that shape individual behavior are social norms. Accordingly, social norms are also institutional rules, but they differ from the previous rules. The previous rules of electronic markets are not evolving, but consciously designed. Social norms emerge as a result of spon-

taneous order within the society (Granovetter 1992; Kasper 2002). While all designed institutional rules are primarily outcome-oriented – the social norms are not (Elster 1989).
Elster nicely depicts social norms as follows:

"The simplest social norm are of the type: Do X, or: Don't do X. More complex norms say: If you do Y, then do X, or: If others do Y, then do X. More complex norms still might say: Do X if it would be good if everyone did X" (Elster 1989, 99).

Apparently, social norms are neither future-oriented nor outcome-oriented. For norms to be social they must be agreed upon within a society. Compliance with those norms is, however, voluntary. Voluntary compliance does not mean that violations are free of repercussions. Violations rather attract spontaneous sanctions. For example, customs and manners that are obeyed are social norms. Violations against customs and manners are sanctioned with a reprimand or shunned. Those sanctions can also be measured in monetary terms, by the costs incurred by the loss of reputation.

In electronic markets there are also many social norms in effect. For example, sociology identifies the "norm of cooperation", which basically says: *cooperate if and only if most other people cooperate*. Translated to electronic markets it could say, *negotiate cooperatively if and only if most other agents negotiate cooperatively*. Apparently, social norms affect individual behavior as strong as or even stronger than the other institutional rules. As social norms are spontaneously evolving, they cannot be planned. A change of social norms, for example, the change of informal protocol (in a non-technical meaning) is possible but requires (re-) education of the society. Basically by providing a technical trading platform social norms change if the agents no longer trade via personal contact but over the new facility.

It was once argued by famous economist Kenneth Arrow that social norms are an expression of collective rationality. The society breeds out the norm to be better off or at least as good as than without. In other words, the social norms are reactions of the society to compensate for market failure.

"It is useful for individuals to have some trust in each other's word. In the absence of trust, it would become very costly to arrange for alternative sanctions and guarantees, and many opportunities for mutually beneficial cooperation would have to be foregone. […]
It is difficult to conceive of buying trust in any direct way (though it can happen indirectly, e.g. a trusted employee will be paid more as being more valuable); indeed, there seems to be some inconsistency in the very concept. Non-market action might take the form of a mutual agreement. But the arrangements of these arrangements and especially their continued extension to new individuals entering the social fabric can be costly. As an alternative, society may proceed by internalization of these norms to the achievement of the desired agreement on the unconscious level.
There is a whole set of customers and norms which might be similarly interpreted as agreements to improve the efficiency of the economic system (in a broad sense of satisfaction of individual values) by providing commodities to which the price system is inapplicable" (Arrow 1971, 22).

This rather optimistic view on social norms would basically suggest that the society already established important rules such that the market firm is released out of the responsibility to implement this rule by the electronic market's institution. Nonetheless is this view on social norms way too optimistic. Accentuating the collective rationality of social norms may overestimate their impact. There are other rules or norms that can attain even further Pareto im-

provements. Social science yet claims that there exist social norms that make every member of the society worse off.
At the bottom line, social norms do not constitute an optimal solution. Altering social norms is possible but an extremely difficult and time-consuming effort. As such, for electronic markets social norms are in the short run fixed and stable. As social norms affect individual behavior, their impact on the performance of the electronic market should not be neglected.

3.1.2.3.7 Enforcement Machinery

All the abovementioned institutional rules aim at prescribing individual behavior. However, all rules of prescribed (or proscribed) behavior require enforcement (Stigler 1970). Enforcement attempts to achieve compliance with the rules imposed on agent behavior. Recall that enforcement is concerned with *all* institutional rules including trading, media and business rules. In general, resource allocation mechanisms are particularly depending on the compliance with the choice and transfer rules. But exactly this compliance is due to the opportunistic nature of agents questionable: In any transaction between parties that have not complete control over one another's actions there exists the inherent risk of opportunistic default. Agents are opportunistic in a sense that they are willing to destroy *"part of cooperative surplus to secure a larger share of it"* (Cooter 1996). Agents may fail to meet their obligations in order to increase their utility. However, the corresponding parties to the transaction suffer a loss through the default. Therefore potential parties seek forms of enforcement that aims at reducing both the probability of default as well as the damage from a default (Aviram 2003).

As previously mentioned, enforcement is not a topic in the microeconomic system framework, as it is assumed that the winner-determination, i.e. the application of choice and transfer rules, and the subsequent (physical) exchange of the resources take place immediately without a risk. Extending the framework to electronic markets the enforcement machinery becomes a topic, as the assumption of no opportunistic default is relaxed. Under the term *enforcement machinery* all regulatory arrangements that attempts to reduce the probability of occurrence or/and to alleviate the consequences of default are subsumed.

Principally, the government is natural candidate for regulating the enforcement of agreements. As the government possesses a monopoly on violence and, moreover, maintains special enforcement agencies that can impose sanctions such as fines, injunctions or in extreme cases imprisonment, the government has the tools to enforce the agreements better than any other potential regulator (Aviram 2003). However, the government cannot assure "complete" enforcement of all rules, as enforcement is costly: No government has sufficient resources to ensure a high probability enforcement for every violation. As a consequence, the probability of being convicted might not be high enough to create disincentive for potential violators such that they are deterred to default the obligations (Becker 1968; Stigler 1970; Aviram 2003).

Third parties other than the government can assume the responsibility of enforcement. For example, those third parties are financial intermediaries such as banks that have advantageous access to information about the participating agents and their potential opportunism. This, however, only reduces the possibility of default but does not alleviate the damage caused by a default. There is, nonetheless, the case where the third party not only has informational advantageous but also can sanction violators. Effective sanctions can be the exclusion of deceptive agents combined with an immediate replacement of defaulted with substituted transactions.
In the electronic market system framework, the market firm has exactly this power to firstly exclude agents from the market process via the participation rules and, furthermore, to find a substitute partner in transaction. Moreover, the market firm can himself act as a substituting partner. In case a partner in transaction defaults, the market firm can step in and accommodate

the obligations. This so-called central counterparty service is frequently established in financial markets – usually in those markets associated with high risk such as markets for derivatives. All transaction partners must settle their agreement via the central counterparty, not anymore with one another. The central counterparty charges fees for this service in order to compensate for the accumulated default risk. By installing a central counterparty the market firm can enforce the transaction described by the choice and transfer rules. Electronic markets that are mediated in a way that all communication is pursued over a central mediator can offer centralized control over the facilities used for the message exchange (Aviram 2003). Centralized control means in this context the ability of monitoring all activities that occur on one trading venue. Monitoring all activities also allows the preventative detection of rule infringement. For example, transactions over internet-based electronic markets, e.g. eBay, frequently involve the use of a centralized server that is under the control of a market firm. This control enables the market firm firstly to monitor for deceptive behavior, and preventing those transactions.

Those two forms of enforcement are usually classified as formal enforcement mechanisms. They require formal contracts between the corresponding parties and filing suits. However, it is widely recognized that agreements are more frequently executed by informal means (Kandori 1992). Instead of formal contracts, social pressure and reputation are the determinants of enforcement. That means agents behave compliantly as compliance is rewarded while defection is punished. Two categories of informal enforcement mechanisms can be identified, being personal and community enforcement:

Personal enforcement refers to situations where *"cheating triggers retaliation by the victim"* (Kandori 1992, 63). Accordingly, those mechanisms are only successful if prompt retaliation is possible. Prompt retaliation implies that the mechanism is (infinitely) repeated with the same participating parties. That is, self-enforcement works best in long-term relationships. In those cases the notorious Folk theorem applies (Rubinstein 1979; Fudenberg and Maskin 1986). Basically, the Folk theorem states that any mutually beneficial outcome can be sustained as a subgame-perfect equilibrium if the same agents infinitely repeat the same stage of the game.[116] As such, the threat of retaliation by the victims is credible, as the strategy does not deviate when a violation occurs. The Folk theorem appears to be a nice game-theoretic exercise and can, moreover, explain self-enforcing long-term relationships. Nonetheless, it is not applicable in cases where the agents change their partners over time.
Community enforcement refers to those cases not captured by the Folk theorem.[117] Infrequent transactions and changing partners neither permits prompt retaliation, nor personal enforcement. Instead of a prompt retaliation by the victim, the violator is sanctioned by other members of the society (Kandori 1992). For example, on eBay, the online feedback mechanism encourages the participants to rate one another. If one party fails to comply with their obligations, they receive a bad rating from the victims. Further participation on eBay will be cumbersome, as a bad rating makes it unlikely to find potential counter-parties. The problem involved with those reputation mechanisms trying to elicit truthful feedback is that the submission of feedback information is voluntary. Lack of concrete incentives the users refrain from providing any feedback or provide either intentionally or unintentional untruthful information. Interestingly enough, although eBay's feedback mechanism is not incentive compatible (cf. Ockenfels 2003), it succeeds in *"encouraging cooperative behavior in an otherwise very risky trading environment"* (Bakos and Dellarocas 2002**,** 2). Current research streams focus on the

[116] Broadly speaking, subgame perfection requires that it is not beneficial for any agent to deviate from equilibrium strategy at any stage of the game.
[117] Technically, the Folk theorem can be generalized from repeated games to matching games (Kandori 1992).

development of better so-called reputation mechanisms, either by explicitly designing incentives for truthful feedback, or implicitly by data mining techniques (Resnick and Zeckhauser 2002).

Designing an electronic market always raises the question which mechanism – either formal or informal – is the most apt in order to assure a balance between the degree of trust concerning the users and the costs of the enforcement machinery. Trust in the electronic market requires that the participants abide to the rules. Yet trust is important for the agents' initial decision of participating into the trading process, as trust denotes the subjective (felt) risk of participation. As aforementioned, trust can be build up by adequate enforcement mechanisms. Enforcement is generally associated with costs such that there is typically a trade-off between costs and efficiency of the enforcement machinery. Generally it can be stated that *community enforcement* is advantageous if the traded resources are of low or moderate value, as the costs of operating a sophisticated enforcement mechanism (third party) or filing suits tend to be equal or lower than the value of the product (Bakos and Dellarocas 2002).

The costs of the enforcement machinery are not independent of trading, business and media rules. For example, trading rules that employ sealed-offer submissions are always suspected to fraud, as the agents cannot trace the outcome to the offers. Media rules have a dramatic impact on cost, scale and performance of the enforcement machinery as the costs of collecting, processing, and disseminating feedback information have tremendously decreased with increasing IT usage. Furthermore, the use of central architectures allows an inexpensive, real-time monitoring facility. As the enforcement costs must be recouped from the participants, the enforcement machinery needs a solid representation in the business rules.

3.1.2.3.8 Institution Description

Having described the rule types, the extended institution of the electronic can be depicted. From the market firm's point of view, the institution span out the setscrews that can be set in providing electronic markets. From the agents' point of view, the extended institution confines the possible activities and also the behavior.

Figure 7 summarizes all rule types of the extended institution. While the microeconomic system only defined the trading rules, the EMS also accounts for additional rules. Those rules become necessary when several assumptions of the (socio-) economic environment – such as absence of transaction cost for carrying out the mechanism – are relaxed.

In short, the EMS framework identifies the following rules: The *participation rules* governs access to the electronic market. *Media rules* are derived from the underlying medium through which the market process is conducted. As such, media rules dictate rules upon behavior stemming from hard- and software such as processing speed, ease of use etc. The *trading rules* define the rules of the game, while the *business rules* are concerned with pricing. Furthermore, the *trading object definition* specifies the resources that are traded over the electronic market. *Enforcement rules*, finally govern the fulfillment of the outcomes, i.e. payment of the transfers and exchange of the resources.

The market firm must specify these rules of the electronic market. This part of the institution is planned and not spontaneously arising: Since the electronic market must embody these rules in software, they must be (deliberately) designed. Figure 7 divides the institution into two parts. The left panel exhibits the part of the institution that is designed by the market firm. Note that enforcement is vertically depicted, indicating that all rule types are subject to enforcement. However, the institution is not fully described by the part that is designed by the market firm. There may also be spontaneous development of norms. Those norms previously denoted as *social norms* refer to informal protocols among the agents. Apparently, these norms are spontaneously arising. If they arise over the venue of the electronic market, the planned institution of the electronic market confines the spontaneous development. Although social norms are informal, they also can be enforced by spontaneous sanctions.

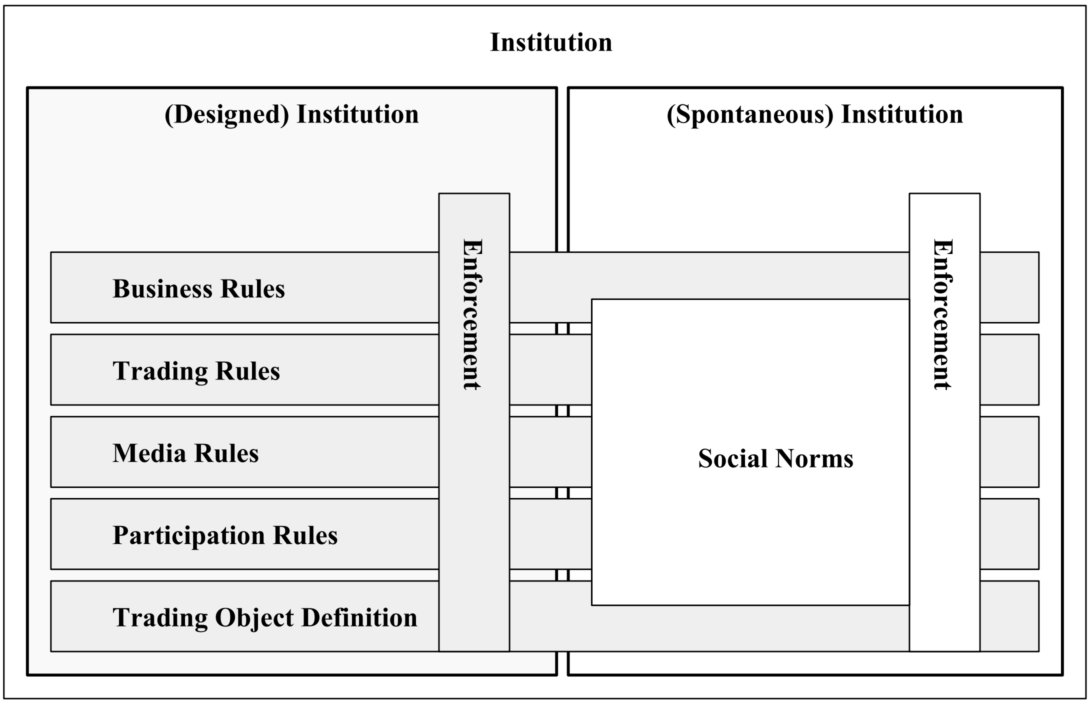

Figure 7: Extended Institution

3.1.3 Electronic Market Performance

Extending the microeconomic system towards an electronic market also affects the system performance measures. While the microeconomic system framework is concerned with a single mechanism in a static environment the electronic market framework investigates complex mechanisms in a dynamic environment. As such, electronic market performance measures are not completely congruent with the ones identified for the resource allocation mechanisms. In fact, all the resource allocation mechanism performance measures also apply to electronic markets. For example, the electronic market may want to maximize the revenue of the sellers. Owing to the extensions of the (socio-) economic environment and the institutions is the space of performance measures expanding. Basically the most intriguing expansions of the resource allocation are the inclusion of dynamics, multiple trade rounds, and competition among mechanisms. Furthermore, the operating firm, regulation and related aspects such as concentration of market power are included. Financial market literature has ever since its foundation dealt with those environments (Demsetz 1968). Accordingly, it makes sense to refurbish the arsenal of performance measures by adding financial concepts.

The most cited performance measure of financial markets is liquidity. Harris describes it as follows: *"Liquidity is the ability to trade large size quickly, at low cost when you want to trade. It is the most important characteristic of well-functioning markets. Everyone likes liquidity. Traders like liquidity because it allows them to implement their trading strategies cheaply. Exchanges like liquidity because it attracts traders to their markets. Regulators like liquidity because liquid markets are often less volatile than illiquid ones"* (Harris 2003, 394).

O'Hara states in similar way liquidity as *"the ability to trade essentially costlessly"* (O´Hara 1997, 216). Consequently, markets are considered as liquid if they accommodate trading with the least effect on price (O´Hara 1997).

Electronic markets are basically search engines that collect information about who wants to trade. As such, electronic markets allow traders to identify corresponding offers at a low cost. Liquidity marks in essence the object of bilateral searches. If a buyer finds an offer at mutually acceptable terms he found liquidity. Likewise, a seller also finds liquidity when he finds an offer at mutually acceptable terms. Consequently, for a trade to take place it requires an antecedent bilateral search. A search in general can also be understood as a productive process where the traders employ inputs to obtain reasonable outputs. In the context of liquidity search, the inputs of traders are basically the time spent searching, whereas the outputs are the prices and the quantity of the corresponding transaction.

This may illustrate the various dimensions liquidity has. If a trader is willing to spend more time searching, he will presumably obtain better prices at a given trading quantity. Furthermore, if a trader wants to trade more quantity, he can expect to invest either more time searching or accept worse prices. Reversely, if a trader offers a good price he can expect to face a higher number of corresponding offers or to spend less time searching. Apparently, those arguments – referring to different liquidity dimensions – exhibit substantial trade-offs (Massimb and Phelps 1994; Harris 2003). More precisely, the following three dimensions are commonly known as liquidity dimensions:

- Immediacy
  Immediacy specifies how quickly trades of a certain quantity can be arranged assuming given costs.
- Width
  Width refers to the costs of arranging a trade of a given size, i.e. quantity.
- Depth
  Depth specifies the size of a trade that can be arranged at given costs.

Width and depth are *dual* to each other. That means the two problems are essentially the same: minimizing the costs of trading taking the size as constant, and maximizing the size of a trade assuming fixed costs. The strategies that solve the primal problem also solve the dual problem. Basically those strategies comprise an efficient search. Both dimensions refer to the same piece of information.

Frequently the dimension resiliency is also treated as a liquidity dimension. Resiliency specifies how quickly the prices return to former levels after the transaction. Having in mind that the performance measure liquidity also can cope with a dynamic environment, it becomes an important measure for electronic markets.

Transaction costs are not a new concept. Nonetheless it is worth mentioning them here again, as it can be used as a closed concept integrating the effect of trading and business rules on the performance. In fact, transaction costs are in the financial markets literature frequently distinguished into two components being explicit and implicit transaction costs. Implicit transaction costs are those costs that occur, because the trader has an impact on the price. Explicit transaction costs include all fees and commissions the trader has to pay, further does it comprise the costs associated with the trading process such as costs of setting up and running a trading desk (Harris 2003). Implicit costs refer to the impact of the trading rules whereas explicit costs reflect the costs associated with the business rules.

Massimb and Phelps introduced the measure concept of operational efficiency. The peculiarity of this concept is that it couples aspects of the trading rules with the media rules. In fact, operational efficiency is concerned with *"how well and how cost effectively"* (Massimb and Phelps 1994, 41) the electronic market facilitates transactions by bringing buyers and sellers together. As such, operational efficiency addresses the technical implementation of processing the trading rules. For example is operational efficiency concerned about the speed how fast offers are executed against each other (Massimb and Phelps 1994).

Now the big picture how these measures work together can be depicted: Transaction costs are the super-ordinate concept as before. The implicit component of the transaction costs can be measured by the concepts of liquidity, whereas the explicit components are easy to elicit since they consists of accounting data like fees or commissions. Liquidity again is clearly affected by the degree of operational efficiency. For example, immediacy is affected by the technical circumstances that the underlying platform offers. Apparently, there is a positive correlation between liquidity and operational efficiency. Furthermore, embattled with this arsenal of measures, the performance of the trading, business, and media rules combined with the enforcement machinery can be reasonably gauged.

Hitherto, electronic markets were treated as a resource allocation mechanism. An electronic market stands, however, also as a proxy for a market firm. All those previously mentioned concepts only implicitly measure the impact on the market firm's performance. For example, the liquidity of a trading venue gives information about the market firm's profitability. However, liquidity does not incorporate the cost side. In order to measure the performance of an electronic market – understood as a firm that emerged for profit or cost coverage reasons – also traditional measures concerning a firm's profitability, such as the ROI (Return on investment) or related measures, such as the ROCE (Return on capital employed)[118] can be applied.

In summary, for measuring the impact of electronic markets on the outcome, the standard microeconomic measures such as allocative efficiency or revenue may be insufficient. On the one hand, dynamic measures are necessary to gauge the impact of electronic markets, on the other hand makes the introduction of a market firm and the information system new objectives necessary.

3.1.4 The Electronic Market as Institution

Having described all amendments necessary for an electronic market system, the institutional view on markets can be presented. In analogy to the microeconomic system, the electronic market system or in short electronic market is defined as consisting of $S^{EM} = (I^{EM}, e')$, where I^{EM} denotes the extended institution and e' the dynamic (socio-) economic environment (see Figure 8). Amendments concern the (socio-) economic environment, the institution and the system performance:

- Economic Environment
  As previously mentioned, the economic environment captures all aspects that are exogenously given. Different than in the microeconomic system framework, the EMS framework is a dynamic version of the economic environment. This also allows the interde-

[118] The ROCE measures the return achieved on the capital employ, i.e. the invested and borrowed capital. The return is therefore taken to be the pre-tax profit earned before charging borrowing costs (Morris 1970). ROCE (or its equivalents) is generally characterized as *"measuring, management's ability and efficiency in using the firm's assets to generate profits"* (Rutherford 2002, 74).

pendence with prior events, e.g. trades that change the state of the environment (e.g. preferences and expectations). The arrow from the outcome to the economic environment accounts for the reference.

Another major change marks the assumption that transaction costs arise carrying out the market process. This makes the introduction of a market firm and medium necessary.
Lastly, the economic environment also captures social aspects of human behavior. By the term of embeddedness, the EMS framework captures the impact of social relationships such as friendships on the behavior of the agents. Hence, the economic environment turns to a socio-economic environment.

- Institution
  The institution is extended in order to capture the electronic market specific aspects such as business and media rules. The institution is only partially under the control of the market firm. This stems from the fact that institutions can arise spontaneously. Those institutional rules are only indirectly influenceable.

  Example 3.1-11: Law and Constitution

  Note that the elaboration here is limited to the operational choice level of electronic markets. Principally, there are two upper-level institutions on top of the electronic market institution, namely, the specific law and the constitution. The constitution determines what laws can be issued and which cannot. The (regulatory) law determines how the electronic market institutions can look like. Apparently, those upper-level institutions also pertain to the electronic market institution. However, in the following those institutional levels are due to space restriction not further elaborated.

  Another aspect that has only rarely been addressed refers to competition. Hitherto, it was implicitly assumed that there is only one market firm providing an electronic market. This must not be the case. As such, the institutions of other electronic markets also affect agent behavior. Since it is not necessary that the alternative electronic markets are located in the same country, they may underlie other laws and constitutions. Apparently, analyzing electronic markets is more complex than analyzing mechanisms in the microeconomic system framework. For simplicity only one institution is depicted in Figure 8.
- System Performance
  Having introduced new concepts in the EMS framework (e.g. market firm, media, etc.), new measures are needed that can account for these concepts (e.g. profit, operational efficiency).

Apparently, the concepts of the electronic market system are highly interdependent. The institution affects agent behavior, which subsequently determines the outcomes. The outcomes, however, affect in turn both the (1) (socio-) economic environment and (2) agent behavior. Firstly, it is easy to see that the outcomes change the (socio-) economic environment: in the easiest case the outcome changes the agents' endowments. Secondly, agent behavior is also affected, as prior outcomes influence the expectations about subsequent allocations.

Comprising, the extension from the microeconomic system to the EMS framework tremendously increases the complexity of agent behavior.

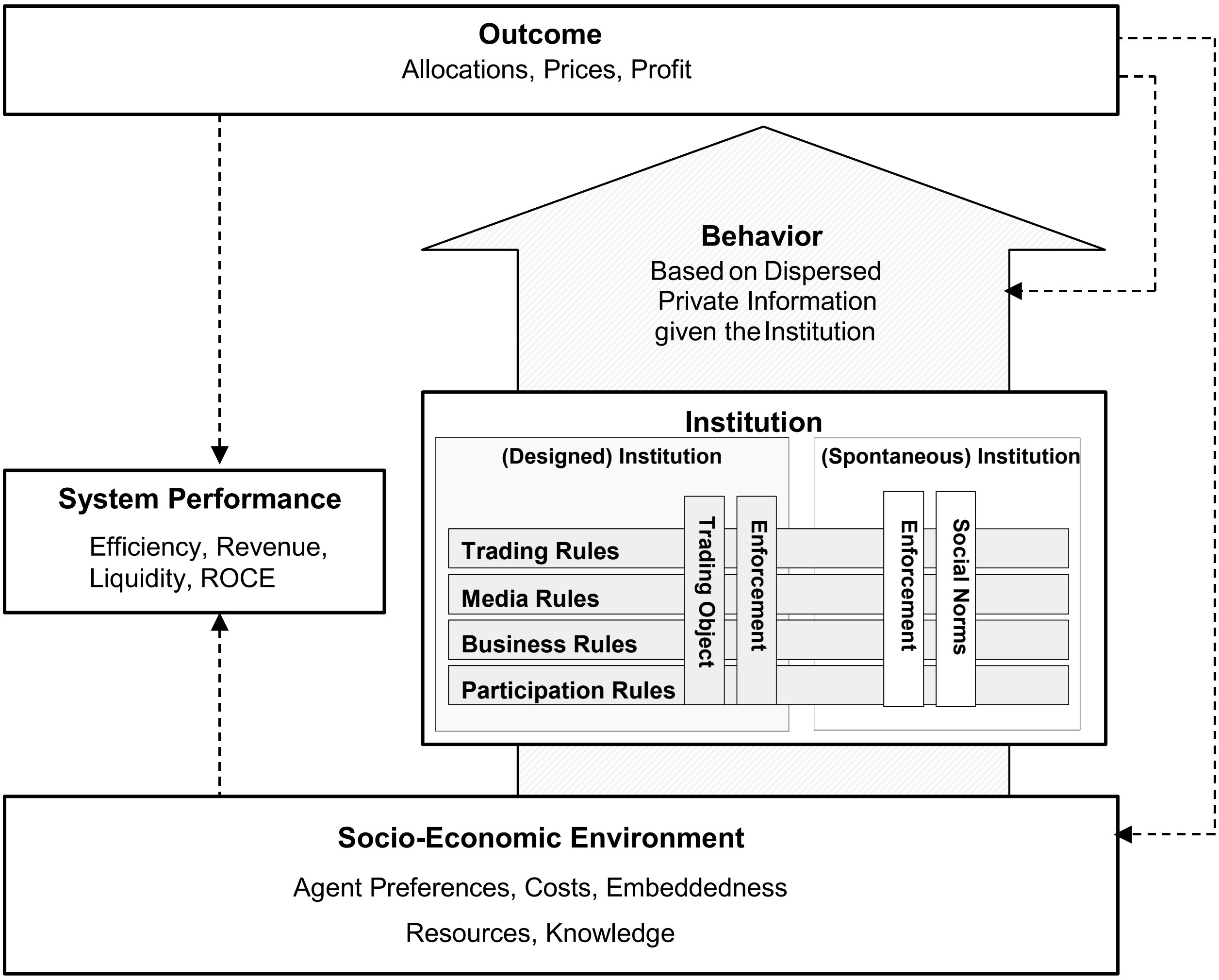

Figure 8: EMS Framework - The Institutional View

3.2 The Organizational View on Electronic Markets

In his salient paper *"The Nature of the Firm"*, Coase introduces two extreme forms of coordination, being the *"market"* and the *"firm"*. The coordination mechanism *"market"* works by means of the price, whereas *"firms"* employ authority for coordination. Those two extremes span out a continuum of coordination mechanisms.

Interestingly, the EMS framework introduces the term *"market firm"* for the entrepreneur who runs the electronic market. On the first view, this sounds paradoxically, as both terms market and firm are extreme forms of coordination mechanisms. Obviously, the nature of electronic markets is ambivalent. Its first facet constitutes the resource allocation process. An electronic market arises by providing an (extended) institution for a given (socio-) economic environment. This interpretation of an electronic market emphasizes the institutional site of an electronic market. It observes, however, only one facet of the electronic market. The other side may refer to the provision and operation of electronic markets, which is essentially an entrepreneurial activity (Coase 1988).

The institutional and organizational facets are apparently two opposite sides of the same coin (Coase 1988; Holtmann and Neumann 2003): Allocation decisions between distant agents are coordinated via the market mechanism (i.e. market coordination); nonetheless is the provision and operation of the market mechanism coordinated via a firm, i.e. hierarchical coordination.

This interpretation reflects the ambivalence of an electronic market, which is addressed by the term "market firm". The electronic market also embodies a firm.

In the sequel the puzzle why an electronic market is coordinated by an organization, more precisely by a firm, is virtually resolved (chapter 3.2.1). Perceiving the *"electronic market"* as a (market) firm raises the question concerning the offered product. Providing the facilities of the electronic market marks the product of the market firm, which is essentially a service as chapter 3.2.2 reveals. Since the market firm offers the electronic market as service, the design of the (extended) institutions transforms to service development. Principally, service development depends on the strategic positioning of the service company. This also applies to market firms. Chapter 3.2.3 introduces two fundamental aspects of the strategic positioning of a market firm, which have a crucial impact on the way the electronic market is provided. Chapter 3.2.4 summarizes the organizational view on electronic markets.

3.2.1 The Market Firm

When the institutional view on electronic markets was depicted, the existence of a market firm was merely postulated. This postulation is now relaxed, emphasizing the organizational view on electronic markets. Firstly, the relationship between institutions and organizations are illustrated. It follows that some institutions require organizational support to be effective (chapter 3.2.1.1). Secondly, the institution of electronic markets exemplifies such institutions that need an organization. Due to the uncertainties and risks associated with the provision of electronic markets this organization will be a firm (chapter 3.2.1.2).

3.2.1.1 Institutions and Organizations

According to the well-known definition of Milgrom and Roberts are economic organizations *"[...] created entities within and through which people interact to reach individual and collective economic goals"* (Milgrom and Roberts 1992, 19).[119] Organizations are *"more or less permanent combinations of production factors"* (Kasper 2002, 38) such as labor and capital in pursuit of economic goals. Formal organizations are those organizations, which glue networks of agents to an entity with independent legal identity together. Examples of formal organizations are corporations, unions, partnerships etc. The formation of organizations, i.e. the gluing together of agents requires either implicit or explicit institutions. Institutions and organizations are often confounded. The reason may stem from the fact that certain institutions can only survive if maintained within a (formal) organization (Loehman and Kilgour 1998; Kasper 2002): That is, organizations give backing and substance to institutions.

Hitherto, the coordination-mechanism *market* was analyzed by referring to their institutions. Markets, nonetheless, also constitute an organization. In essence markets can be understood as humanly created entities, which aim at providing a facility for trading that *"minimizes"* the transaction costs. The institution determines the allocation and the corresponding outcomes, whereas the organization defines the relationship between buyers and sellers.

From at least medieval time, it was common in Europe to found markets as (formal) organizations for trading. For example, in finance and international trade very early examples of organized markets have been emerged (Greif 1993; Kroszner 1999). The reason why (formal) organizations are introduced stems from the fact that these organizations can tremendously reduce the costs that adhere to trading with strangers. A comparison will illustrate this ability.

[119] In organization literature the term *organization* often also refers to the process of creating entities.

- Unorganized Trade
  In cases, where there is no organization, agents that are willing to trade have to identify their potential transaction partners. Identification requires double coincidence of supply and demand such that a transaction can take place. The potential trade is exacerbated by the fact that potential partner are strangers. This implies that information about their reliability, credit-worthiness, promptness, and honesty, as well as information about the qualities of the goods is missing. Acquiring information about the agents and their offers and demands creates costs, which are basically transaction costs. Comprising, unorganized trade resembles trade-by-barter (Telser and Higinbotham 1977).
- Organized Trade
  Organizations can streamline this trade-by-barter by introducing a standardized medium of exchange, i.e. the transaction product. The standardization of the transaction product allows trading without knowing the identities of the corresponding parties. Comparable with the introduction of money, the standardization of transaction product permits its interchangeability. As all participating agents are forced to a common understanding concerning the transaction product, it is irrelevant from whom the product originally comes from (Telser and Higinbotham 1977). This practice enhances the liquidity and fungibility of those products among the participants (Kroszner 1999).
  Furthermore, an organization can firstly design a meaningful code of business and can also monitor its compliance. A meaningful code of business refers to the trading rules, which can streamline coordination of the resources and simultaneously reduce information costs. As a matter of fact, the organization can impose those trading rules and, moreover, enforce them (Kasper 2002).
  Hitherto, it was implicitly assumed that the agents in transaction comply with their obligations. However, there is still the risk of default. An (formal) organization can alleviate this risk. As the participating agents may prefer to deal with someone with whom they have regular business and who has a reputation to lose, the formal organization can intermediate between the parties in transaction. Instead of dealing directly with the counter party, they can clinch their deal with the formal organization of the market: the seller receives a payment incurs a liability to market organization, whereas the buyer incurs a payment but receives an asset (i.e. the transaction product) from the market organization. Failure to comply can be legally enforce by filing suits. Furthermore, the (formal) organization can ban those violators form the market. As the (formal) organization can realize economies of scale in the enforcement, they can reduce the transaction costs. However, it is not necessary that the formal organization actively takes part in the trade; instead intermediation can be confined to convey information about the potential counter parties.
  On the one hand, the facilitation of trade reduces costs, on the other hand, it incurs costs which the formal organization has to pay (Telser and Higinbotham 1977; Kasper 2002).
  Comprising, the introduction of organizations entails substantial advantages concerning standardization of the transaction product and process as well as their enforcement, incurs, however, also costs, which can be substantial as well.

Whether a market organization evolves depends on the net effect of cost reduction and creation of such an organization. If the cost reductions outweigh the cost creation, as it is the case in financial markets, organizations will eventually emerge.

3.2.1.2 The Organization of Electronic Markets

Now the question arises whether *electronic markets* are organized? In essence, electronic markets evidently give rise to organizations. Electronic markets embody institutions that are necessarily being planned or designed. Imposing and monitoring institutions requires some sort of authority that is either above or outside the group of agents the institution regulates

(Simon 1991, 39). Designing institutions is, thus, always associated with the appointment of distinguished agents that receive their authority by creating an organization. In most of the cases the organization will be formal, as the organization gets more weight when it can independently act as a legal entity.

Hitherto it was assumed that there exists a formal organization – called *market firm*. But where does this market firm come from? This becomes critical, as it is not self-evident that an electronic market emerges. Having relaxed the *"free-lunch assumption"*, facilitation and enforcement of trade creates costs for setting up the trading infrastructure, operating and controlling the trading process. Setting up the trading infrastructure in turn means investing in the appropriate hardware, acquire the necessary trading software and distributing it to the participating agents. In short, operating an electronic market requires specific investments. These investments are, nevertheless, obligatory to go into service.

The claim here is that the creation of formal organizations for electronic markets requires either cooperative or entrepreneurial spirit. If neither of those spirits is present, electronic markets will not emerge, as the associated costs and risks take their toll.

- Cooperative spirit
  A major advantage of formal organizations in markets is to coordinate behavior by promulgating standards such as the transaction product definition and the trading rules, which helps the agents to form better expectations about the behavior of the environment, including the other agents (Simon 1991). By doing so, transaction costs among the agents can be substantially reduced. This section is labeled cooperative spirit, which hints at the origin of the formal organization: The participating agents may together constitute a kind of ring that takes responsibility of setting up an electronic market. By charging fees from the ring members the costs that are incurred by setting up and operating can be recouped. Such membership organizations are frequently vulnerable to free riding. Free riding is possible if agents can benefit from the organization without paying for it. For example, if agents that are not members of the ring can participate in the market process, they enjoy the benefits without being chargeable. In those cases the participation rules can be an effective tool to force participation – those agents unwilling to pay for the organization are excluded from the process.

  Example 3.2-1: The Chicago Board of Trade

  For example, the Chicago Board of Trade (CBOT) was initially founded in 1848 as a voluntary membership organization. In 1850 the CBOT started with trying to promulgate standard definition of grain as a trading products. Having achieved the adoption of the standards in 1856, the main focus of the board was to encourage adherence to the new standards. Cheating was mainly enforced by the expulsion from trading. As trading in grain was almost centralized over the board, this threat was credible (Kroszner 1999).

  Basically, the formal organization can be manifested by a legal firm or by a cartel of members. A cartel of members is still a cooperation, which strives for streamlining the market process by simultaneous full coverage of costs. The formal organization is in that case basically a not-for-profit organization (Pirrong 2000). In the case of a legal firm, provision and operation of the electronic market are backed up by a legal enterprise. As long as the firm belongs to same members, it is likely that this joint venture still seeks for cost coverage as maxim.[120] Once the ownership is altered, the firm exhibits more entrepreneurial instead of cooperative spirit, reflecting profit maximization goals.

- Entrepreneurial spirit
  In the second case, the formal organization is build up by an entrepreneur. Inspired by the aspiration for profit combined with the personal innovation power, the entrepreneur gives rise to a firm. As there is a demand for establishing an electronic market, the supply of a trading venue appears to be germane to extract profit. This would, however, only entail that the trading venue is provided not necessarily that a firm is founded.

  In the tradition of Coase, it is referenced to the Knightian uncertainty argument: The intention the entrepreneur has in mind is to a great extent shadowy due to the high uncertainty involved with the endeavor. As the entrepreneur cannot provide the service of market operation alone, he must coordinate the activities that are necessary. However, due to the shadowy forecast what activities exactly the task of providing and operating requires the centralization of deciding and control within a firm is inevitable (Coase 1937; Coase 1988; Foss and Foss 1999).

  "In the first place, goods are produced for a market, on the basis of entirely impersonal prediction of wants, not for satisfaction of the wants of the producers themselves. The producer takes the responsibility of forecasting the consumers' wants. In the second place, the work of forecasting and at the same time a large part of the technological direction and control of production are still further concentrated upon a very narrow class of producers, and we meet with a new economic functionary, the entrepreneur. […] When uncertainty is present and the task of deciding what to do and how to do it takes the ascendancy over that of execution the internal organization of the productive groups is no longer a matter of indifference or a mechanical detail. Centralization of this deciding and controlling function is imperative; a process of "cephalization" […] is inevitable […]" (see Knight (1933) qtd. in Coase 1988).

  There is another possibility why an electronic market is established. An industrial firm producing some kind of goods, may want to introduce an electronic market as an additional channel of distribution. In those biased markets (recall chapter 3.1.1.1) it is rather dubious whether all market participants can realize the benefits of an organized trading venue. Instead the market firm is suspected to exert market power on the participants and thus extract rents from the buyers. Conversely, the market firm can also establish the electronic market as a channel for procurement. But again, the market firm as buyer is suspected to exert market power on the sellers.

  In general, novelties are introduced by firms for profit reasons and are tested in the market process. The same applies to the provision and operation of electronic markets: an entrepreneur, denoted as *market firm*, scent out an attractive niche for which he intends to provide an electronic trading venue. Whether this trading venue will ever yield the envisioned profit depends on how successful the electronic market is on the *"market for markets"*.

The main idea of this section is to demonstrate that the electronic market is not merely the provision and operation of an institution, but also *"as the other side of the coin"* an entrepreneurial or – at least – cooperative activity. Entrepreneurial and cooperative activities – under the roof of a formal organization – also have in common that they fill market deficiencies

[120] In electronic markets the dawn of mutualized "cartels of members" is nearing. As the marginal costs of an additional member has sharply decreased – due to information technology - to zero. Thus, charging fees for a membership is in a contestable market (for markets) economically untenable (Steil 2002).

(Leibenstein 1968). Schumpeter once coined the term of an innovative entrepreneur who conjectures potential of profit by introducing either new goods or services or by superior production technologies or organizational structures (Shane 2001). Nonetheless as entrepreneurial activities are devoted to profit maximization, cooperative activities also seek to fill the market deficiencies but for some mutually agreed-on goals. As before, the formal organization in charge of the electronic market will be called – regardless of their goals – *market firm*. Where the distinction is necessary, it will be explicitly annotated in the following.

3.2.2 The Product of the Market Firm

The previous chapter closes with the remark that the market firm emerges in order to fill the market deficiencies. But what deficiencies are those market firms precisely filling? What is their product? Principally, the product of the market firm consists of the provision and operation of an electronic market or more precisely of the provision and operation of the institution. In abstract terms are provision and operation nothing else but services. Services are different than physical goods. In the following, the characteristics of services and their production are elaborated. Provision and operation of the electronic market are thereby analyzed from the viewpoint of services.

3.2.2.1 Services

As there is a difference between retailing goods or services, it appears to be apt to characterize services in more detail. Adam Smith emphasized the first noteworthy differentiation between goods and services. This differentiation initiated a fierce discussion between classical economists concerning what kind of labor is productive. Labor productivity was only deemed productive if the labor was engaged in the production of goods. Although ramifications of this discussion are still in effect, the differentiation into goods and services was in meantime dismissed. By treating services as immaterial goods the distinction became to a great extent meaningless (Marshall 1920; Hill 1977).[121] In fact, services are no goods as their characteristics fundamentally differ.

Services basically exhibit two primary characteristics. Firstly, services effect a *change* in the condition of an agent or a good, in agreement with the agent concerned or with the owner of the good (Hill 1977). For example, the service haircut brings about a change in the hairstyling of an agent or the service 'car repair' changes the state of the car from malfunctioning to functioning. Secondly, the change is attained by an activity of an external agent (Lovelock 1983). Those two characteristics are sufficient to constitute a service.

> *"A service may be defined as a change in the condition of a person, or of a good belonging to some economic unit, which is brought about as the result of the activity of some other economic unit, with prior agreement of the former person or economic unit. This definition accords with the meaning of the word "service" as used in ordinary speech and by economists. It is consistent with the underlying idea, which is inherent in the concept of a service, namely that one economic unit performs some activity for the benefit of another"* (Hill 1977, 318) .

By defining services as a change in the condition of an agent or of a good, some implications about services can be drawn: The production and the consumption of a service must necessarily coincide. As the input of the service, i.e. the activity of the service-producing agent, must affect in some way the other agent or the good, the output itself is simply the change in the condition of the agent or good concerned. That means, not the process of the service-

[121] Thus, it is not astonishing that an economic treatment of the service industry is missing.

production is the output but the change (Hill 1977). Furthermore, as services represent any kind of change, it becomes clear that changes cannot put into stock.

3.2.2.2 Services as Product

A service is generated along a process. This process constituting the service is, however, different from those in which goods a manufactured. In the latter case, the good is manufactured at one time and the (potential) customer is typically not present. This is totally different in the case of services, since the customer is involved in the process as (co-) producer. Quality and added value thus depends on the consumer. The position of a consumer shifts towards the producer; in literature this phenomenon is dubbed *prosumer* (Toffler 1980). Regarding the customer as co-producer of the service has a major ramification. As the quality of a service hinges upon the behavior of the customer, offering a service must necessarily take the customer perspective into account. The service producer has not control over the whole process and can accordingly not assure a good outcome. Nonetheless, what the service producer can do is to create the best possible prerequisites for providing the service (Gummesson 1994; Edvardsson and Olsson 1996).

Figure 9 demonstrates the logical decomposition of the service provision process. The prerequisites of the service basically denote the provision of the facility that makes the service possible. Thereupon multiple service processes can be offered and facilitated through the prerequisites. The peculiarity is that the agents or goods are involved in the process, which finally generates the change as outcome.

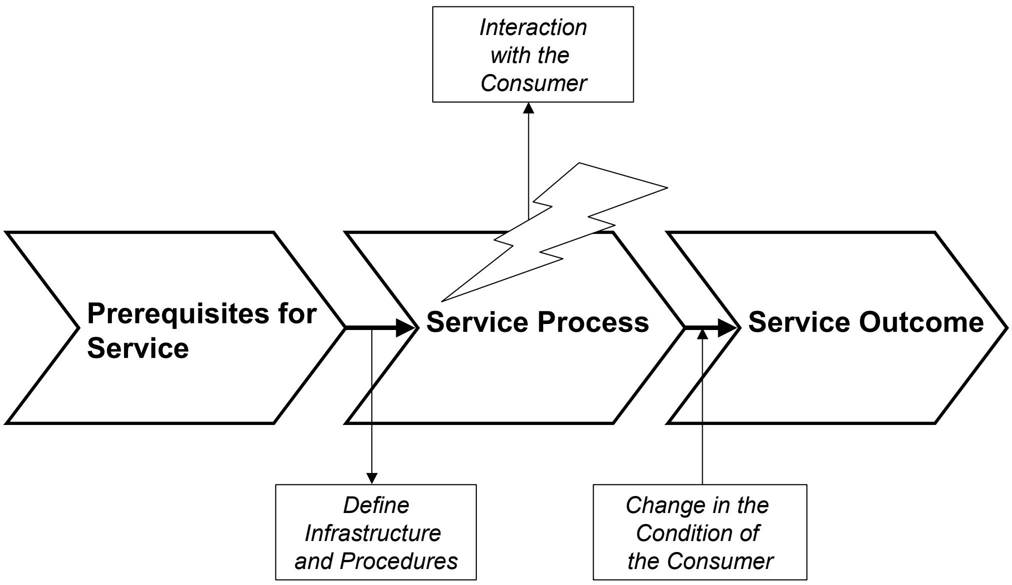

Figure 9: Logical Decomposition of Service Provision Process

The primary goal of a service company, i.e. the firm that produces the service, is not to provide the service, but to provide the prerequisite for multiple services. Obviously, the service company does not sell services the same way they sell goods. Instead, they offer opportunities for services that are produced in encounters with the customers. Those encounters entail at least partially unique processes with different outcomes. Now the intuition behind the maxim of providing the prerequisites becomes evident. As these processes do not occur in a vacuum, the service company provides the best and certainly the right prerequisites for a well-organized service process. The development of these prerequisites is most important to actually produce the service in co-operative work with the consumer (Edvardsson and Olsson 1996; Haksever, Render et al. 2000).

Comprising, two major inputs, the prerequisites for the service provided by the service company and the costumer as co-producer influence the service process and thus the service quality. The prerequisites for the service comprehend the infrastructure and the procedures necessary to facilitate the service process. Depending on these prerequisites the customer is also involved in the production process. Being outside the control of the service company, service companies can only indirectly affect the behavior of the consumers. As such, the customer *"is either an asset or an disruptive factor"* (Edvardsson and Olsson 1996, 147). Retailing service thus requires a sound creation of the prerequisites. The prerequisites are the result of the service development process.

> *"It is clear that a smooth running service operation offers competitive advantages particularly where differentiation between services is minimal. But effective and efficient systems do not operate by chance they operate by design. Developing and launching a new service is as much concerned with the design of service delivery processes and procedures as it is the design of the services themselves"* (Cowell 1988, 310).

3.2.2.3 Service Development

Offering services as products requires a profound development of the services, which boils down to build up the right service prerequisites. The right prerequisites comprise three primary components, which are subsequently sketched (Shostack 1984; Edvardsson and Olsson 1996).

- Service Concept
- Service Procedure
- Service System

The term *service concept* denotes the fully-fledged description of the new service, with which specific customer needs are attacked. In other words, the service concept refers to the demands of the customers and how these are met by the service (Scheuning and Johnson 1989).
Sometimes it is distinguished between primary and secondary customer needs. The primary needs are basically the trigger why the customer experiences a need. Secondary needs accrue from the core service that are consumed in order to satisfy the primary needs. Secondary needs are thus derived from the use of core services, which meet the primary needs.
When setting up a service concept both needs primary as well secondary have to be taken into account. This is crucial, as the customers perceive the quality of the service apart from the core service on the basis of peripheral services that aim at secondary needs (Edvardsson and Olsson 1996).

Setting up a service concept is not enough. The service company has also to keep track that any service process meets the service concept in all respects. Thus, the functioning and orderly sequencing of all activities must be guaranteed. The *service procedure* denotes a blueprint for all service processes describing the chain of activities of a service (Scheuning and Johnson 1989). The challenge in designing a service procedure is that it not only consists of activities under the control of the service company but also of customers' activities. Despite the involvement of the customer as co-producer, the service company must control the entire service procedure.

The *service system* comprises all resources that are available in order to implement the service concept. Those resources can further be specified as (1) the employees of the service company, (2) the customers as co-producers, (3) the physical & technical infrastructure and (4) the organizational structure:

1. Employees
   The employees of the service company are the crucial factor of the service system if they personally render the services. In those cases their experience, knowledge, demeanor and commitment are the pivotal success factors (Crane and Clarke 1988). Education and training thus stands at the beginning of a service development process.
2. Customers
   The customers as co-producer assume, as the service quality is dependent on the customer, a key role in the service system. Not only is their knowledge and experience with the service company relevant for the quality, but also their equipment. Nonetheless, education and training of the customers is thus also an essential part of the prerequisites. Frequently, the importance of marketing is in this context emphasized. This importance of marketing may become clear if it is assumed that marketing not only comprises advertising, but also informing the customers about their role as co-producer in the service process (Edvardsson and Olsson 1996). By an extensive informing of the potential customers marketing can contribute in a way that the customers become an asset rather than a disruptive factor (Edvardsson and Olsson 1996; Johns 1999).
3. Physical & technical infrastructure
   The physical & technical infrastructure has a broad meaning, as it comprehends premises, IT infrastructure, and equipment. Thereby the technical infrastructure is not necessarily limited to the service company, but can also – as abovementioned – refer to equipment at the customers'. The infrastructure can be essential for the conduct of the service. By improving the infrastructure within the scope of technical advances, the opportunities of a service company may increase: The technical development, and in particular IT development, opens the door for better conditions for better/more complex services. Nonetheless, a well-balanced development of the infrastructure is desirable, taking not only the opportunities but also the investments into consideration (Carr 2003).
4. Organizational structure
   Lastly, the service system includes the organizational structure that defines the responsibilities and authority of a new service. Furthermore, the administrative support systems such as planning or the financial system are to be defined before a service can start working.

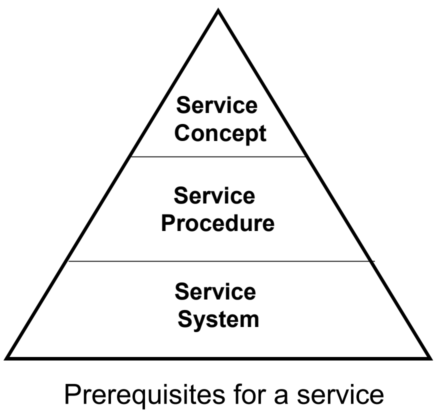

Figure 10: Components of the Prerequisites of a Service (cf. Edvardsson and Olsson 1996)

In summary, developing new services is a question of developing adequate prerequisites for the new service. Designing the prerequisites comprises as Figure 10 illustrates three components, service concept, service procedure and the service system. The service concept, principally, includes the idea the service company wants to offer. As the service pyramid arranges the different service models according to their degree of abstraction, the service concept –

being the most abstract description of the service – is depicted as the tip of the service pyramid. The service concept is bolstered by the service procedure, which basically gives a dynamic view on the service. In essence, the service procedure shows the flow of activities that in their totality constitute the service concept. The service procedure is in turn supported by the service system, which specifies the resources necessary for performing the service. As such, the service system represents the foundation of the service concept. All three components together form the prerequisites for a service. When introducing a new service all three components of the pyramid must be thoroughly designed.

3.2.2.4 Application to Electronic Markets

As aforementioned, the provision and operation of an electronic market is a service. The core service basically denotes the determination of a market-based price (transfer payments) and corresponding allocation (choice). The electronic market service is thus defined as follows:

Definition 12: Electronic Market Service

The electronic market service basically comprises the price determination and allocation according to the institution of the electronic market.

Complementary services are mainly concerned but not limited to information services (e.g. real time information about the actual demand and supply situation via the orderbook). The electronic market service is apparently generated along the market process. Within the market process the participating agents – the customers of the electronic market – submit offers to buy or sell according to the institutional rules. Those offers subsequently determine the price and the allocation. Consequently, the participating agents are also co-producers of the electronic market service. The quality of the service is also dependent on the co-producers. In other words, the market firm has not control over the whole market process and can accordingly not assure good performance. Control over the whole process can be misleading. Surely, the market firm has perfect control over the message flow; what the market firm cannot control is the behavior of the agents. In analogy to services the market firm cannot guarantee good quality of the market process but the best possible prerequisites for the market process.

Another particularity of the electronic market service is that at least two co-producers are involved. Co-production of the market participants basically comprises the submission of offers. For a transaction to take place it needs two corresponding offers that can be executed against each other. A transaction is thus termed *composite good*; one offer has no value without the corresponding (Economides 1996).[122] Moreover, as the co-producers of the composite goods are independent firms, coordination of the service that creates the transaction becomes difficult. As a consequence, the market firm tries to attract as many submitted offers as possible.

Figure 11 illustrates in analogy to Figure 9 the electronic market service. The prerequisites of this electronic market service basically refer to providing a trading facility. Over this trading facility the participants negotiate about their demand and supply within the lines of the institutional rules. The market outcome of this service comprises the prices and allocations, which are discovered according to the trading rules (choice and transfer rules). More precisely, the market outcome is formed in the encounter of the market participants with the electronic market facility, the service prerequisites, of the market firm. Apparently, the market firm can only

[122] For the submitting agent, the offer is assumed to generate no value, as no transaction occurred. However, it can be possible that the offer generates value for *other agents*. In financial markets *payment for order-flow* demonstrates that unmatched offers have a value and can be sold. Due to space restrictions, it is referred to Harris (Harris 2003).

influence the market outcome and thus the quality of the service by the way the electronic market is provided. By the deliberated design of the institutional rules as primary setscrews, the behavior of the co-producers – the market participants – is directed in a way that good outcomes are generated.

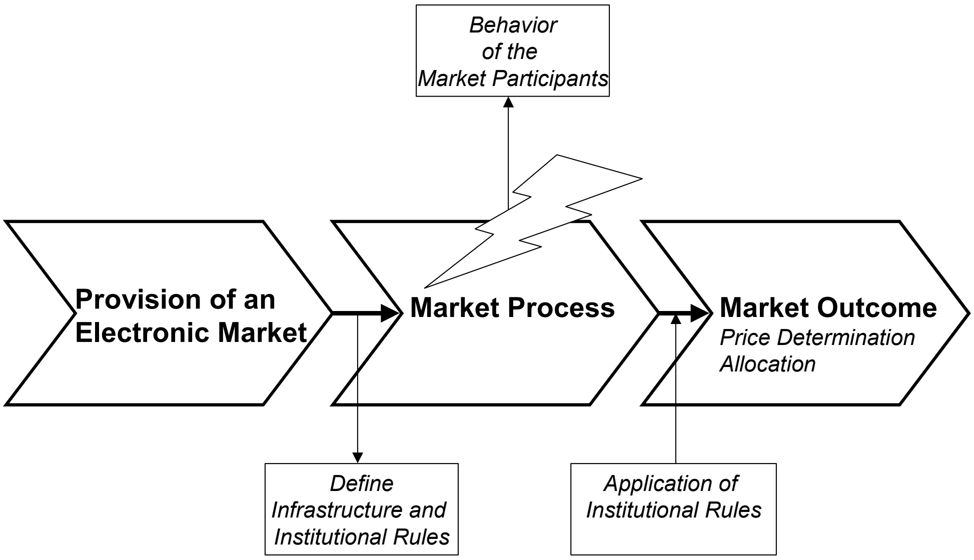

Figure 11: A Service View on Electronic Markets

As with any other service, the design and implementation of the right prerequisites is essential for the success. The right prerequisites are under full control of the market firm and thus subject to careful design. Recall that service development consists of the three primary components being service concept, service procedure and service system.

Transferred to the particular service of an electronic market, the service concept embodies the value proposition of the electronic market. Or differently stated, the service concept describes the coordination problem the electronic market seeks to solve. The process with which the service concept is implemented is actually confined by the service procedure. In the electronic market context the institutional framework, in particular the trading rules, constitutes the service procedure. The service system, defining the available resources to the service procedure consists of the market participants, the infrastructure, and the organizational structure of the market firm. Figure 12 visually clarifies the components of the prerequisites for electronic market provision.

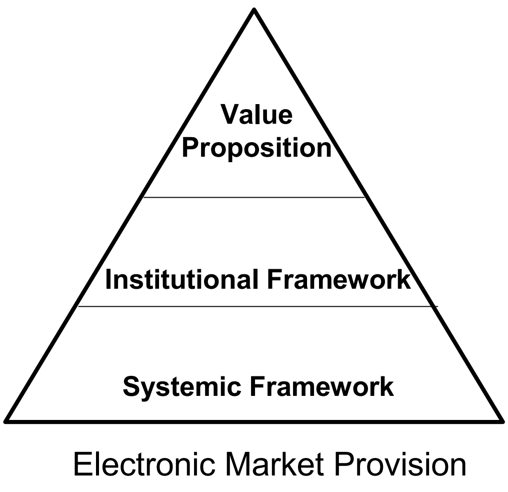

Figure 12: Components of Providing an Electronic Market

Value proposition as service concept

The service concept is a concise description of the customers' needs and the service that are intended to meet these needs. In the electronic market context the customers' needs are overlaid by coordination problem the electronic market is actually devoted to solve.

Example 3.2-2: Coordination Problem in the Electricity Context

From an abstract level trading electricity creates a coordination problem that is characterized by its inherent incompleteness and imperfect competition. Incompleteness is to a large extent inevitable as power is a flow of energy. A perfect monitoring of the flow is difficult; the storage is expensive. Furthermore, those flows on transmission lines are constrained by operational limits and environmental factors. Comprising, supply of electricity is subject to fluctuations. On the other hand, is demand extremely variable and is largely insensitive to price changes of the spot market (Wilson 2002). The coordination problem of bringing demand and supply into balance is thus very difficult.

Apparently, the coordination (or allocation) problem is the most urgent (primary need) of the potential customers. This primary need can be matched by adequate institutional rules embedded in an infrastructure. The particular stress is on the trading rules again, as they define the original allocation problem and further a procedure to solve it. Nonetheless, primary needs are not limited to the allocation problem (e.g. trading over electronic media can also reason primary needs). If the resource allocation solving capacity of an electronic market represents the core service, there are usually supplementary services bolstering the core functionality. For example, an electronic market can offer its customers a call center. Those supplementary services satisfy, however, secondary needs. A market firm must tackle both needs primary as well as secondary needs such that the customers are satisfied. Frequently, the supplementary services are the factors that make the wide difference in the customer satisfaction.

In electronic markets the value propositions of the market epitomize the service concept. Value propositions are generally defined as the statements of benefits that are delivered by the firm to its customers (Bagchi and Tulskie 2000). As electronic markets are competing with non-electronic markets, they must create real value in a sense that they offer superior (e.g. cheaper or faster) services than the non-electronic ones. Electronic markets are frequently pulled together with the following value propositions (Bailey and Bakos 1997):

- Aggregation
  In pursuing new opportunities firms engage in a search process identifying potential transaction partners. An electronic market can aggregate submitted offers and thus ameliorate the problem as well as the associated costs of search (Geertz 1978; Bakos 1997).
- Facilitation
  Facilitation aims at two primary issues. Firstly, the electronic market place facilitates trade by standardizing the traded object. This standardization reduces the uncertainty over the quality of what is to be exchanged and likewise the associated chunk of the deliberation costs[123] (Rangan 2000). Secondly, the electronic market facilitates 1-to-many, many-to-1, or many-to-many interconnections. The electronic market can thus tremendously reduce the coordination costs via a standardized process with standardized data formats (Bailey and Bakos 1997).
- Trust
  Part of the deliberation costs concerns the trustworthiness and reliability of the partner in transaction. As electronic markets typically facilitate short-term relationships even one-

[123] Broadly speaking deliberation costs denote costs of the making decisions (Stigler and Becker 1977).

shot transactions, trust plays a major role. The electronic market can build up trust by a sound enforcement mechanism.

- Matching and Pricing
  Matching denotes the capability of electronic markets to efficiently match buy with sell offers via the price mechanism. The institutional rules of an electronic market presumably yield better matches than the participants would do without them (Malone, Yates et al. 1987; Bailey and Bakos 1997). However, a proper matching requires sufficient participants because otherwise the matching is less predictable.[124]
- Anonymous trading
  By means of electronic markets, it is also possible to trade anonymously. Agents are often reluctant to reveal their identity. For example, in procurement settings the manufacturers may want to conceal the price they have to pay for the inputs, because their customers may abuse this information in subsequent transactions. Anonymous trading can hence constitute the value proposition (Kambil and van Heck 2002).

The sample of value propositions addresses questions concerning the core functionality, which refers to the coordination mechanism.[125] Apparently, they can all be expressed in terms of transaction costs. The market participants eventually evaluate the electronic market in terms of how well those value propositions are fulfilled.

Institutional framework as service procedure
Formulating the value propositions is a first step on the way to develop a sustained electronic market. But those propositions must be put to work. The institutional framework comprises the totality of all institutional rules the market firm can set (recall chapter 3.1.2.3). Those rules characterize the service procedure in detail.

Systemic framework as service system
The systemic framework is actually a composite that proxies for the resources that are available to the service. As the previous discussion showed, the service system comprehends physical and technical equipment, customers and the organizational structure. In the electronic market context the technical equipment, i.e. the infrastructure, assumes a focal position[126]. The infrastructure is the foundation of the electronic market, being in charge of processing the offers. The infrastructure imposes media rules on the behavior of the agents and has thus an anchor in the system procedure.
Employees and organizational structure are naturally important assets. Employees of the market firm are only rarely involved in the market process.[127] Usually the knowledge and the experience of the employees help in providing the service, but also in designing it.

[124] For example if a Vickrey auction with a single participant will be initiated, this one participant will be awarded with the good and pays 0. Accordingly, this type of auctions is from the sellers' point of view suspicious leaving the seller with no payment. The question of how many participants are necessary to ensure a proper matching is dependent on the type of auction, which is being used.

[125] Note that these value propositions are fairly general. For design they must be described in much more detail.

[126] Chatterjee, Pacini et al., give a vivid definition of infrastructure *" IT infrastructure consists primarily of physical assets, intellectual assets, and standards. Whereas the physical components include hardware and software related to computing, communications, and database management, the intellectual and standard components of IT infrastructure refer to the human skill set, policies, and procedures required to combine the physical components to create shared IT services like network service, database management, video conferencing, electronic data interchange (EDI), hypertext publishing, and electronic messaging"* (Chatterjee, Pacini et al. 2002, 8).

[127] In the case of biased electronic markets the market firm is actively trading over the own market facility. As such there is a direct encounter between the customers and the (employees of the) market firm.

The customers of the service – the market participants – are the primary factor that determines the quality of the market process. Basically, the market firm can train their customers concerning how to use the electronic market adequately. Frequently, stock exchanges offer training programs for traders as complementary service.

In summary, a market firm is a service company that provides the electronic markets for electronic market services. As any other service company market firms cannot determine the quality of their service. By carefully designing the provision of electronic markets, the market firm can nonetheless indirectly affect the quality of their service.

3.2.3 The Strategic Positioning of the Market Firm

When the *provision of electronic markets* is seen as a product of a firm, strategic aspects of the market firm move into the center of attention. This accentuation of the market firm's strategy is reasoned by the fact that the provision of electronic markets is dependent on the strategic positioning of the market firm. It is the market firm that determines the (1) the overall mission of the electronic market and (2) the product program:

The overall *mission* of the electronic market defines the aim of electronic market. In the first place *"organized"* markets were introduced in order to realize transaction cost saving. However, the fees charged from participating agents counter the transaction cost savings. Which effect dominates depends on the mission the market firm has in mind.

The product program specifies the range of products the market firm is offering. As such, the previous assumption that the market firm is only offering a single electronic market is relaxed. This is obviously more realistic, as market firms realize high economies of scope when serving not only one, but several market places (Bakos 1991). This introduces another source of complexity: There may be interdependencies between different electronic markets that either complement or cannibalize each other. In state-of-the-art literature a thorough treatment of these interdependencies is not available.[128]

Furthermore, the view that market firms only offer electronic market services may be too narrow. On the contrary, market firms can also make their appearance as a buyer or seller. When the market firm is concurrently a (major) player on the electronic market, the electronic market is suspected to reduce to another distribution or procurement channel of the market firm.

Apparently, those strategic aspects enter the analysis when introducing the market firm. In the microeconomic system framework, those aspects were defined away – practice has shown, however, that these aspects are crucial for the success of an electronic market.

3.2.3.1 Mission of Market Firms

Electronic market services can either be seen as an instrument to save transaction costs for all participating traders or as a source of revenue (Picot, Bortenlänger et al. 1996). Transaction costs savings reflect the cooperative, whereas source of revenue points at the entrepreneurial notion of electronic markets. The extent to which the transaction costs of the traders can be reduced consequently depends on the strategic mission of the electronic market. If the cooperative overcompensates the entrepreneurial mission the transaction costs are ceteris paribus decreasing.

<u>*Cooperative Mission*</u>

The service can be offered to establish institutions that reduce transaction costs. Basically, due to incomplete information about the environment (i.e. (informationally) decentralized envi-

[128] This deficit is less surprising, as the topic of competing markets is currently only briefly touched (see 3.1.2.3.3)

ronment) coordination creates transaction costs. As transaction costs reduce the gains from trade, they reduce individual utility and on the society level social welfare.

By offering the electronic market service, which basically consists of rules and their enforcement, transaction costs can be decreased. The rationale lies in the better predictability of traders' actions. Thus, activities that insures against opportunistic behavior, which are generally costly, can be omitted as the institution of the electronic market will forbid or sanction this detrimental opportunistic behavior. From this perspective, the electronic market service is designed for reducing transaction costs. Coase emphasizes the transaction cost decreasing impact of institutions:

"Economists observing the regulations of the exchanges often assume that they are an attempt to exercise monopoly power and aim to restrain competition. They ignore, or at any rate fail to emphasize an alternative explanation for these regulations: that they exist to reduce transaction costs and therefore to increase to volume of trade" (Coase 1988, 9).

The cooperative mission of the electronic market paraphrases a *not-for-profit* firm. This view on the mission of electronic markets typically reflects the neo-institutional paradigm.

<u>Entrepreneurial Mission</u>
The electronic market service can, furthermore, be offered as an instrument to extract profits. The service is provided only if the participating agents pay fees (recall chapter 3.1.2.3.5). Those fees are for the participants, however, part of the transaction costs that occur on trade. When the transaction costs rise, previously profitable trades turns to detrimental ones and thus are left undone. The demand curve for this service is hence not inelastic – an increase in the fees reduces demanded quantity of services. Conceiving the market firm as a service company allows the application of the neoclassical price theory.

The neoclassical price theory investigates the firm's price setting behavior in dependency of the competitive situation. In the model of *perfect competition* (infinite number of supplier of a good) the firm faces a vertical demand curve, which entails that the individual firm cannot charge more than the competitive equilibrium price. Owing to the profit maximization assumption the price equals the marginal costs. This implies that the firms in perfect competition cannot attain supernormal profits.[129]
In the model of the *monopoly* (one supplier of a good) the demand curve – or at least a part of it – is decreasing. In this setting the monopolist can set the price above the marginal costs.[130] Because the demand schedule is not vertical demand will shrink but not vanish. Optimality requires the price to be higher than the marginal costs resulting in a decrease in the quantity demanded. In other words, the monopolists raises the price by reducing quantity such that only those agents are served, who are willing to pay not only the marginal costs for this good but also an additional monopoly rent. The magnitude of the monopoly rent depends on the monopolist's market power to exclusively occupy the supply side. Comprising, the monopolist can realize supernormal profits.
As the monopoly model reflects the optimum for firms, they try to establish a situation, in which they face a partially decreasing demand curve. Gutenberg dubbed this situation an *acquisitory potential.* Firms will thus seek to establish such a situation by for instance product differentiation either by physical attributes or by advertisement.

[129] For those unfamiliar with the classical price theory it is referred to standard microeconomic textbooks (Kreps 1990; Varian 1992).
[130] This implicitly assumes that no price discrimination is possible (Wilson 1992).

Assuming the market firm to be a neoclassical firm, the market firm strives for market power in the service segment. By providing different service prerequisites the market firm can differentiate their service from the others. Recall in this context, that the service procedure comprises the description how the service is performed via the institutional rules in particular the trading rules. Service differentiation creates a new sub-segment, which displays an acquisitory potential. In those cases the market firm can charge prices for the service that are higher than the marginal costs.

The struggle for market power has another reason that was previously not covered. The marginal costs associated with the service are almost zero – the reason stems from the fact that those costs are mainly costs of information technology. Accordingly, a situation comparable with perfect competition is impossible. The reason is that the profit maximizing condition requires the price equaling the marginal costs. As the marginal costs are zero, the price cannot be higher than zero leaving the market firms with no revenues at all. Since recouping the initial investments is impossible, the market firms make a loss. Market firms facing such a situation, consequently have to differentiate their services or to discriminate prices to earn money with the provision of the service (Varian 2000).

The entrepreneurial mission of the electronic market stands for a *for-profit* firm. This view on the mission of electronic markets typically reflects the neoclassical paradigm.

Empirically the traditional organization as *"cartel of members"* exhibiting cooperative mission in its purest form – where the members finance the trading venue through a fixed membership fee – has been vanishing. For example, stock exchanges that were previously organized as a cooperative club have recently turned to profit-oriented firms reflecting the entrepreneurial mission. The German Stock exchange, Deutsche Boerse, is the prototype for this shift. The reason for this creeping extinction of cooperative vehicles lies in the electronification of the market process, which has made these organization forms economically untenable (Steil 2002). The marginal costs of an additional member to participate have dropped to zero. In fierce competition the possible levies that can be charged for access must also drop to zero. The rationale is straightforward: Competing market firms may offer the electronic market service with lower access levies as their competitors attracting additional participants. The other competitors have likewise an incentive to undercut the prevailing lowest access levy. At the end of this process these access levies converge to zero. Access levies are just another expression for membership fees. Comprising, membership fees are economically infeasible facing competition among market firms. Accruing funds for financing the investment and operation is possible only via transaction-based fees. Eliminating membership in favor of transaction-based fees entails that the participating agents are more treated like a customer of a firm than members of a club. As the electronic market service is a "*a valuable proprietary product not costlessly replicable by traders, it is feasible for the owner to operate it, and sell access to it, as a normal for-profit commercial enterprise"* (Steil 2002**,** 3). Apparently, this theoretical argument bolsters the empirical observation.

The discussion of the mission has revealed that profit-maximizing firms may prevail. Thus, in the following, market firms are regarded as profit-maximizing firms: Although one have to keep in mind that also cooperative spirit may influence the strategic mission, it is, nonetheless, the entrepreneurial spirit that prevails.

3.2.3.2 Product Program

Principally, market firms are not confined to the product *electronic market service*. Especially, when market firms strive for maximizing profit, it is reasonable to assume that they diversify their product program. The product program of the market firms can, however, have a deep impact on the electronic market service. Suppose the product program suggests the market firm to become an active player in the market process. That is, the market firm can use the electronic market as an additional distribution or procurement channel. Then, the rules of the game may change, as the circumstances of the electronic market have changed.

To account for the changes in the circumstances stemming from the product program, Kaplan and Sawhney suggest in their influential paper a distinction of electronic markets into *neutral* and *biased* electronic markets. Their reasoning is appealing, as they argue that the aims of the market firm totally differ in those two cases, incurring different problems (Kaplan and Sawhney 2000).

- Neutral electronic markets
  In neutral electronic markets the market firm does not actively take part in the market process. Instead the market firm maintains a fair, unbiased market process. The pivotal question for electronic markets is attracting as many buyers and sellers on the platform such that the critical mass can be surpassed. Critical mass is a term from the network economics; it states the minimum size of a network that can be sustained (Shapiro and Varian 1999; Shy 2001). As markets are *"network goods"*, the concept of critical mass can also be applied to electronic markets. Since neutral electronic markets do not bring per-se influential buyers and sellers with them, they somehow have to attract and lock-in key traders (Raisch 2001).
- Biased electronic markets
  In biased electronic markets the market firm actively takes part in the market process. That is, the market firm uses the own market venue as a different distribution or procurement channel. By acting as buyer or seller, the electronic market already starts with a potential trader. The size of the market does not completely rely on the participation decision of others, as the operator itself has some market power. But exactly this market power marks the basic problems of biased market venues. Potential partner could distrust the market firm who unites market as well as operational power.

From the lessons learnt of business-to-business markets, it becomes clear, that the participants prefer neutral electronic markets. However, experiences also revealed that neutral electronic markets have rarely surpassed the critical liquidity. For example, the global food exchange Efdex struggled with the acquisition of sufficient participants, which eventually forced Efdex to shut their electronic market down.
Biased electronic markets have advantages there, but are suspected to systematically disadvantage other market participants. For example, the Dell eMarketplace was designed as a venue for trading computer hardware. Although the electronic market admitted not only Dell as seller, the potential participants always distrusted the tight connection between the market firm and the producer Dell. As a consequence Dell eMarketplace also had to close the electronic market.[131]

3.2.3.3 Impact of Strategic Positioning on Electronic Markets

Obviously, the strategic positioning of the market firm affects the electronic market in two ways: Firstly, in the design of the (extended) institution and, secondly, on the behavior.
If the market firm's mission is *cooperative*, then the electronic market intends to reduce the transaction-cost as much as possible. As such, the electronic market is designed to efficiently

[131] More examples of unsuccessful electronic market endeavors can be seen on the dot.com graveyard (http://www.b2business.net/Startups/Graveyard/).

allocate the resources, which resembles the classical mechanism design problem. Only the costs for operating the electronic market are charged from the participants. On the other hand, the market firm may strive for maximizing its profit. Then, the market firm will probably skim off the transaction cost savings. As aforementioned, market firms will eventually adopt the later model.
Secondly, when the market firm is also market participant it is very likely that the institution is designed in a way to match the own needs. For example, if the market firm is also buyer, the trading rules may strive for forcing the prices down by some sort of reverse auction. The interweavement between market firm and participating agent directly affects agent behavior. For example, the lack of trust in the electronic market may prevent the wide adoption of the biased electronic market.

Although there are some arguments favoring biased electronic markets (e.g. liquidity, industry knowledge, etc.), the trust argument inevitably favors neutral electronic markets. As such, this book primarily concentrates on profit-maximizing neutral electronic markets.

3.2.4 The Electronic Market as Organization

As a result of the previous discussion the electronic market framework can be extended by an organization view. Note that an institution and (socio-) economic environment define electronic markets. Institutions determine the outcome of an electronic market; it is, however, the organization of the market firm that gives meaning to the institution. The market firm has actually the authority to control and enforce the market process. As such, the market firm enables the streamlining of the market process – which materializes as decrease in transaction costs. This decrease in transaction costs gives rise to a service. The market firm, now, becomes a service company that creates value for their customers. For their service the market firm can also claim some of their created value by charging fees from their customers. Charging fees, however, increases the transaction costs again. As such, the initial transaction cost reducing effect – incurred by the electronic market – is, however, countered by another effect. Putting it to an extreme the market firm can exclusively strive for maximizing their own profit.

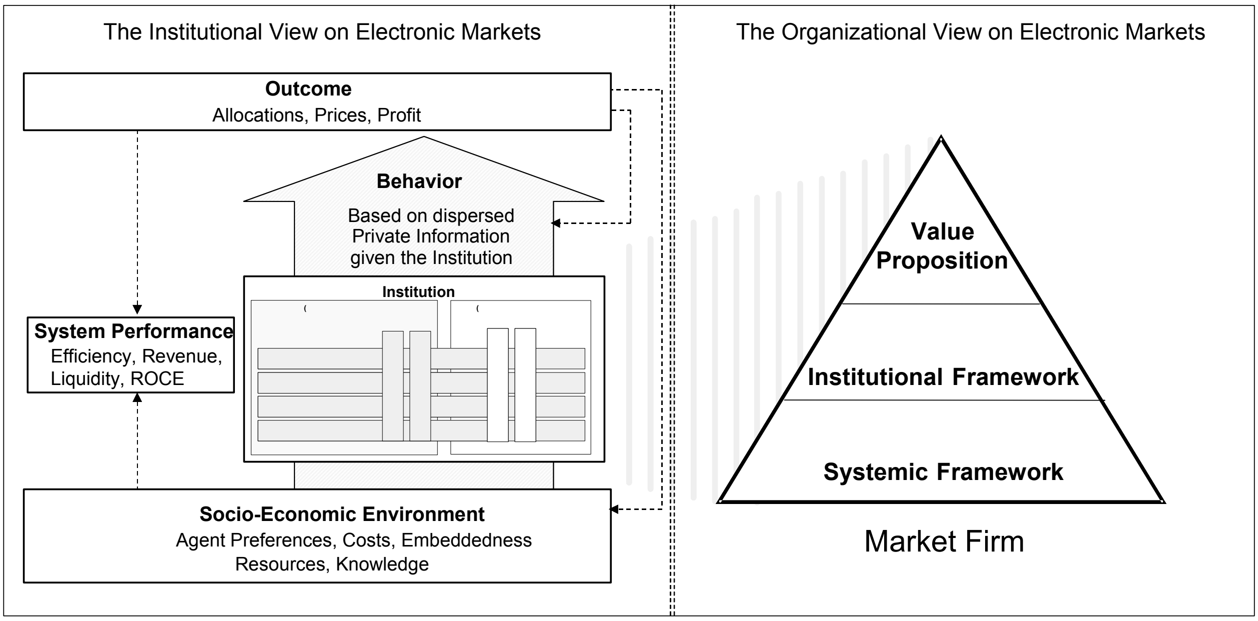

Figure 13: Two Sides of the Same Coin

Taking both effects together, it is rather undetermined which effect dominates. Principally, it is conceivable that the transaction costs decrease, since the market participants would other-

wise opt out. The alternative, unorganized trade would then be more attractive. However, the existence of barriers of an exit (lock-in costs) may impede this opting out.
Figure 13 summarizes the ambivalence of the institution and organization of an electronic market. On the one side the electronic market is an institution, which regulates trade, while, on the other hand the institution is part of a service, the market firm offers for sale. Analyzing on side without the other, may be dangerous due to the strong interdependencies between the market institution and the market firm's organization.

3.3 The Industry View on Electronic Markets

Having characterized the market firm as a profit-maximizing enterprise, competition becomes a factor. Principally, the pricing behavior of the market firm for their electronic market service is an individual decision. However, competition among several market firms will delimit the possibilities for the market firms to skim off supernormal profits. This chapter provides a brief insight into the industry view on electronic markets.

The theory of (perfect) contestable markets demonstrates that the supernormal profits of incumbents will erode away as newcomers enter the market[132]. Market entrance requires the newcomers to lower the price under the prices charged by the incumbents. Since those prices are still above the marginal costs, supernormal profits can be generated. Nonetheless, any additional newcomer diminishes those rents by the competitive pricing behavior as mentioned before. This process of newcomers entering the market slicing a little bit of the rents results in a situation comparable with perfect competition.
Even the threat of entry let the incumbents set reasonable prices below the maximum possible, i.e. the Cournot price. This reduced price setting behavior is intended to disguise the existence of monopoly rents. As the potential newcomers cannot sense any signals that may point at overpricing, they hence may relinquish their entry intents (Baumol, Panzer et al. 1982; Spence 1983).

Transferred to market firms it would mean that the threat of so-called hit and run entry have a disciplinary effect on the price setting behavior of the incumbents. However, hit and run entry requires free entry in a sense of costless access to markets (Appelbaum and Lim 1985). This condition is not met in the market firm industry. Free entry requires the absence of legal and economic barrier.

<u>*Legal barriers*</u>
Legal barriers are restrictions that prevent firms from entering markets and competing. For instance, government can restrict entry into mail delivery service, or they can limit competition in the mobile phone service sector by licensing selected firms and excluding others.

When existing legal barriers restrict free entry and higher prices are most likely to occur. For example, the securities markets are in general legally restricted.[133] The intuition for this restriction stems from the fact that the government is extremely concerned about the functioning of the capital market. The admitted stock exchanges are thus frequently organized as statutory corporations assuring a fair and transparent trading process.

[132] The term "market" is used here as the abstract aggregation of all transactions in a certain product. Clearly, analyzing market firms in competition comprehends the industry view on electronic markets.
[133] Although entry is restricted, the competition among the stock exchanges is extremely high, such that those legal barriers do not result in higher prices for the transaction service.

Currently the economic discussion about the legal barriers emphasizes the harmfulness of legal entry barriers. Under the key word liberalization artificially restricted market are increasingly open up to competitive markets.

Economic barriers
In most of the times economic barriers block the legally free entry. The reasons are for instance either sunk costs, or network externalities or combinations thereof.

- Sunk costs[134]
  Establishing a new electronic market is associated with investments to operate. The magnitude of the investments depends on the type of systemic framework, involving the technical infrastructure, the market firm is intending to realize. A "fat" high-scalable real-time trading system such as the stock exchange trading systems, e.g. SuperMontage[135] or Xetra, is more expensive to set up than a "thin" low-scalable near-time trading system such as Island.com or Archipelago. In those cases sunk costs are there, but fairly small.
  Advances in information technologies further reduce the amount of investment necessary for setting up an electronic market. The best example is given by the so-called electronic communication networks (ECN), which established functioning markets over their interbased trading venue. Without the use of IT, the sunk costs of establishing an exchange was apparently too high, such that the incumbent stock exchanges could hold competition to low level. With the rise of the Internet, newcomers appeared following an aggressive pricing strategy, i.e. hit and *not yet* run entry.
- Network externalities
  Network externalities specifies the cases where *"[...] the utility that a given user derives from a good depends upon the number of other users who are in the same network as is he or she"* (Katz and Shapiro 1985, 424). Accordingly, a good becomes more valuable as more agents use it. Katz and Shapiro define those network externalities as direct, which are generated *"through the physical effect of the number of purchasers on the quality of the product"* (Katz and Shapiro 1985**,** 424; Liebowitz and Margolis 1994). The classical example of a direct network good is the telephone as the individual utility depends on the number of potential conversational partners in the telephone network (Katz and Shapiro 1985; Economides 1996). Indirect network externalities involve those circumstances *"that lack that physical effect"* (Liebowitz and Margolis 1994, 135). For instance, software for certain hardware becomes cheaper and more abundant as the number of hardware users increase. Those indirect network externalities arise due to the compatibility with other increased use of complementary goods (Farrell and Saloner 1985; Liebowitz and Margolis 1994; Shy 2001). Network externalities can give rise to economic barriers: The advantage of the incumbents' network is the enhanced utility that a consumer derives from participating in the network. Newcomers will face severe problems to unglue the consumers from the incumbents' networks due to those network externalities.

  Electronic markets in general exhibit indirect network externalities. Basically, there are two channels from which these externalities can arise.

  Firstly, externalities can arise along the service generation. The electronic market service brings together an agent who is willing to buy and another who is willing to sell. This

[134] Sunk costs are investment costs that have been incurred before a certain activity takes place, and which cannot be reversed. Specific investments (e.g. R&D) are frequently sunk costs.
[135] NASDAQ's trading system is a fully integrated order display and execution system for securities. http://www.nasdaqtrader.com/trader/tradingservices/productservices/productdescriptions/smdescription.stm.

bringing together under the cloak of a transaction combines two complementary goods being "willingness to buy at price p" and "willingness to sell at price q", where $p \geq q$.[136] Hence the composite good *transaction* materializes the service outcome that finally has a value. The two original complementary components of the composite good, either willingness to buy or sell, respectively, had no value without the other. Clearly, the availability of counteroffers is critical for a transaction to occur (Economides 1996). Electronic markets exhibit indirect network externalities in a way that an increasing number of buy or sell offers increase the expected utility of all participants. The reason why an increasing number of offers increases the expected utility is that the variance of the allocation price is decreased. Assuming risk aversion, less variance of the prices increase the expected utility (Garbade and Silber 1979; Economides and Siow 1988).

Secondly, network externalities can also arise in the light of the service itself that creates the transaction. The greater the service network of the electronic market is the more can the market firm spread its fixed costs of operation on more transactions (Katz and Shapiro 1985; Economides 1996). In other words, the fixed costs that are generated regardless of the number of offered services could be recouped by more transactions. Accordingly, there are increasing returns to scale. Those increasing returns are fairly mild when the service consists of "processing" clients and only barely technologically supported (Arthur 1996). In those cases the service must be manually processed in a sense that an additional service requires additional labor. As labor is costly, increasing returns of scale are not as distinctive. Electronic market services are, notwithstanding, highly automated, entailing substantial service network externalities.

Accordingly, both forms of network externalities may apply to electronic markets favoring the incumbents. A larger number of services may be cheaper to produce than smaller numbers. Incumbent electronic markets thus presumably have a cheaper cost structure and additionally offer a better service quality through higher participation reducing the variance of the price.

Those economic barriers point at the fact that the market for electronic market services is not contestable. Hence market firms are left with an acquisitory potential to freely set the price for the electronic market service.

Furthermore, these barriers for newcomers are basically strategic resources for the incumbents assuring sustained competitive advantage. From a resource-based point of view, sustained competitive advantages may simply arise through the availability of strategic resources. Underlying this view are the assumptions that strategic resources are heterogeneously distributed and, moreover, that this uneven distribution is more or less stable over time. Strategic resources are inputs such as equipment, skills and knowledge of the employees, capital endowment, patents, brands, and so on into the production process. Resources that hold the potential of sustained competitive advantages must have four attributes: (a) it must propose value in a sense that it *"exploits opportunities and/or neutralizes threats"* (Barney 1991, 105), (b) it must be rare such that not all competitors have the resource at their disposal, (c) it must be imperfectly imitable, (d) it requires the absence of substituting resources that are neither valuable, nor rare, nor imperfectly imitable (Barney 1991, 105; Grant 1991; Bharadwaj, Varadarajan et al. 1993).

[136] Note that the good "willingness to buy" is the production contribution of the buyer that finally leads to the service *"price determination and allocation"*.

As previously discussed, incumbent market firms primarily possess specific resources in the form of a grown network of participants and a functioning infrastructure.[137] The *latter* resource, the infrastructure, is essential for the provision of the service, as it implements the service procedure. Self-evidently, it is valuable (assumed it meets the defined value propositions) and it is rare, as it requires possibly large investments to replicate it. Principally, the infrastructure and the implemented procedure are, however, replicable. Nonetheless the forth argument – absence of substitutes – is hardly given. Competitors can install a less expensive infrastructure and a comparable procedure. Nonetheless the service quality is dependent on the co-producers' behavior, i.e. the customers, either. Consequently, the infrastructure alone does not constitute a strategic resource in the sense of the resource-based view.

The *former* resource, the grown network of considerable size, is undoubtedly also a resource. But is it a strategic resource that can generate sustained competitive advantage? First of all it needs clarification why grown network of participants is a valuable input factor. Recall that the electronic market service requires – as any other service – the co-production of the customers through their submitting buy and sell offers. The size of participation increases the value of the service by reducing the variance of the potential price. Furthermore, the magnitude of the total average costs per transaction is also clearly dependent on the number of transactions. Total average costs not only contain the fixed but also the variable portion of the total costs. Being virtually information processing costs the variable costs converge to zero. Once the infrastructure is set up, the costs per transaction are negligible. Consequently, the total average costs are mainly dependent on the number of transactions, as the market firm can recoup the fix costs through more transactions. Comprising, established networks are valuable for the market firm as they, firstly, decrease total average costs leaving room for price drops, and, secondly, increase the quality of the offered service. Furthermore, established networks of considerable size are rare, as the totality of agents in a society do not belong to an arbitrary large number of networks. Accordingly, there cannot exist an infinite number of networks that have considerable size. In deed this argument is fairly week on the first view, but if it is conceived that taking part in networks requires access costs – say through the investment in equipment that is compatible with the electronic market – it becomes obvious that it is not rational for any agent to participate in an infinite number of electronic market. Using the same argument grown networks are difficult to imitate. The problem with networks is that they are difficult to direct. Setting up switching-costs as a barrier to lock the participating agents in the network is one option that is often proposed (Shapiro and Varian 1999). This is principally possible nonetheless there is still the danger of a collapse. If the network members expect that participation of another electronic market yields a higher expected return they may switch.

In summary, a network of considerable size is definitely a resource as long as the network is alive. Networks can, however, collapse within a short time. For example, in 1998 the network of the Bund Future market at the LIFFE eroded away and shifted to a concurring imitator the DTB (Seifert, Achleitner et al. 2000). Since the evolvement of networks is difficult to predict – historical events matter – building business merely around networks is thus dangerous (Arthur 1989; North 1990).

Accordingly, market firms are in a competitive business; the first discussed strategic resource is replicable whilst the second is outside the control of the market firm. All that the market firm can do is to offer good service prerequisites in order to attract and re-attract a network of

[137] Legal "resources" such as licenses or patent are in this discussion omitted.

considerable size. Offering good services depends mainly on the experience and knowledge of the employees, which become the originally strategic resource.

3.4 The Comprehensive View on Electronic Markets

Having discussed all facets of the EMS framework, the pieces can be put together. Figure 14 summarizes the previous discussion in a single figure – representing the EMS framework. Principally, the EMS framework resembles the microeconomic system framework but it differs in many respects.

1. Socio-economic Environment
   The EMS framework sketches a highly dynamic environment. Factors determining demand and supply can dynamically change. Furthermore, social aspects play a role. The economic environment thus turns to a socio-economic environment.
2. Institution
   The most fundamental change concerns the institutions on the operational level. As the medium through which the trade is conducted affects transaction costs, it must be added in the framework. For electronic markets the medium refers to an inter-organizational information system (Bakos 1991). Since providing and operating an electronic market is associated with costs, there must be an economic entity who is taking over the risk. This economic entity is the market firm. The market firm defines the trading object, regulates participation, provides the medium, defines the trading rules, charges fees and enforces the rules. In comparison to the institution of the microeconomic system, the EMS framework apparently employs a broader institution definition. Principally, these elements of the institution are subject to a deliberate design process. The market firm determines these rules. However, there are institutions that cannot (or at least indirectly) be planned by the market firm. Social norms may evolve to which the market participants – although not codified – adhere. Basically, these amendments – depicted in the institution panel in Figure 14 – reflect the institutional view on electronic markets.
   The organizational view also analyzes the electronic market but turns the attention to the market firm. Essentially, the electronic market is a hierarchically coordinated firm. More precisely, the market firm constitutes a service company. Its service comprises the allocation of resources and price determination on a basis of bids from the participants. As services require the incorporation of the participants as co-producer, offering services reduces to the provision of a service system that is capable of attaining the service. In the electronic market context the electronic market service denotes the provision of the institutional rules. However, different than the institutional view, the design of the institutional rules follows the plans and desires of the market firm. As the market firm (presumably) strives for maximizing profit, the institutional view on electronic markets alone is insufficient. In Figure 14 the organizational view is depicted by the triangle representing the three components of services prerequisites.
   The EMS framework also accounts for competing market firms offering different institutions for the same socio-economic environment. Competition forces the fees of profit maximizing market firms down. It is principally the competition that drives the market firms to introduce innovations concerning the institutional rules. This industry view is represented in Figure 14 by multiple market firm boxes.
   As aforementioned, the EMS framework focuses on the operational level. The operational level is embedded by the legal framework, which denotes in turn institutions. Lastly the constitution as deeper-level institution nests the legal framework.
3. System Performance
   The system performance measures of the microeconomic system framework pertains only to economic concepts. Introducing a technical infrastructure and a new player requires new performance measures.

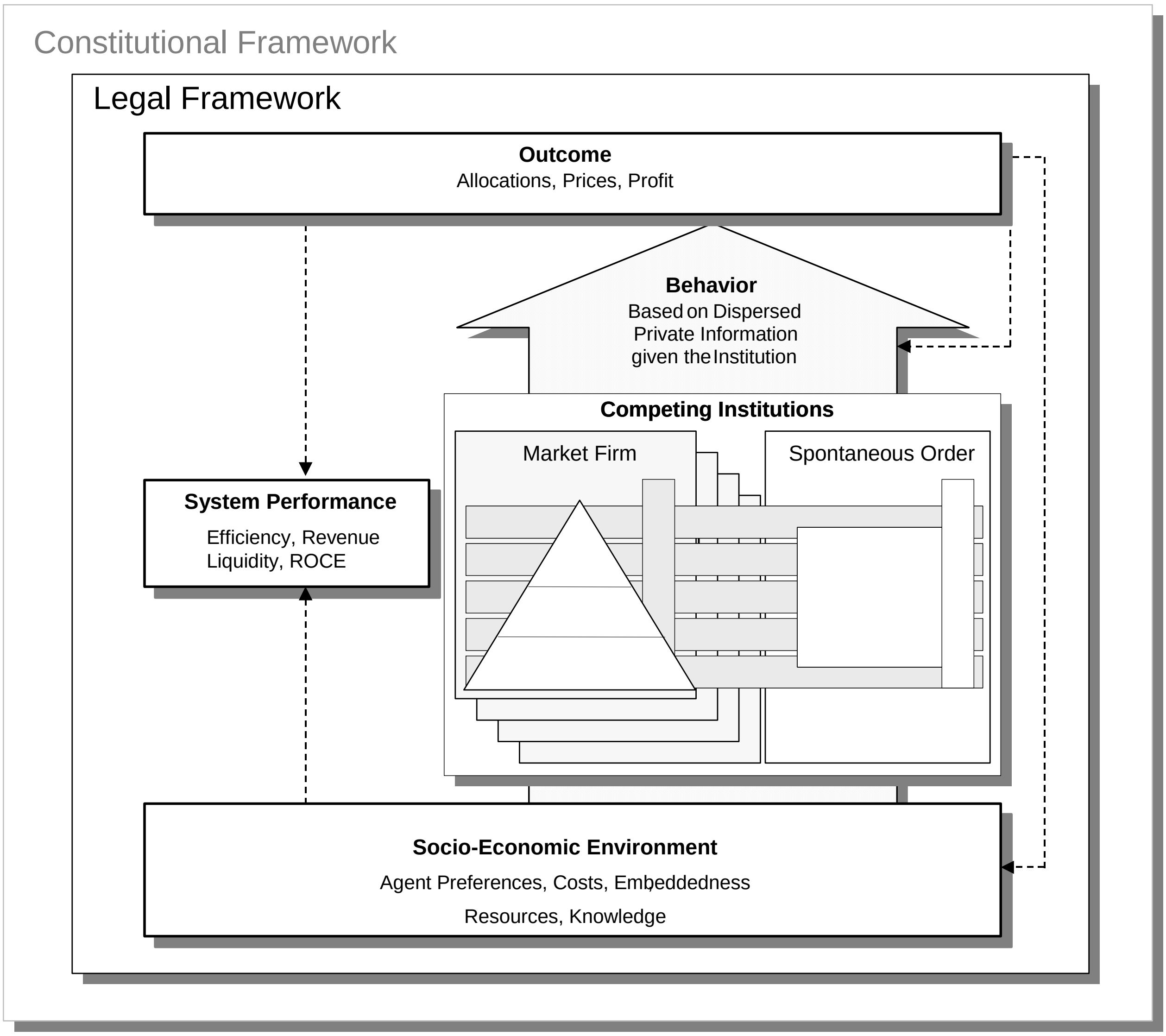

Figure 14: The EMS Framework

3.5 Chapter Summary

The previous chapter introduced the *market* as a microeconomic system. When analyzing electronic markets the microeconomic system definition incurs several restrictions. The restrictions basically refer to the assumptions imposed on the elements of the microeconomic system. On the one hand, those assumptions make the mechanism design problem mathematically tractable. On the other hand, the assumptions define away reality.

The EMS framework extends the microeconomic system framework in a way that (1) idealistic assumptions are relaxed, and, (2) concepts used to describe electronic markets are added. This occurs on the expense of mathematical tractability. The problem of designing institutions is no longer mathematically well defined. Principally, the EMS framework consists of three facets from which the electronic market can be analyzed.

- Institutional view
- Organizational view
- Industry view

The institutional view is originally derived from the microeconomic system framework. At heart, the EMS framework relaxes the assumption of transaction cost freeness of carrying out the market process. This relaxation has major ramifications upon the institution definition. Firstly, providing and operating an electronic market is no *"free-lunch"*. As resources devoted for providing electronic markets are limited, not any conceivable segment of the economic environment will support an electronic market. It is the decision of the market firm, which segments to deliver (i.e. transaction object definition). From the institutional point of view, the market firm is some economic entity that uses resources in order to provide the electronic market. Providing the electronic market basically refers to the deployment of an information system over which the market process is carried out. The information system itself imposes rules of conduct on the participants (i.e. media rules). For compensation the market firm charges fees from the market participants (i.e. business rules). It may make sense to exclude agents from accessing the electronic market. For example, the market firm may rule out untrustworthy agents along the participation rules.

Apparently, there are many more institutional rules than the trading rules defined by the microeconomic system. The assumption of transaction cost freeness also implies that agents no longer blindly obey to the institutional rules. Instead, the market firm has to define sanction mechanisms such that the agents follow the rules (i.e. enforcement machinery). Beside the institutional rules that can be defined by the market firm, it can happen that institutions spontaneously evolve. Those spontaneous institutions are of social nature and define an informal code of conduct. Those social norms make the design of institutional rules very difficult – however denying them would bias the expressiveness of the framework. The institutional view also redefines the static economic environment of the microeconomic system framework to a dynamic socio-economic environment.

The organizational view on electronic markets emphasizes the market firm. Accordingly, the market firm is an organization that conducts the institution. As such, the organization is backbone of the institution. As provision and operation of the electronic market is associated with risk, the organization materializes as a firm. The term market firm represents the ambivalence of an electronic market, being an institution, on the one hand, and an organization, on the other hand.
The product of the market firm is not a good, but a service. More precisely, the electronic market service comprises the allocation of resources and the determination of a price depending on bids from the market participants. From this perspective, conducting the institutional rules refers to a service. Apparently, the organizational view shifts the attention from the institution (coordination mechanisms) to the market firm (intermediaries).

The industry view principally extends the organizational view. In essence the attention is still on the market firm – in competition. The market-industry addresses the competition among several market firms offering a trading venue for comparable or even the same segment of the (socio-) economic environment. In the *market for markets*, market firms are trying to attract more customers through "innovation", e.g. fee cut.

Obviously the EMS framework, integrating these three views, draws a complex picture of electronic markets. Many different aspects must be covered when designing the institutions. Institution design is no longer a well-defined mathematical problem. The design becomes rather engineering, as the real world is too complex to put them in models. In other words, the mechanism design problems mutates to a market-engineering problem.

4 Towards a Structured Market Engineering

"Other men look at things that are and ask "why?" – I dream of things that never were and ask "why – not?"

J.F. Kennedy paraphrasing Theodor von Karman comparing scientists, who ask *"why?"*, to engineers who ask *"why not?"*

The microeconomic system framework characterizes markets as a combination of an institution and an economic environment. Within this framework the institution is very narrowly defined as rules of conduct. Where this institution comes from cannot be answered by referring to the framework itself. The framework only describes the constituents of the market system and not its origin. Since the times of the Austrian School it was common sense that institutions evolve over time. Compatible with the invisible hands theory the Austrian Economists Hume, Menger, Popper or Hayek believed that a spontaneous order of institutions attains better solutions than designed order (Menger 1883/1969; Richter and Furubotn 1997). As a consequence, they typically favor *laissez-faire* of institutions.

When shifting the framework from the microeconomic system to the EMS framework this conclusion cannot be kept upright. Electronic markets inherently require a conscious design of its institutions. The design of electronic market institutions is indispensable, as the (institutional) rules must be implemented in some sort of information system. Nonetheless, the definition of institution is within the EMS framework much broader than in the microeconomic system framework. More precisely, the institution of electronic markets contains at least six different components being the trading-object definition, participation rules, trading rules, business & media rules, and enforcement rules. Any of those six rule types affect agent behavior. One can imagine that the pure design of the institutional rules into a functioning system is very difficult. If the functioning system also tries to direct the economy in a way that some (economic) desiderata are attained, the design problem nearly becomes intractable.

The design of the institutional rules is furthermore constrained by institutions on a higher level. For example, formal law confines the way the institutional rules of electronic markets *may* be determined. Lastly, the institutional rules cannot be seen as monopoly – many electronic markets may occur for the same trading object. Institutions in competition can induce different agent behavior than the pure institution itself. Altogether the conscious design, which is per definition required, turns to a practical impossible endeavor. How can the institutional rules be reasonably defined considering all interdependencies?

Different than in the microeconomic system framework the institutional rules of the electronic market cannot be computed as an optimization problem. It is rather obvious that the market firm cannot find the optimal configuration of institutional rules, as the space of conceivable institutions is huge. Furthermore, the relationship between the institution and the outcome is hardly known; the design of institutions is an inherently ill-defined problem. In other words, design decisions must be made without complete knowledge about the phenomenon. To cope with this ill-defined problem, institution design shifts from pure science to engineering – market engineering. Market engineering is intended to develop economically founded approaches and methods that support the designers in facing the difficulties associated with the design problem. As such, market engineering does not contradict science, but works beyond the boundaries of science.

This chapter is devoted to the derivation of market engineering. Firstly, the realm of market engineering is pinpointed characterizing the problem structure of design (chapter 4.1). Secondly, strategies for tackling design problems are presented based on the theoretical discussion of design science. Subsequently, a design strategy for market engineering is motivated (chapter 4.2). Thirdly, this design strategy is augmented with methods and guidelines (chapter 4.3). The chapter concludes with a summary (chapter 4.4).

4.1 Introduction to Market Engineering

The motivation of market engineering stems from the intuition that electronic markets requires conscious design. As this aspect is central for market engineering, it will be discussed in chapter 4.1.1. If it is agreed upon the necessity of design, the question arises how will be designed and what exactly will be designed? To understand the notion of institution design, it is helpful to review design of institutions within the microeconomic system framework. In this case design is well-structured and reduces to an optimization problem. Once the structure-giving assumptions are relaxed, design is ill-structured, in a way that the strong problem-solving method (e.g. optimization) no longer applies. There is apparently a shift towards engineering (chapter 4.1.2). Turning the attention to the institution definition of the EMS framework the design problem – called market engineering – transforms to a wicked problem (chapter 4.1.3).

4.1.1 The Origin of Electronic Markets

The importance of institutions is generally accepted, particularly if the transaction costs are significant. As any other social and economic institutions electronic markets do not appear from nowhere. Rather are those institutions either evolving over time or they are consciously designed (North 1987). In the economic debate, there still has been prevailing a dispute on the normative level, whether institutions *should* evolve by spontaneous order or by conscious design:

- Spontaneous order
  Some authors, including famous economists Hayek, Lerner, Menger and Mises, view an economic institution as an undesigned ecological system that emerges out of a cultural evolutionary process. As such, they strictly favor a laissez-faire development (Mises 1932; Hayek 1935; Lerner 1972; Smith 2003a). The reason for their conclusion stems from two sources. Firstly, the socio-economic environment is unstable, meaning that it is inevitably changing. Secondly, no agent possesses *"Godlike knowledge about the presence"* (McElroy 1998**,** 282). Thus, the conscious design of institutions is inferior to spontaneous order, as only spontaneity recognizes and embodies both the dynamic flux in the environments and the inadequacy of agents' knowledge (McElroy 1998; Vaughn 1999). The advantage of spontaneity is that the participating agents react on any changes in the environment and adjust their behavior accordingly. Spontaneous order is thus self-correcting, *"Social and economic institutions have in many important cases evolved by spontaneous processes based on trial and error"* (Sertel and Koray 2003, 1).
- Conscious design
  The other stream of scientists denoted here as constructivists diametrically oppose to the previous idea of spontaneous order. The constructivist epistemology stems from Descartes (also Bacon and Hobbes), who basically argued, *"that all worthwhile social institutions were and should be created by conscious deductive processes of human reason"* (Smith 2003a**,** 467). The main point of the constructivists to come to this conclusion is that the

society has a function independent of the individual agents who form the society. For example, a society can have the function to assure its members secure living. Therefore, the individual agents must be coordinated in order to achieve this social goal of the society (McElroy 1998). Institutional rules are an instrument to coordinate the agents. As those rules create transaction costs, there is a need to deliberately design them.

From a constructivist point of view, spontaneous order appears to be inappropriate. Laissez-faire in the evolution of social and economic institutions bears the danger of cumbersome failures. This potential danger gave rise to the need of designing those institutions. Design refers here to the creation of new institutions so as to achieve a socially targeted objective. By means of a structured well-accepted and understood design process it is intended to minimize the danger of institutional failures. The advocates of spontaneous order, however, retort that designing institutions is quite an ambitious objective, because the rules only limit agent behavior but not directly govern it: Institutions with their incentive scheme and enforcement machinery rewards desired and sanctions undesired behavior. Exact predictions and accordingly total control of behavior is impossible.

But are those two views inevitably contradicting? This thesis supports the view that they are not. The difference in the conclusion of the constructivist and Hayek's spontaneous order approach is reasoned by the definition of the society. Hayek regards the society as an abstract aggregate of all interactions among the agents without any super-ordinate objective (McElroy 1998). As such, it becomes clear why Hayek puts weight into the conclusion that agents should act freely. Through their spontaneous interactions they can better adjust their behavior to changes in the environment as a central planner could do. Spontaneous order can also arise within the bounds of institutional rules no matter whether those rules are evolving or designed. That means spontaneous order and conscious design must not constitute a contradiction when the (designed) institutional rules – intended to achieve a specific objective – still leave the agents enough room for spontaneous interaction.

Different to non-electronic markets electronic markets must be consciously designed. Spontaneous order of electronic markets is always limited by the constraints imposed by the technical infrastructure. Institutional rules must be implemented in some way, which necessarily requires design. Even if the software is kept extremely flexible it is still result of a conscious design. One might argue that although institutions of electronic markets are designed, they can still evolve over time. Clearly, changes in the institutions require great effort adapting, implementing and testing the code and is moreover limited, but possible. This book, however strongly supports a proactive design of institutions *"rather than waiting for new institutions to evolve"* (Loehman and Kilgour 1998, 1) because it can reduce the number of errors in a trial and error evolution process.

4.1.2 Designing Markets as Engineering

Electronic markets simply require the deliberate design of the institutional rules. The requirement alone, however, does not reveal how *deliberate design* can look like. Again the reference to the microeconomic system framework may be helpful, as the discipline of economics is also concerned with the *deliberate design* of markets via the trading rules. The study of markets has a long tradition. Since the pioneering work of Adam Smith in 1776 economists have been occupying the analysis of the coordination mechanism *"market"* and, correspondingly, the trading rules (Smith 1976). Nevertheless, the theory of designing social and economic institutions governing resource allocation processes is currently in its infancy. *"Until the last century conscious social design was confined to modifications of already existing institutions"* (Sertel and Koray 2003, 1).

The reason for immature design theory stems from the neoclassical paradigm that prevailed the economic research. Basically the neoclassical paradigm frequently paid only attention to the price formation as result of interplay between demand and supply. In a so-called Coasean world free of transaction costs, institutions have indeed no impact on the market outcome (Richter and Furubotn 1997). As such, the importance of institutions was defined away – an inclusion in the theories was consequently meaningless.
With the relaxation of this critical assumption, the new institutional theory also brought forth an economic design theory: "*The creation of new institutions so as to achieve a socially targeted objective is very novel and yet awaits future scientists to be put into practice with full strength*" (Sertel and Koray 2003**,** 1). Economic design theory is, however, broadly defined and is concerned with the design of institutions of all analysis levels, e.g. constitutions or markets. The sub-field concerned with designing markets is called mechanism or market design. Principally, mechanism design is devoted to well-defined problems[138] (cf. chapter 2.2.1.1). In other words, the optimal or efficient mechanism can be computed.
In recent time *"economists are increasingly being called on to give advice about how to design markets"* (Roth 2002; Varian 2002**,** par. 2). For designing real markets, e.g. the physician market (Roth and Sotomayor 1990) or the spectrum auction, the problem is not well-defined. In this ill-defined context market design strives for designing the trading rules by applying mechanism theory (in particular auction theory). Roth defines the realm of market design as follows *"Market design concerns the creation of a venue for buyers and sellers, and a format for transactions. A market as a "pure venue" can be seen in perhaps its clearest form in Internet auctions, where some of the questions that arise about the location of a market are almost purely conceptual"* (Roth 2000**,** 7). In contrast to the well-defined world of the microeconomic system framework, the real world is inherently complex. The complexity stems from two sources: Firstly, from the strategic behavior of the agents and secondly from the (socio-) economic environment. To cope with these complexities, market design makes use of experiments and simulations.

Apparently, there is a shift of the focus from pure science, i.e. understanding the natural phenomena of markets to the design of the trading rules. Hal Varian titled his article in New York Times felicitously *"When economics shifts from science to engineering*" (Varian 2002). The newly emerging popular field of market design exemplifies this shift. It is to note, though, that engineering in economics is not a completely new topic as Wilson nicely summarizes:

"My perspective is normative, akin to the Lange-Lerner debate of the 1930s in which the theme was how best to organize and conduct markets. The focus then was on a national economy; here it is on an industry" (Wilson 1999**,** 1) *"The normative tone reflects the increasing role of economics as an "engineering" discipline capable of providing guidance on details of market design. This role has grown as game theory and derivative theories of incentives and information have expanded economists' tools to include methodologies for predicting how procedural aspects influence participants' strategies and affect overall performance"* (Wilson 2002**,** 1299-1300).

[138] According to Simon, a problem is well-defined or well-structured, when (1) the problem and the structure of the solution are clear from the outset of the problem solving process (in other words the problem can be put into a suitable form) and (2) it can be solved by using standard methods (Simon 1973). Those problems, for which these two operations do not apply, are denoted as ill-defined or ill-structured (Simon 1973). For well-defined problems "strong", for ill-defined at most "weak" solving methods exist (Newell and Simon 1976).

In summary, the design of trading rules within the bounds of the microeconomic system is a computational problem. When some of the assumptions are relaxed, the design problem changes from a mechanism to a market design problem. The growing field of market design also includes ill-defined environments and/or unknown strategy spaces.[139] To solve those ill-defined design problems, market design employs an engineering approach (Roth 2000; Roth 2002; Varian 2002; Wilson 2002). Stated differently, market design adopts a view compatible with the EMS framework. However, it focuses on the design of the trading rules neglecting all other institutional rules of an electronic market.

4.1.3 Holistic Market Engineering

Designing electronic market is certainly not only restricted to the trading rules. Principally, market design views the market as a microeconomic system without relying upon the assumptions. As the microeconomic system treats the institution merely as trading rules, it is obvious why market design is concerned with the design of trading rules only. Market design is rather challenging because the designer does not necessarily know the underlying environment (cf. chapter 2.1.2).

When electronic markets are analyzed the reference framework turns from the microeconomic system to the EMS framework. This framework change entails that not only the trading rules, but also all other institutional rules (e.g. business rules, media rules, etc.) must be designed. Market engineering, however, does not end with the *design* of the institutional rules. The change of the underlying framework implies that the conduct of the market process is no longer free of transaction costs. As such, operation of the trading venue becomes an issue. Comprising, market engineering consists of two core activities:

1. *Design* – directed towards creating an electronic market
2. *Operation* – directed towards maintaining the effective operation of an electronic market.

Design and operation are, however, meaningless without understanding of how electronic markets work. Market engineering is thus inherently associated with the study of the phenomenon electronic market. This describes the third core activity:

3. *Research*– directed towards an understanding of the phenomenon electronic market

This third activity also implies that the field of economic design is essentially integral part of market engineering. With those three core activities in mind, *holistic market engineering* can be defined as follows:

Definition 13: Holistic Market Engineering

Holistic market engineering comprises (1) the engineering design of all institutional rules of an electronic market, (2) the operation thereof, and (3) the study of institutions.

As this definition is fairly broad comprising three different activities, it is dubbed the holistic definition of market engineering. Covering all three aspects is way beyond the scope of this book. Instead the attention is restricted towards the design activity of market engineering.

[139] For instance, Ledyard describes the working assumption of mechanism design as follows *“The analysis [of mechanism design] has usually been carried out under the working assumption that infinite computing capacity is always available. Any computation required of the individuals or of the system can be instantaneously and correctly completed”* (Ledyard 1993).

Whenever market engineering is mentioned in the sequel, it refers to the following more narrow notion.

Definition 14: Market Engineering

Market engineering is the engineering design of all institutional rules of an electronic market.

This narrow working definition resembles the market engineering definition of Shmuel Oren, who regards market engineering as the goal-oriented development of market institutions: *"Such development should be viewed as "Market Engineering" which builds on the "physics" of markets explored by social sciences (including economics) but focuses on the harnessing of market forces and human behavior to achieve a desired outcome"* (Oren 2001, 10).[140]

Different than Oren's view, Definition 14 conceives a broader institution, which corresponds to the EMS framework. Apparently, market engineering according to Definition 14 can be can be interpreted as the generalization of market design. In fact, this generalization entails that market engineering is endemic interdisciplinary. For instance, software engineering and management issues enrich the economically founded market design. In contrast to market design, market engineering – understood as engineering design of institutions – is also concerned with the development and evaluation of *methods for the design*.

4.1.3.1 Market Engineering as Design Problem

Both market engineering definitions are apparently behavioral definitions, as they describe the activities of a market engineer (Lewis and Samuel 1989). Engineering design of institutional rules is, in essence, a complex problem solving activity. In the following, it is envisioned to pinpoint the market-engineering problem, i.e. the problem that market engineering tries to solve.

The term problem is one of those basic and all-embracing words whose meaning is generally accepted without close examination. There are, nevertheless, a variety of different problem types. Problems in general do not exist in a vacuum, but arise when agents perceive an objective, but not the means of attaining it (George 1970; Lewis and Samuel 1989). In the attempt of achieve this goal and to maintain conditions at a desired level of performance, the problem-solving engineer basically has to conduct the three major activities of engineering design, operation and research.
The emphasis of market engineering is, however, on design as a form of engineering problem solving. It follows that the market-engineering problem entangles with the design of the prerequisites for an electronic market service in a way that a specific value proposition is offered. This problem description is, nonetheless, still very vague and thus inapplicable. Again a look back to the microeconomic system framework and the associated mechanism design theory may help to clarify the market-engineering problem.

Principally, the market-engineering problem resembles the mechanism design problem. While mechanism design is concerned with the design of trading rules, market engineering pertains to the design of the composite institutional rules. Both approaches set the rules in a way that the design objectives are satisfied. The design objectives of market engineering and mechanism design may, nevertheless, not be congruent.

[140] It should be noted that McCabe, Rassenti and Smith use the term Market Engineering for the study of institutions by means of laboratory experiments. As such it covered by the holistic definition of market engineering (McCabe, Rassenti et al. 1993).

To recapitulate, the mechanism design problem can be formulated as the identification of a mechanism such that the equilibrium outcome satisfies the given objectives or desiderata, which are expressed by the evaluation function $U(X,e)$. The evaluation function values the outcome attained by the mechanism in a specific environment e. This formulation is more general (and abstract) than the previous one given in chapter 2.2.1.1, as it not only regards the preference profile but also all other arguments of the environment.[141] Now mechanism design seeks to describe mechanisms (M,y) that maximize the evaluation function U subject to three constraints. The first constraint, the incentive compatibility constraint, requires that the agents truthfully report their information about their local environment. In such a case, the outcome X is the same as if a benevolent arbitrator would have chosen the outcome on the basis of the full information about the environment. The second constraint, computational compatibility, refers to the complexity of the outcome function y. Outcome functions can be very demanding concerning computational tractability (Ledyard 1993; Rothkopf, Pekec et al. 1998; Kalagnanam and Parkes 2003). The computational compatibility constraint assures the feasibility of the applied outcome function. The third constraint, the participation constraint, requires that the agents voluntarily take part in the mechanism. The agents participate if the benefit they draw out of participation is higher than participation in an alternative mechanism. The abstract mechanism design problem can thus be expressed in the Ledyardian form (Ledyard 1993):

$$\max_{(M,y)} \; U(X(e),e)$$

$$\begin{array}{ll} s.t. & \\ \quad \textit{Incentive compatibility} & [i.e.,\ X(e) = y(m)] \\ \quad \textit{Computational compatibility} & [i.e.,\ y \text{ can be computed for all } m] \\ \quad \textit{Participation constraint} & [i.e.,\ v_i(y(m),e) \geq v_i(y'(m),e) \text{ for all } i \text{ where } v_i \text{ is } i\text{'s own} \\ & \text{evaluation of the outcomes } X \text{ in } e \text{ and } y' \text{ is an alternative} \\ & \text{mechanism}] \end{array}$$

As the electronic market framework generalizes the institution definition of the microeconomic system framework, it is analogously attempted to extend the mechanism design problem to the market-engineering problem. Recall that market engineering can take on the two extreme goals: *cost coverage* or *profit maximization* reflecting the cooperative and entrepreneurial spirit of the market firm (recall chapter 3.2.3.1).

Cost-Coverage

For a fixed time period t, it is straightforward to formulate the cost-coverage problem in reference to the mechanism design problem. The cost-coverage-oriented market-engineering problem is to identify a set of institutional rules – including the trading rules but also the media and business rules and so forth – such that the sum of the individual utilities is maximized. In terms of the mechanism formulation variations in the trading object definition are expressed by a change in the socio-economic environment[142]. Apparently, the action space comprising

[141] Furthermore one can account for the fact that mechanisms can work differently in different environments. The general design formulization, following a Bayesian approach, adopts prior beliefs about the probability of any economic environment e in the space of all possible environments E and ranks mechanisms according to their expected valuation (Ledyard 1993).

[142] In chapter 3.1.1.3 a Lancastrian utilization of the utility function was motivated. The argument was that the economic environment has to be stable by definition. In the formulization of the market-engineering problem this definition is implicitly dropped. The reason for this relaxation lies in convenient way to

all feasible design decisions is tremendously augmented. The maximization problem is, however, constrained by four additional requirements. Firstly, the demand for cost-coverage of the market firm, i.e. the market firm's profit must at least be zero or greater. This constraint becomes relevant as market engineering relaxes the assumption of costless provision of the electronic market service. Accordingly, the market firm must recoup these costs through fees, which subsequently diminish the benefit of the participating agents. Secondly, in order to attain a maximization of the sum of individual utilities, it must be guaranteed that the agents only truthfully provide the necessary private information for maximization. Thirdly, the agents must have an incentive to participate. They participate only in the case that taking part yields higher utility than any alternative. Fourthly, as in mechanism design this more technical constraint applies requiring the outcome function to be computationally feasible.
To summarize, market engineering that focuses cost-coverage extends the notion of a mechanism by introducing the environment as a variable through the determination of the trading object definition, including costs and fees and introducing the additional constraint of a cost-coverage compatibility (i.e. costs are not higher than the accrued fees). In analogy to the mechanism design problem, the cost-coverage-oriented market-engineering problem can be formulated as follows:

$$\max_{(M',y),e} \sum_{i=1}^{N} v_i(X,e) - P_i$$

$s.t.$

Cost − coverage compatibility	$[\,i.e., \sum_{i=1}^{N} P_i - \left(F + \sum_{i=1}^{N} C_i\right) \geq 0\,]$
Incentive compatibility	$[\,i.e., X(e) = y(m)\,]$
Computational compatibility	$[\,i.e., y \text{ can be computed for all } m\,]$
Participation constraint	$[\,i.e., v_i(y(m),e) - P_i \geq v_i(y^*(m),e) - P_i' \text{ for all } i\,]$

where

M' =	*Extended Mechanism including not only the trading rules but also the media and business rules,*
P_i =	*Fee charged from the i-th agent for the electronic market service,*
F =	*Fixed costs for the electronic market service,*
C_i =	*Variable costs per agent for the electronic market service.*

Individual utility is again formulated as a quasi-linear utility function as the fees are merely subtracted from the utility drawn from participating in the trade. The action space not only includes the extended mechanism components but also the environment, which accounts for the fact that the market firm can affect the environment through the trading object definition. The costs incurred by running the system can be distinguished into a variable and a fixed portion, whereas it is assumed that the variable costs are induced by the participation of the i-th agent.

The similarity between the mechanism design problem and this extended market-engineering problem may not conceal that the latter problem is much more complex as it widens the action space.

formulate the market-engineering problem with designable trading object definition rules and its structural resemblance with the mechanism design problem.

Profit-Maximization
The entrepreneurial formulation of the market-engineering problem looks, in contrast, different. The goal of the market firm in time period t is to identify a set of institutional rules – including the trading rules but also the media and business rules and so forth – such that the profit of the market firm is maximized. All extensions that were introduced for the cost-coverage version also apply to the profit-maximization problem. Nevertheless the maximization problem is different, as some constraints become meaningless. Rather than making entry into the system, a probabilistic function of the net value, the probability that agent *i* participates in the electronic market provides maximum utility.

$$\pi_{it} = prob\{ v_i(y(m),e) - P_i \geq v_i(y'(m),e) - P'_i \, | \forall y' \in S \setminus y \}$$

In other words, the i-th agent chooses to trade in the electronic market if the expected utility associated with trading in this market is higher than trading in any existing alternative (electronic) market described by the set S.[143] The maximization problem of the market firm is then as follows:

$$\max_{(M',y),e} \quad Profit_t = \sum_{i=1}^{N} \pi_{it} P_i - \left(F + \sum_{i=1}^{N} \pi_{it} C_i \right)$$
$$s.t.$$
$$\text{Computational compatibility} \qquad [\text{i.e., } y \text{ can be computed for all } m]$$

The market firm just strives for maximizing their own profit. As the utility of the participating agents is no longer subject to maximize, incentive compatibility is no longer a binding constraint. From the market firm's point of view, it is secondary whether the agents report their true private information. The main objective is rather to promote participation. The participation constraint is, furthermore, incorporated into the objective function via the participation probability. The contribution of agent *i* in time period t to the market firm's profit is weighted by the probability that this agent does not find a more attractive trading venue. The maximization is of course also constraint by the feasibility of mechanisms.

Remark 4.1-1: Biased electronic market

The previous market-engineering problem definition refers to a neutral market firm, meaning the market operator is not actively engaging trade on its own platform. In many business-to-business electronic markets, the operator is the decisive or even the only participant on the buy or sell-side. In those cases the market firm is suspected to fleece on the other participating agents. In those cases the objective function would also incorporate the net utility of the market operator as trader. The choice of the institutional rules would also depend on the trading interest of the market operator.
It is rather obvious that the profit-oriented formulization of the market-engineering problem differs from the traditional mechanism design problem. The numbers of the decision variables as well as the objective functions are different. And there is another – though not yet mentioned – difference. Market engineering is concerned with multiple resource allocations. Hitherto market engineering was defined as a one-shot allocation at time period t. To view the market-engineering problem in its totality one has to integrate the profit function over time.

[143] This formulization adopted here assumes a quasi-linear form that is dependent on the outcome and the fees only. This assumption is only for convenience; an extension to other arguments such as preferences concerning employed mechanisms, inclusion of time-dependency or effects such as lock-ins is possible.

Remark 4.1-2: Multi-product electronic markets

The term multi-product electronic markets points at the fact that electronic markets are not restricted to a single product for which a trading facility is offered. Instead, the market firm usually provides trading venues for many products. The market-engineering problem is in such cases clearly affected, as there may be substantial economies of scope. In fact, the provision of an additional electronic market service is in essence not as expensive as the establishment of the first service, because the trading platform can be reused (Bakos 1991). Thus, trading in more than one product also affects the market-engineering problem.

The profit-oriented market-engineering problem reflects a simplified optimal service design problem (Karmarkar and Pitbladdo 1995; Pullman and Moore 1999). Extensions concerning capacity, capacity improvement, non-linear pricing, marketing and so forth are also possible (Dewan and Mendelson 1990). As profit-orientation and cost-coverage mark two extremes, the actual market-engineering problem is approximately somewhere between optimal service design and mechanism design.

4.1.3.2 Challenges of Market Engineering

Having formulated the market-engineering problem, it is now the question how the market firm can solve this problem. Solving the market-engineering problem already marks the shift from science to engineering. *The focus of the market firm is not to acquire knowledge about the phenomenon but to use the existing knowledge to construct an electronic market service as a solution to the problem*. Clearly, the construction without knowledge is more of a guessing game. Market engineering is thus deeply interested in understanding how markets work in order to come up with adequate solutions.

The market-engineering problem is apparently a very complex problem. The difficulties stem from the environment, the institutions and, notwithstanding, their interdependence: Institutions indirectly influence the outcome by affecting the behavior of the participating agents, who subsequently determine the outcome. The direction and the impetus of the effect the institutions has on the behavior are dependent on the environment. The challenges of market engineering can thus be characterized as mastering the institutional rules in a turbulent environment (Neumann, Holtmann et al. 2002c).

Engineering the design of the institutional rules in order to direct agent behavior is extremely difficult to attain because *details matter*. Any small change in the institutional rules can totally turn agent behavior into a diametrically opposing direction. For example, remember Example 2.1-17, where Roth and Ockenfels show that small changes in the closing rule, ceteris paribus completely change the bidding behavior (Roth and Ockenfels 2002). Instead of submitting almost exclusively bids in the last seconds of the auction, as it is common on the commercial auction market eBay, the agents avoid this late bidding behavior on the alternative auction market Amazon. Both auctions share exactly the same trading rules except the closing rule. But this small change in the institutional rules suffices to alter bidding behavior. The fact that details matter not only refers to the trading rules but also to the other institutional rules. For example, details of the media rules also affect the perceived utility of the electronic market service. Technology acceptance models (TAM) try to capture the effects of technology on the participation behavior (Haynes and Thies 1991; Atkins 1998; Stafford and Stern 2002). It is to note that knowledge about the pure effects of the single rules on agent behavior is not enough to design the electronic market, since the institutional rules are inherently interdependent. This complexity requires that the impact of the composite of the institutional rules as a whole must be evaluated instead of parts of it.

Furthermore, the size of the design space, i.e. the collection of all conceivable institutional rules that can be generated, entails that the market-engineering problem is necessarily ill-defined. In literature it is often demonstrated that the design space of an extremely restricted set of trading rules is already extremely huge (Bulow and Roberts 1989; Wurman, Wellman et al. 1998; Neumann, Holtmann et al. 2002c). Suppose that six rules – including the offer language – are sufficient to fully describe the trading rules of a certain class of electronic market services. That is any service must define an offer type, an opening rule, a closing rule, a domination rule, a choice, and, lastly, a transfer rule. If the market designer has five different proposals for any of these six rules at hand, already 6^5 = 7,776 different electronic market services can be constructed. Since all of those 7,776 services are principally relevant a well-defined market-engineering problem would suggest that the market designer knows the functional relationships between the institutional rules combined to a service on the agent behavior. As details matter, it is difficult to obtain simplifications. The problem is further aggravated when also the other institutional e.g. media and business rules, are also taken into consideration.

Engineering design of institutional rules becomes even more cumbersome due to the fact that institutions are sensitive to the underlying environment. This problem is already prevalent in the case of mechanism design: If the functional form of agents' preferences is changed, the results of mechanism can alter completely. This sensitivity requires the designer to have a *"Godlike knowledge"*(McElroy 1998) about the environment for which he wishes to design an institution. In this context, Hayek points at the difficulties for a designer to acquire this necessary knowledge from the agents *"[...] to assume all the knowledge to be given to a single mind [...] is to assume the problem away and to disregard everything that is important and significant in the real world"* (Hayek 1945**,** 530). Wilson addressed in his notable doctrine this sensitivity issue by insisting the design of institutions to be detail-free, i.e. independent of distributions or functional forms of the environment (Dasgupta and Maskin 2000).[144] Mechanism design has reacted by shifting the attention towards a robust mechanism design (Bergemann and Morris 2003). For market engineering sensitivity to the underlying environment also constitutes a severe problem: The market designer needs detailed knowledge about the environment. Unfortunately, this profound *God-like* knowledge is – as Hayek's critique addresses – impossible to acquire. Furthermore, the environment is rather turbulent than stable. This turbulence may be briefly illustrated at the example of preference: In their noted paper *"De Gustibus Non Est Disputandum"* Nobel laureates Stigler and Becker assert preference to be stable over time. However, they already conceded that this is not a *"proposition in logic"*, just an assertion about the world. The reasoning is simply that tastes are stable despite effects such advertisement, addiction, or fashion (Stigler and Becker 1977). However, due to the incomplete information about the presence and the uncertainty about the future, it is highly unlikely that these preferences are stable (North 1978; Richter and Furubotn 1997).
When preferences or other parts of the environment are inherently instable, design becomes fairly difficult. As the impact of institutional rules on the agent behavior is crucial upon the environment, a dynamic environment would require a continuous re-design process to adjust to those changes.
However, even without turbulences in the environment and without the knowledge problem market engineering additionally causes a *political problem*. Recall that agents can have different preferences over mechanisms allowing them to rank the mechanisms, starting from the most preferred one to the least desirable. These individual rankings hinge on their demands for factors such as simplicity and immediacy. Assuming various agents with different demands, these rankings will differ from agent to agent. An explanation for this heterogeneity

[144] Harvard Professor Roth dedicates his paper "The economist as an engineer" to the "Dean of Design" Robert Wilson (Roth 2002).

can reflect different trading motives or social embeddedness aspects such as culture or habits. However, mechanisms *„…typically favors one investor group at the expense of another group"* (O'Hara 1997), Hence, not all agents' preferences can be met creating a political choice problem.

Another challenge for market engineering refers to the competitive environment of the market firm. Trading venues are frequently not giving rise to a monopoly. Hitherto the literature of trading venues in competition is a rather neglected field (McAfee 1993; Peters 1999; Santos and Scheinkman 2001). As the neoclassical market structure-conduct-performance hypothesis (Mason 1939; Bain 1968) from industrial organization already suggests, is the success of an electronic market strongly affected by alternative trading facilities. This means that the knowledge about the relationships between a monopolistic electronic market service and its performance cannot be blindly transferred to polypolistic service.

In short, the market-engineering problem is a *wicked* problem. Wicked problems denote a particular class of ill-structured problems that share the following characteristics (Rittel and Webber 1973).[145]

- the requirements can be contradicting,
- the problem may change over time, and
- there is uncertainty whether the offered solution is the optimal solution or *is* even a solution.

This is exactly – as abovementioned – the case in market engineering: Requirements concerning the outcome are contradicting, as different participants have heterogeneous preferences. The (socio-) economic environment can change over time. Even worse, it is not possible to measure the goodness of the institution. Stated differently, the market-engineering problem is aggravated by incomplete knowledge about the impact of institutions on agent behavior by the incomplete knowledge about the turbulent socio-economic environment and by the degree of competition in the market for electronic market services.

For those wicked problems it is virtually impossible to find the optimal solution, because the design space is so large. According to Simon, the design process can terminate once a satisfactory solution is found (i.e. *satisficing*) (Simon 1981).

4.2 A Design Process Roadmap for Market Engineering

In colloquial speech, *design* is loosely defined as a description of *"how to get from here to there"* (Petroski 1992; Loehman and Kilgour 1998). Design is thus concerned with the identification of some solution that satisfies a given set of objectives. If the requirements – the "*there"* – and the specification of the initial conditions – the *"here"* – are given design comprises merely the construction of a solution, which allows the transformation from the initial conditions to a feasible solution that satisfies the requirements. But how can this transformation – the design - be effectively attained?

Knowledge plays an important role in this transformation process (cf. Cross 1999; Tate 1999; Zdrahal, Mullholand et al. 2003). The designer performs a series of activities, in which given inputs are transformed into a solution – the design object. Thus, the transformation basically

[145] Rittel defined even further criteria of wicked problems. The here presented criteria are, however, give a good notion about wicked problems (Rittel and Webber 1973).

depends on the knowledge of the designer concerning design methods and specific domain knowledge. In other words, design knowledge comprises two areas:

- the design process,
- the design object.

The *design process* refers to the organizational environment specifying the *"set of activities by which designers develop and/or select the means to achieve a set of objectives, subject to constraints"* (Tate and Nordlund 1996). The organizational environment is typically expressed in the form of a conceptual model of the design process. In other words, the conceptual model describes in words the sequence of activities that are to performed to arrive at the final solution (Eder 1998; Beckert 2003).

The *design object* refers to the product of the design process. Recall that design strives for attaining a solution, which embodies a specific function. The study of (existing) design objects may reveal a good deal of design knowledge regarding its potential functionality or feasibility. This implies that design naturally entails the use of precedent cases of identical or related design objects (Cross 1999).

The areas of design knowledge naturally consist of design theories, where a theory is understood as *"a network of statements, which, in conjunction with initial conditions, lead to explanations and predictions of specific phenomena"* (Laudan 1996, 83). For example, a design theory referring to the design object may provide a causal explanation, why a design object causes a specific phenomenon under given circumstances. A design theory concerning the design process may for instance explain an observed phenomenon in the design process.

Remark 4.2-1: Design and Science

The notion of design has always created concerns with respect to the relationship of science. In other words, is *"design"* a science or not? In the early sixties it was a rather popular view to distinguish all intellectual activities into three major groups.

- The first group is concerned activities such as gathering data and describing phenomena.
- The second group is concerned with finding connections between the gathered data and setting up testable theories.
- The last group is called reduction-to-practice and comprises all activities that are concerned with application of the general theories and principles to the single instances (Nadler 1967).

Following this view the first two activities are subsumed as scientific research, whereas the last one with engineering design. In other words, scientists try to identify the elements of existing structures, whereas designers try to shape the elements of new structures (Loehman and Kilgour 1998; Cross 2001). Grant underlines this separation of science and design *"Most opinion among design methodologists and among designers holds that the act of designing itself is not and will not ever be a scientific activity; that is, that designing is itself a nonscientific or a-scientific activity"* (Grant 1979, 46).
The aspiration to *"scientize"* design can be traced back to the beginning of the twentieth century (Cross 1969). The term "design science" was originally introduced by Gregory but coined by Buckminster Fuller to mean the development of a coherent, rationalized design method as a scientific method (Gregory 1966; Cross 2001). The reason for the emer-

gence of such a design science was based on the assumption that modern design processes have become too complex so that intuitive methods have become inadequate (Cross 2001).

Whether there is something like a design science remains as the previous quotation exhibits controversial. Though it is less controversial that the study of designing, i.e. study of principles, practices, and procedures, may be a scientific activity (Cross 2001). This stream of *"science of design"* has been clearly stated by Gasparski and Strzalecki: *"The science of design (should be) understood, just like the science of science, as a federation of subdisciplines having design as the subject of their cognitive interests"* (Gasparski and Strzalecki 1990; Cross 2001, 53).

The study of design (or the science of design, see Remark 4.2-1) that supports practitioners thus involves both types of knowledge – knowledge about the design object and about how the object will be designed. The study concerning the design object is traditionally assumed by fundamental sciences such as physics, chemistry or biology. The study concerning the design process is foremost assumed by the discipline of engineering design.

As previously defined, market engineering is in essence an application of the science of design to electronic markets. Interestingly, the study of the design object – the market – is widely accepted, whereas the study of the design process is almost completely missing.[146] This depreciation of design process in science may explain, why market engineering is in practice more of a trial-and-error than deliberate design (O´Hara 1997; Neumann and Weinhardt 2002). This chapter aims at filling the need for a design process model that that empowers market engineers to make rational and consistent design decisions along the entire design process.

Markus and Arch have noted that any design process description consists of two patterns. Firstly, a design process recognizes design methods, which specify the individual decision-making process aiming at the creation of solutions. Secondly, the design process also consists of a management process that structures the design problem and recommends design methods for solution (Markus and Arch 1973). Accordingly, the chapter is structured along those two patterns, design methods and processes. As Figure 15 illustrates, this chapter is primarily devoted to the development of a design process models for market engineering. In the first step, descriptive design process models are reviewed. Principally, there are two types namely activity-based and phase-based models. The evaluation of both types yields that phase-based models are more appropriate for market engineering. Furthermore, market engineering demands for a prescriptive process model, determining how a proper design process should look like. As a matter of fact, there are two general types of prescriptive phase-based models conceivable, namely product- and problem-oriented approaches. The service development process represents the product-oriented version, whereas the engineering design process embodies a problem-oriented process models. It will be shown that the problem-oriented engineering de-

[146] The journal of economic design, the Review of Economic Design, defines in the editorial its aims and scope as follows: *"Economic Design comprises the creative art and science of inventing, analyzing and testing economic as well as social and political institutions and mechanisms aimed at achieving individual objectives and social goals."* Apparently, analysis and design of any kind of institutions are conceived as core activity of economic design. The Journal further specifies these activities: *"These designs, the methods of analysis used in their scrutiny, as well as the mathematical techniques and empirical knowledge they employ, along with comparative assessments of the performance of known economic systems and implemented designs, all of these form natural components of the subject matter of Economic Design."* As such, analysis receives a strong recognition whereas the design process is only stepmotherly treated.

sign process is more genuine for market engineering –albeit issues from the service development process are also useful.

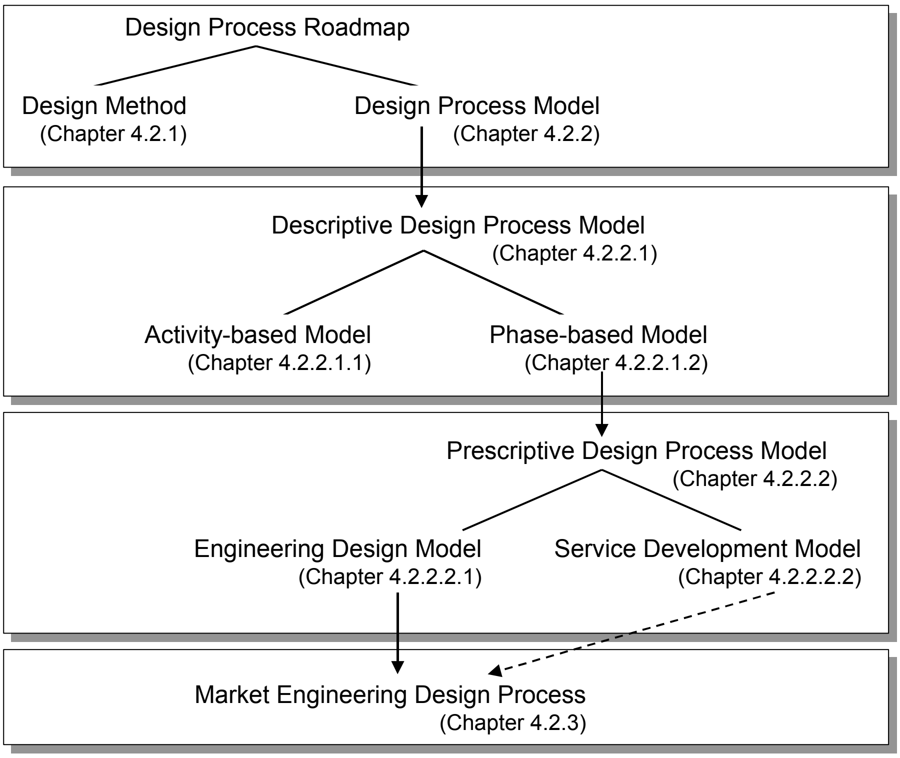

Figure 15: Towards a Design Process Model for Market Engineering

4.2.1 Design Methods

In the engineering context a design method basically refers to a way, procedure, technique, or *"tool"* for solving an individual design problem. This individual design problem is typically concerned with the creation of alternative solutions and a choice. A formal design method is characterized by explicitly prescribing the way, how the design problem can be solved. Principally, design methods can either be *intuitive* or *discursive*. Intuitive methods involve creativity in the forms of fairly complex associations of ideas. Thus, intuitive methods aim at increasing the flow of ideas. Examples of intuitive methods are brainstorming, Delphi-method, or others (Pahl and Beitz 1984). Despite the fact that intuitive methods have been leading to many excellent solutions, a purely intuitive approach incurs major disadvantages. The crux of intuitive methods is that good ideas are not discovered or undiscovered; they just come. As such, the right idea might not come at the right moment. Furthermore are the results of intuitive methods strongly dependent on the expertise, skills, and experiences of the designer. It also cannot be excluded that the intuitive ideas are not already circumscribed by the education and experience of the designer (Pahl and Beitz 1984). At the bottom line, pure intuitive approaches are questionable in complex problems where the engineer can normally not determine the solution intuitively.

It is accordingly often preferable to use discursive approaches instead. Discursive methods are formal design methods that specify the reasoning pattern of how to proceed when to solve a design problem (Clancey 1985).[147] As such, they describe the strategies to solve the individual design problem. Principally, they rely on heuristic knowledge, which is either derived by means of logic or empirical observations. Since the reasoning is formalized, discursive meth-

[147] A discursive design method can be understood as problem-solving method.

ods typically render reproducible and consistent solutions. Empirically it can be shown that discursive methods are usually employed in situations that are associated with (Maffin 1998):

(1) lead-time pressure,
(2) high product complexity,
(3) high design capability requirements, and
(4) high technical performance and reliability.

As such, discursive design methods are at heart of any design endeavor, as they provide the transformation of the problem into a solution. Examples for discursive methods are in the area of product design notable methods such quality function deployment (Hauser and Clausing 1988) or Taguchi methods have emerged (Cross 1993). Furthermore, in the area of artificial intelligence many design methods have been developed that structure the design problem into basic tasks and provide strategies for solving those basic tasks (e.g. parametric design) (Schreiber, Wielinga et al. 1994).

4.2.2 Design Process Models

For complex design problems intuitive methods may fail to achieve satisfactory solutions. It is likely that not a single design method solves the entire but parts of the design problem. Accordingly, a design strategy is necessary that decomposes the complex, ill-structured overall problem into several smaller, less complex problems. Problems are not tackled in their totality but transformed into smaller problems. For those smaller problems "stronger" design methods may exist that solve them.[148] As such, the design strategy applies a deliberate, step-by-step procedure to aid the designer in the matching of the unique problem situation along the overall design process with the available design methods (Grant 1979). Since the design strategy intends to describe the processing along the design process, it is subsequently called design process model. The design process model thus contains:

- the identification of activities or phases by explicitly defining their inputs and outputs, and
- the provision of tools and rules (i.e. design methods) to guide the designers in performing the activities.[149] The use of design methods is thereby not limited to discursive design methods. On the contrary, experience has shown that intuitive methods are stimulated when embedded in a step-by-step procedure (Pahl and Beitz 1984).

The advantages of systematic, step-by-step design process models are comparable with those of discursive design methods: they produce in general valid solutions that are reproducible. Furthermore, the management of the design process can be tremendously improved, as the systematic approach allows the construction of a reliable time schedule. Correspondingly, the prediction of how much time and resources must be spent can be precisely stated. The improved time-management can reduce the overall process time by means of waiting time reduction or activities synchronization. Overall, the cost management of any complex design endeavor will be eased, as budgets can be assigned to single steps of the approach. The systematic approach also makes the standardization of the specifications and methods possible. This way experiences gained in previous design projects can be reused in subsequent projects. With the standardization also an optimization and rationalization of the steps can be attained.

[148] The better structured the problems are, the more powerful are the applicable design methods (Newell and Simon 1976).

[149] Hence, there is a clear difference between design process models and design methods. Design methods facilitate the solution of an individual design problem, whereas design process models guide the management of the overall design process (Maher 1990; Cross 1993).

Standardization is also necessary for an integrated computer-support that in turn can result in quicker development time, and better solutions.

In literature, two types of design process models are typically distinguished (1) descriptive and (2) prescriptive models (Finger and Dixon 1989). The distinction refers to the following *"Some […] models simply describe the sequences of activities that typically occur in designing; other models attempt to prescribe a better or more appropriate pattern of activities"* (Cross 1994**,** 19). While descriptive models describe the reality, prescriptive models try to theorize a normative pattern, which may improve overall design. This distinction is fairly weak as descriptive models can also be used to prescribe a design process. Both types of models contain knowledge about the design – the distinction between those models is that prescriptive models evolve from the application of some design theory, whereas descriptive models reveal tacit design knowledge of designers.

Market engineering essentially requires a prescriptive design process model. This follows from the observation that the design object – the institutional rules – are too complex to design them simultaneously. Recall that the market engineer has to design six different institutional rule types (i.e. transaction object definition, participation, trading, business, media and enforcement rules), where the design of one rule type constitutes a complex software engineering project (i.e. the media rules). Ad-hoc methods may be inappropriate taking the importance of the design into consideration. Failures in the design of the institutional rules can force the market firm out of business. Faced by competitive pressures the market firms are forced to accelerate their market engineering time. Simultaneously the costs of the engineering process are to be minimized, yet assuring that the quality of the resulting electronic market service remains consistent. These ambitious goals, acceleration, *"minimal"* costs and consistent results of market engineering underline the demand for a dependable and prescriptive engineering design process model.

As aforementioned, currently there does not exist a prescriptive design process model for market engineering. As such, it is strived for deriving an appropriate process model. However, there does not exist a discursive method that supports the derivation of a design process model, i.e. design process model engineering. The working plan of this book is thus based on intuitive observations followed by incremental changes to existing design process models. To do so, state-of-the-art descriptive design process models are analyzed and compared against each other. The comparison is thereby guided by the question whether the descriptive model can be useful for prescription.

4.2.2.1 Descriptive Design Process Models

Principally, the number of various design process models that have been covered in literature is simply huge. In many times these deviations between the single models are very small. This stems from the fact that there is an inherent order concerning the sequences of activities. For example, any design task starts with a problem definition. Then, a possible design description is identified, which is subsequently evaluated. Deviations occur mainly in the process of revising a previous design description or the design requirements (Maher 1990).

One central characteristic concerns the definition of the process either structured along activities or abstract phases (Tate and Nordlund 1996). This characteristic can be used to distinguish the design process models into two categories: activity-based models and phase models.

4.2.2.1.1 *Activity-Based Models*

One popular view in literature assumes that the design process can be decomposed into three sub-activities, each represented by a step (Grant 1979; Tate and Nordlund 1996). Figure 16 illustrates activity-based design process in more detail. In essence the stylized process model matches the version that was introduced by Asimov, who divided the design process into three steps analysis, synthesis, and evaluation (Asimov 1962).

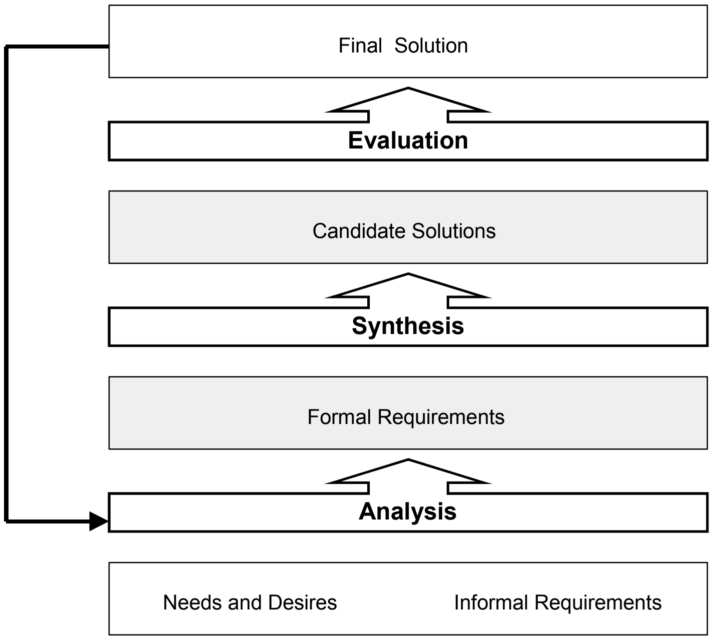

Figure 16: Cyclical Analysis-Synthesis-Evaluation Model

<u>Analysis</u>

The inputs of the design process are the needs and desires and the informal requirements concerning the solution, i.e. what features must the solution satisfy, and which are the disturbing features? Step 1 comprises an analytical task, which identifies the problem class. In other words, the design problem is analyzed and transformed into operational, formal requirements.

<u>Synthesis</u>

Step 2 comprises the original synthetic problem of constructing the solutions. In particular, step 2 always involves creativity concerning the generation of candidate solutions. As the set of candidate solutions can become extremely large or even infinite, the generation of all feasible solutions may in many cases not be attainable. Thus, in order to solve synthetic problems the use of further domain[150] knowledge, e.g. precedent cases in a specific domain, can delimit the design space. In other words, domain knowledge imposes structure on the design problem and can hence help to simplify the synthesis in two ways. Firstly, it may allow the generation of a restricted set of candidate solutions, which excludes infeasible or unpleasant solutions. Secondly, domain knowledge may simplify the control of the search through the large design space.[151]

[150] A domain denotes some area of interest. Example domains are chemical processes or securities trading.

[151] One could argue that in case of extremely well structured problems there are methods that simply compute the solution without the use of any search. However, here the view of Chandrasekaran is supported, who regards such methods as degenerated cases of search, where at every point of the design process sufficient knowledge is available to make the correct decisions (Chandrasekaran 1990). From an implementation point of view there is of course a distinction between those methods and search.

Evaluation

Finally in step 3, the decision concerning the final solution is made. This decision is guided by the appraisal of the candidate solution against the requirements.

Any activity-based model necessarily comprises these three core activities that are iterated. Due to these predominant activities, the activity-based process models are frequently dubbed analysis-synthesis-evaluation model (Maher 1990).

The activity-based sequencing of the activities is rather intuitive. Design process models are, however, also intended to provide tools or design methods that can support the designer in performing the activities. As such, the design process model ideally suggests for any activity a design method or a tool, e.g. configuration method, parametric design, etc (Kusiak and Wang 1993; Motta and Zdrahal 1996; Wielinga and Schreiber 1997).

Example 4.2-1: Design Process Model and Problem-Solving Methods

The integration between design process model and (design) problem-solving methods is exemplary depicted according to the generate-activity (synthesis step). This step is selected because designers often make use of ad-hoc methods in a trial and error way. Although it is indisputably easier to select from a set of inadequate candidate solutions, the real challenge of design lies in the creation of better solutions. *"There should be a shift [...] in our approach to problems – a shift from searching for the best way between unsatisfactory answers to searching for a better answer"* (Nadler 1967, 644). Hence, a discursive method that supports this task may contribute to improvement along the design process.

Chandrasekaran distinguishes three groups of *proposal methods* for generating restricted design spaces by the use of domain knowledge: (1) decomposition (2) case retrieval (3) requirement[152] satisfaction (Chandrasekaran 1990). The complexity of the design process can be tremendously reduced, if the creative process of generating the design space (step 2) is simply replaced by one of the three *proposal methods*.

- Decomposition
  In this case domain knowledge is used to map the problem or parts of it into several sub-problems that are treated as a separate design task. The corresponding solutions are subsequently recomposed into a solution for the original design problem. The re-composition can be aggravated by the complexity of the problem. Consider the following scenario: two solutions of sub-problems are connected in the final solution for the design. In order to connect them, certain pre-conditions and post-conditions might need satisfied. These conditions may a-priori not be available. In those cases the recomposed solution must be checked whether it satisfies these newly introduced conditions.
  Another issue concerns the order in which the sub-problems are in a given decomposition attacked. The primary determinant of the order pertains to knowledge about the dependencies among the sub-problem. If the sub-problems are totally independent, a sequential approach appears to be possible (Chandrasekaran 1990; Maher 1990; Kusiak and Wang 1993).
- Case retrieval
  Case retrieval refers to case-based reasoning in design. It involves the solution generation by using already-completed solutions from previous design problems as a basis. The de-

[152] In artificial intelligence frequently the difference between requirements and constraints is emphasized. As this discussion is of more theoretical nature, this book uses the term requirements only.

sign strategy simply suggests choosing a solution to already solved design problem that resembles the current design problem most. The primary problem of case retrieval marks – no wonder – the matching of the problems: which already-completed solution is the closest to the current problem?
Apparently, case-based reasoning has a lot in common with analogical reasoning. Analogical reasoning, i.e. finding the appropriate related cases, *"is at the heart of design creativity"* (Chandrasekaran 1990**,** 65).

- Requirement satisfaction
  Requirement satisfaction suggests an approach to design in which the initial set of requirements is mapped into a solution. That means the solution is located in the space determined by several requirements; computational algorithms, such as linear, integer or dynamic programming techniques, can detect this space.

4.2.2.1.2 Phase-Based Models

Phase-based models assume a top-down hierarchical approach to design processes. The core problems are firstly treated on an abstract, high level. Then, the solutions of a previous phase are progressively refined to more detailed solutions until the final solution is reached. As such, the approach can be characterized as coming from the abstract to the detailed design. Principally, any phase constitutes in turn a design process, which can be represented by the analysis-synthesis-evaluation process. The difference lies in the different level of abstraction, which increases as the design process progresses until the detailed final document is reached (Pahl and Beitz 1984; Hubka and Eder 1988; MacPherson, Kelly et al. 1993). Though individual models may differ, phase models are usually divided into four parts (Eder 1998).

Planning and clarifying the task
The product idea that is to be designed is specified as requirements and constraints.

Conceptual Design
The design problem is abstracted and decomposed. For any sub-problem an abstract solution is produced, which are integrated into a concept. The concept is evaluated in terms of economic and technical criteria.

Embodiment Design
The concept of the product is elaborated in the form of a preliminary layout. As such, embodiment design bridges the gap between the abstract concept and the detailed solution.

Detail Design
In the last phase all details of the solution must be generated. Also the final economic and technical feasibility of the solution can be re-checked. Furthermore, all necessary production documents are finalized.

When the design process is strictly linear, a clear border between the phases can be drawn. However, iterations are most likely and accordingly blurring away those clear borders.

4.2.2.1.3 Comparison

Activity-based and phase-based models typically characterize state-of-the-art design process models. But what model type appears to be superior? Which one to take? These questions can be answered referring to the list of criteria Tate and Nordlund compiled (Tate and Nordlund 1996). Basically, the criteria specify desired characteristics any useful design process must explain or predict, or allow for explanation or prediction (Tate and Nordlund 1996). The desiderata comprise the following key characteristics

Desiderata	Description
Decision Making	The general purpose of a design process is to achieve a decision concerning a solution that solves a design problem. As such, the design process requires clear decision points and criteria.
Performance Measures	The performance of a design process is evaluated in terms of the used resources time and costs along the design process.
Iteration	Typically, the design process must allow for iterations. When a failure occurs, the designer must have the possibility to fall back to a precedent activity. As such, similar activities may be performed at different times.
Sequence of Activities	The design process must also explain or predict the sequencing of activities. The activities can thereby sequenced in different ways in order to allow for flexibility in the design process.
Levels of Scope and Abstraction	The design process model is usually concerned with problems “on multiple levels”. As such, the design process model must cope with problems that have either a different impact on the overall design (i.e. some problems have a greater impact on the design than others) or a different level of abstraction.
Information management	Information about the design object is generated and collected and forms the basis for subsequent decision-making. This information can furthermore be stored for subsequent related design problems.

Table 5: Desiderata for Design Process Models

Embattled with those criteria the weaknesses and strengths of the two types of models can be analyzed (Tate and Nordlund 1996; Tate 1999).

Activity-based models

The greatest strength of the activity-based models is the emphasis of decision-making. In the evaluation step, the candidate solutions are assessed concerning their match with the requirements. As the steps of the design process model are clearly defined, it is principally possible to measure the performance of the single design steps in terms of used resources and the time. Although some activity-based models explicitly incorporate iterations of activities (cf. Gero 1998), activity-based models usually recommend repeated iterations of all three activities (Tate 1999). This also implies that activity-based models cannot cope with iterations of the same activity, which may be necessary when the problem is on multiple levels (Tate 1999). As such, activity-based models lack flexibility in sequencing the activities. Lastly, the process yields information in the form of factor lists, or partial and combined solutions.

Comprising, activity-based models are especially strong in supporting the decision, which candidate solution is selected. Their weakness concerns the flexibility of sequencing the activities. Suppose the design problem is complex and the design object consists of many parts. Then, the activity-based model suggests designing one part at a time. As one part affects the design of another, backtracking must be possible. However, the activity-based models only allow iterations after the evaluation. Apparently, activity-based models are vulnerable to complex design problems.

Phase-based models

The greatest strength of the phase-based models concerns the information that is produced along the design process. Firstly, information about the design object is available in its progression from the abstract to the detailed. Secondly, the amount of information that is produced increases with the progression of the design process. Another great strength of phase-models is that the solution generation during the conceptual design phase is decoupled from specific solution details. As such, the understanding of the design problem is moved to the very beginning of the design process.

As the understanding of the design problem is emphasized, phase-based models are especially useful for complex design problems. The complex design problem is firstly abstracted and conceptually solved. It is thus independent of design details that exert a good deal of the design complexity.

Opposing Tate's opinion, the phases of the model are clearly bordered (Tate 1999). Any phase ends with a decision concerning either the concept, or the preliminary or the definitive layout (Pahl and Beitz 1984). Those boundaries are, however, blurred if iterations occur. Nonetheless, it is possible evaluate the performance of the single phases in terms of resources and time.

The greatest weakness of phase-models concerns – as aforementioned – iterations. When the designer is forced to reiterate a phase, the subsequent detail information must be revisited. As such, iterations are highly undesirable. However, empirical studies have shown that the design process is characterized by zigzagging making the process highly iterative. Prescribing a phase model is thus often criticized to be of inferior value, as the designers anyway do not use such methodology, as it hinders creativity.

Conclusion
Having stated the pros and cons of the two types of design process models, it becomes apparent that neither model satisfies all desiderata. On the one hand, activity-based models are suspected to be vulnerable to complex design. On the other hand, phase models are too idealistic (no iterations) to trace the progression of design. The conclusion to dismiss design process models as inadequate since the designers will not exactly stick to the process is certainly oversized. Design process models seek to structure the design process and can thus only work as a general guide – the exact procedure will vary from project to project. Nonetheless these models *do* provide general guidance, which is more effective than ad-hoc or intuitive methods. As market engineering is an inherently complex design task, it is referred to phase-based models.

4.2.2.2 Prescriptive Design Process Models

Descriptive design process models are often criticized, because they can only partially describe the design behavior of designers in the field. The list of criticism concerning prescriptive models is even longer. On major criticism for example questions the concept as a whole: *"if any conceivable strategy, list of operations or route is permissible in finding a solution then none of them can be prescribed as mandatory"* (MacPherson, Kelly et al. 1993**,** 480). Other criticism concerns the prescriptive power of the models. As any design process follows in different ways than predicted, process models are often dismissed as inadequate. Bucciarelli thus concludes that to *"anyone interested in process, these diagrams shed very little light on how design acts are actually carried out or who is responsible for each of the tasks within the various boxes"* (Bucciarelli 1994, 112-113). Those criticisms are, however, overstated. Prescriptive models are essentially structuring the design process (MacPherson, Kelly et al. 1993). The proposed sequences of activities along the phases are meant as a general guide not as law. They are heuristic, because the use of the design process model requires interpretation by the designer. This need for interpretation stems from the fact that the process models are formulated at an abstract level to be applicable for a variety of the design problems. But even if the process is properly applied, success is not guaranteed. The structuring of design process is intended to improve the process in a way that it is more efficient and effective than intuitive, unaided ways of designing.

This idea also motivates the development of a process model for market engineering. The market-engineering problem, as stated in chapter 4.1.3.2, is extremely complex. Accordingly, market engineering is not a theoretical *"end in itself"*, but a strategic weapon: The institutional rules – understood as service prerequisites – affect the goodness of the electronic market service that is generated along the market process in interaction with its customers (recall chapter 3.2.2.4). Failures in the configuration of the institutional rules as service prerequisites can even force the market firm out of business. Faced by competitive pressures, market firms are forced to accelerate their market engineering time. Simultaneously the costs of the engineering process are to be minimized, yet assuring that the quality of the resulting electronic market service remains consistent. These ambitious goals, acceleration, “minimal” costs, and consistent results of market engineering, demand for a dependable and prescriptive engineering method.

In the following two sub-chapters two examples of phase-based models are presented. As such, they are closely related on an abstract level. The first model is taken from the discipline of engineering design. Basically, the use of this model assumes that any design process is essentially a problem-solving method. The second model is taken from the discipline of service development. This model is more specific and detailed than the engineering design model. It is chosen because market engineering is a service development problem. Having presented both models, they are compared whether they are adequate for market engineering.

4.2.2.2.1 The Engineering Design Model

In engineering design the study of phase models has a long tradition and much research has been undertaken into streamlining the design process. Already in the 1850s the Karlsruhe professor Redtenbacher pioneered some of the earliest recorded ideas on the principles of machine design (Redtenbacher 1852; Pahl and Beitz 1984; Wallace and Blessing 2000). More than half a century later again a German scientist, Erkens, introduced the first step-by-step approach. Systematic design approaches became popular during the 1950s and 1960s. Several phase concepts with different phases and steps for different domains were identified. Furthermore, the research focus was on analyzing specific steps and, particularly deduce recommendations how to tackle upcoming problems within the single steps (Wallace and Blessing 2000). In the 1970s the emphasis was on the development of an engineering approach that is domain-independent, i.e. generally applicable to all design problems. The Anglo-Saxon approaches stressed, in contrast to the German problem-oriented approaches, a more product-oriented point of view. The product-oriented approaches propose intuitive methods to generate the product idea and later on discursive when the idea is stepwise refined to the final product. The emphasis of the problem-oriented approaches is, in contrast, on the concept generation. This concept generation links the identified requirements for a product (i.e. the problem) with mathematics and science and creates a concept, which is intended to provide the desirable outcomes (Parkinson and Hudson 2002). As the concept generation is one of the most demanding and least understood parts of the engineering process, problem-oriented approaches are considered to bear additional potential. Accordingly, the editor-in-chief of the journal, Research in Engineering Design, Blessing notes that product-oriented approaches exemplify best practices in design, whereas problem-oriented approaches propose way to improve those best practices (Blessing 1996; Wallace and Blessing 2000).

In the following the engineering design approach is illustrated in more detail. As the problem-oriented approach promises to be the more potential approach than the product-oriented approach, only an example of the former approach will be discussed. However, the engineering processes are rarely defined in exactly the same way by authors. Hence it will be referred to one of the most cited engineering process provided by Pahl and Beitz (Pahl and Beitz 1984; Eekels 2001; Pavkovic and Marjanovic 2001).

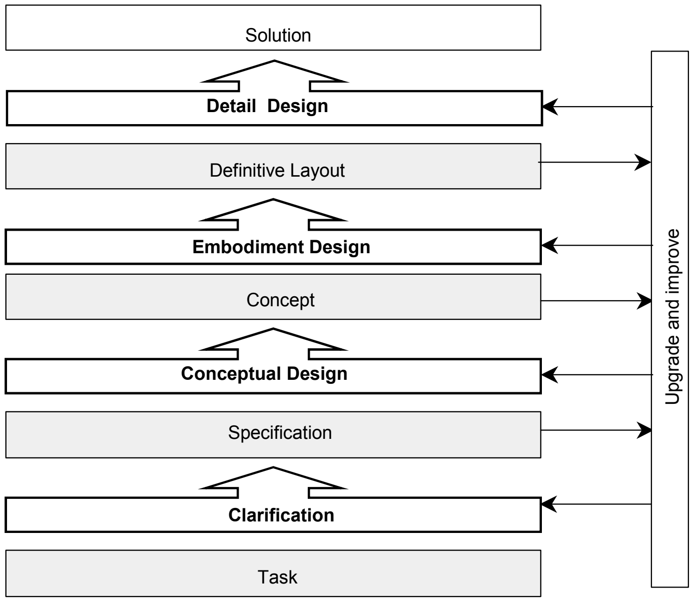

Figure 17: Engineering Design Process (Pahl and Beitz 1984)

Figure 17 shows the steps of the canonical engineering process. Basically, the phases are exactly the same as the ones in the phase-based model. What differs is the way, how the phases are performed. While the descriptive phase-based model merely describes design as a *"from the abstract to the concrete"* process, the engineering process model by Pahl and Beitz prescribes, how the design steps can be solved.

As with any phase-based model, the market engineer has to make a decision, whether the process is to be continued or whether previous steps have to be repeated at any step if the process. Those iterations are necessary in order to improve upon previous decisions. Ideally, the iterations are kept to a minimum, although it must be avoided to hurry through the process only to discover that serious mistakes have been committed at an earlier stage. It is to note that one important decision has been omitted in Figure 17, namely the prevalent decision to stop the development due to cost reasons. Furthermore, Figure 17 does not include prototypes. Prototypes provide the engineer with helpful information, which can be needed at any point at the engineering process. As such, they do not fit into a particular time slot (Pahl and Beitz 1984).

Clarification of the Task

Every engineering activity commences with a particular problem. Presumably there are requirements that the solution must meet. Note that these requirements may not be stable over time. For the engineer it is important to understand the problem in its totality, in order to find the "optimum" solution. From the beginning, the task needs a clear and comprehensive definition so that amendments in subsequent steps are limited. The clarification step is accordingly concerned with the gathering of information about the requirements a solution must satisfy. The result of this step is a full specification (i.e. a requirement list) of the design problem. The specification ideally comprises four components: Firstly, the specification contains a list of the objectives and performance criteria as well as their relative importance. Secondly, it also comprises a list of the resources that are available such as time, space, budget, employees, specific knowledge and also physical facilities. Thirdly, the specification defines the boundaries of what is to be designed. Lastly, it also specifies a list of sub-problems that may occur during the design process.

Conceptual Design

In the conceptual design step, the artifact that is to be designed, say a machine, is described on an abstract level. The machine is subsequently regarded as a system that is connected to the environment by means of inputs and outputs. This system – representing the machine– can be fully depicted on the basis of its functionality, i.e. the relationship between the inputs and outputs. In technical domains the relationship between the inputs and outputs is rather deterministic. For example, it is usually expected from a machine to produce identical outputs for identical inputs. In non-technical (especially in social) domains this relationship is naturally less deterministic. Either way, those relationships are subject to a thorough design in order to meet the previously gathered requirements. The relationships can be represented by a function. At this stage of the engineering process there is no need to specify what solution embodies the function. The function apparently constitutes an abstract version of the artifact, e.g. as previously the machine, that is independent of any particular solutions.

Furthermore, the *overall function* explains the behavior of the entire system, by expressing the relationships on the aggregate level between inputs and outputs. Depending on the problem, the resulting overall function will be either more or less complex. Complex overall functions are characterized by nontransparent input-output relationships, by intricate processes that are necessary or by high numbers of components involved. Reducing complexity, the overall function can be divided into several sub-functions that are less complex. The combination of all sub-functions yields the function structure, which in turn represents the overall function.

During the step of conceptual design the function structures of the problem are established. Then, the appropriate solution principles for the single sub-functions must be investigated. A solution principle is intended to ease the search for solutions. The functions are hitherto represented more or less as black boxes with no link to particular solutions. Now these black boxes are replaced by combinations of physical effects and form design features that can constitute such a function.

- Physical Effects
  In engineering design the emphasis is on physical processes: *"nearly all engineering solutions are based on physical phenomena"* (Pahl and Beitz 1984, 26). Accordingly, most functions can be fulfilled by means of physical processes, which are in turn based on physical effects. Sometimes more effects have to be combined in order to satisfy a function.
- Form Design Features
  The functions can also be satisfied by the arrangement of surfaces or the choice of motions. In this case, the shape and the type of a surface may meet the function. For example, a car wheel receives its function through the form of the wheel and through the material.

Both components together form a solution principle. Basically, a solution principle must reflect the (physical) effects and the form design features required for the fulfillment of the function. In other words, it is searched for an abstract explanation how a solution can satisfy the function. The major ramification of this approach is that the solution space – comprising all feasible solutions – can be confined to the (much smaller) space that can be constructed by varying the applicable physical effects and the form design features.

Usually the reduced solution space still involves numerous solutions. At this early stage of the engineering process those solutions that are theoretically possible but practically unattainable are sorted out. Apparently, this decision, on the one hand, makes the design problem more manageable but on the other hand also bears the disadvantage that "good" solutions are sorted out early in the process. Those solution principles that surpassed the sorting are firmed up into concepts. Firming up comprises the enhancement of the solution principles with more concrete qualitative and also (rough) quantitative information. This information can be obtained by means of simulations verifying the intended solution principles. Up to this point, solutions exclusively focus on the technical function. A concept, however, must also satisfy general constraints such as economic feasibility. Information about the satisfaction of the general constraints also belongs to a meaningful concept. At the end of the conceptual design step the concepts are evaluated against each other and the most promising concept is selected.

In summary, in the conceptual design step the requirements are abstractly stated as functions that are, if necessary, decomposed into sub-functions. For each sub-function a possible solution class is provided from which the most promising solutions are firmed up to concepts. At the end of the conceptual design step the concepts are evaluated according to some criteria and the most appropriate concept is chosen.

<u>Embodiment Design</u>
Having developed a solution concept during the conceptual design step, embodiment design attempts to work out the concept in layouts and forms. In abstract terms embodiment design strives for filling the overall function with an appropriate layout, component shapes and materials.
An overall layout design basically determines the general arrangement and the spatial compatibility of the function carriers, i.e. the entities, which embody the functions. Furthermore, also the form designs, particularly the material, of the function carriers are to be elaborated. Layout and form of the function carriers are stepwise developed taking technological and economic aspects into consideration.
As a matter of fact, the embodiment process is rather difficult, as the resulting layout and form must meet the all the general constraints but still must fulfill the overall function. Thus, embodiment design is naturally characterized by a large number of corrective steps. A typical embodiment design process can be conceived to proceed as follows: the engineer proposes a concrete layout and form for the relevant function carriers. The downstream verification may yield that this layout and form proposal satisfies the technical function but fails in terms of reliability as a general constraint. The engineer has then to identify the design faults and adapt layout and form, which is again followed by a subsequent evaluation. Through these iterations the engineer learns more about the problem and can attain better layout and form solutions.
The definitive layout is reached if the layout design and form exhibits no serious design faults in function or in the other general arrangements (Pahl and Beitz 1984).

<u>Detail Design</u>
Finally the step of detail design is concerned with the completion of the detailed layout and form. That is, all function carriers are fully defined including the definitive selection of the material and a final scrutiny of the production methods and costs (Pahl and Beitz 1984). Furthermore, the elaboration of the details such as the production documents, detailed component drawings, and appropriate parts lists is in the center of attention. The result of the detail design step and also the solution of the engineering design process is the final production documentation.

4.2.2.2.2 Service Development Process

As previously mentioned, the engineering design process is a more general design process that can be used for any design purpose. This approach can accordingly be used for service development as well.[153] However, services literature has bred out a more specific design ap-

[153] Parallel to the concept of *new service development* in America, the discipline of *service engineering* has been emerged in the mid-nineties particularly in Germany and Israel. While new service development is

proach that reflects the uniqueness and peculiarities of the product to be developed – the service. Services are not produced as goods but are generated along the service process. Customers do not buy services like goods, instead they buy solutions to their problem or satisfaction for the desires and needs (Haksever, Render et al. 2000). To provide the service in consistent quality the prerequisites of the service, consisting of the service concept, procedure and system must be deliberately planned. Thus, service development is not left to chance, but is thoroughly designed.

Designing services is not a one-shot endeavor; it is rather a frequently repeating task: A service company must create new services, and improve services that are already in use in order to meet the changing needs of the customers. The success of a services company in the competition hinges on its ability to discover the needs of their customers quickly and, moreover, on the ability to meet those needs with the development of adequate services.

Having the dynamic and competitive environment of service companies in mind, the need for a systematic service development process becomes clear. Coming up with innovative service ideas that meet the actual needs of the customers is a creative activity. Creativity cannot be forced, but by following a systematic approach the risk of product failure are alleviated. The systematic approach helps to address all relevant questions concerning the development of new services that could be easily forgotten in intuitive approaches: Not only is the service concept, i.e. the idea, developed but also the service procedures as well as the service system. These two latter components are in most of the time the hindering factors of a successful launch of new services. Due to a lack of a clear description of the service content, the processes and the necessary resources the successful implementation of a service is heavily impeded (Scheuning and Johnson 1989; Haksever, Render et al. 2000; Bullinger, Fähnrich et al. 2003).

Traditionally, service development had received only scant attention in the service literature (Tax and Stuart 1997). Bowers summarizes this observation as follows *"The single most compelling criticism of the new service development literature is the lack thereof"* (Bowers 1985**,** 42; Bullinger, Fähnrich et al. 2003). In recent years this deficit was tackled by a rising number of publications proposing several more or less sophisticated product development processes. The efforts can be classified into two groups according to their core theme.

1. The first class of themes focuses on the derivation of key factors on the basis of comparisons between successful and unsuccessful new service developments (de Brentani 1995). Those approaches, however, are descriptive in nature and give only little advice how to approach a new service development (Tax and Stuart 1997).
2. The second class of themes comprehends prescriptive planning frameworks to new service development. Several planning frameworks have emerged for the last years (Cowell 1988; Scheuning and Johnson 1989; Edvardsson and Olsson 1996; Ramaswamy 1996).

All these approaches have in common that they origin in the linear planning framework for product development by Booz-Allen & Hamilton (Booz-Allen & Hamilton 1968; Scheuning and Johnson 1989). Linear planning frameworks decompose the planning process into several

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purely marketing oriented, service engineering adopts a more holistic view on service design. In essence service engineering can be understood as *"a technical discipline concerned with the systematic development and design of services using suitable models, methods and tools"* (Bullinger, Fähnrich et al. 2003, 276). Market engineering is apparently a special form of service engineering. However, service engineering is like market engineering a very young discipline. Currently, the precedent disciplines engineering design and service development are more mature and currently offer more detailed insights into special problems. As market engineering is devoted to the special problem of designing electronic markets, the general approach of service engineering does not yet provide answers to those problems. As such, market engineering founds more on the originally engineering design and service development.

phases that are linearly proceeded one at a time. Those approaches differ with respect to at least three issues. Firstly, the terminology among the different approaches varies considerably, although the underlying notion of the phases is too a large extent alike. Secondly, the approaches distinguish themselves by the degree of their formalization. Some approaches are highly elaborated and formal while others are very simple and informal. Thirdly, the different approaches vary in their prospected way through the phases. Some approaches prescribe that the phases must be followed in strictly linear way while others allow phases to be repeated. In short, the differences among those approaches are not as compelling than the similarities (Cowell 1988).

In the following, the service development approach from Scheuning and Johnson is presented. The approach is chosen as it provides a rather detailed view on the development of new services and thus accounts for the additional complexity that services adhere. The entire process is divided into 15 different steps that can be grouped into four stages: direction, design, testing, and introduction (cf. Figure 18). For comparison, traditional product development approaches consists of at most seven different steps (Booz-Allen & Hamilton 1968; Scheuning and Johnson 1989). Nevertheless, all 15 steps may not be necessary for any service development. Much will depend on the characteristics of the new service, the competitive pressure or on the time and resources that can be spend (Cowell 1988).

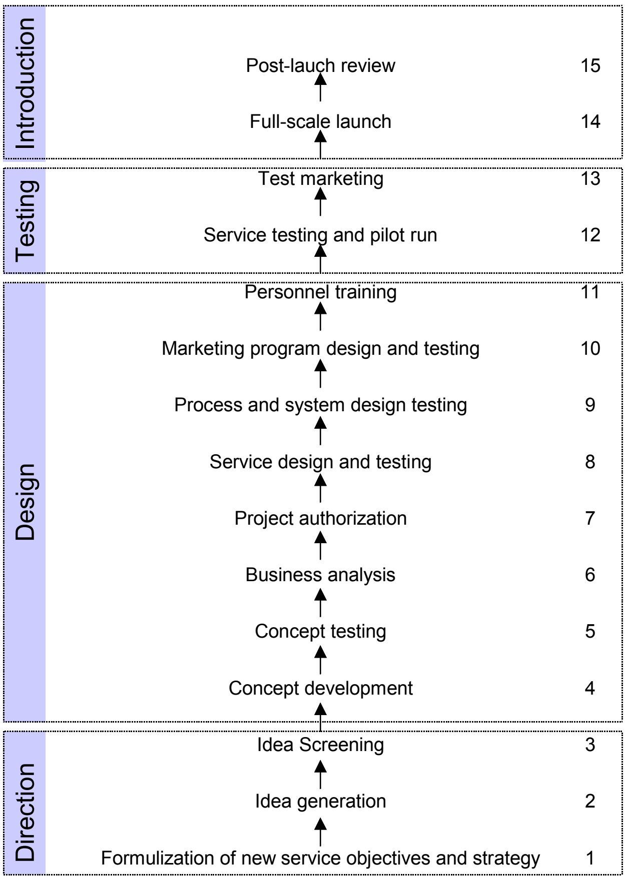

Figure 18: Service Development Approach (Scheuning and Johnson 1989, 30)

Sometimes the approach by Scheuning and Johnson is specified as a linear framework, but in fact it constitutes a phase-based model, which allows for iterations. Feedback loops are not only possible, but also even necessary to cope with the complexity of the service development process. As such, iterations can occur at any step of the process (Scheuning and Johnson 1989; Tax and Stuart 1997).

Direction

The first stage commences with determining the direction of the development process. As depicted in Figure 18, the first stage consists of three primitive steps: The process starts with a concise formulization of the objectives and the strategy of the envisioned development process. In other words, it must be clarified what customer needs are to be targeted. At this stage the service company can principally configure new services and/or address new customer groups. Either way, this definition of the customer needs and the corresponding strategy must take place before ideas for its fulfillment are generated. Scheuning and Johnson paraphrase this as follows:

"Driven by a sense of urgency and a perceived need for the "quick fix" many service firms jump right into idea generation. Doing this is akin to lifting anchor without first determining the desired direction. The course of the ship then becomes the result of whim and happenstance" (Scheuning and Johnson 1989, 28). Self-evidently, the service development strategy must be derived from the corporate objectives and strategy.

Subsequently in step 2, ideas for the fulfillment of the objectives are generated. Sources for idea generation can be drawn from internal (e.g. employees) and external sources (e.g. customer - in particular from their complaints, suppliers, competitors). Not all of these generated raw ideas are adequate for the operation as a service. Thus, in step 3 the raw ideas are crudely screened and evaluated. Only the most promising ideas in terms of feasibility and projected profitability are kept.

Design

Steps 4 to 11 comprise the original designing effort of the service prerequisites including the service concept, procedure and the system. The design of services is a rather intricate process as the number of individual steps within this stage already indicates.

At the outset of the design stage, step 4, the ideas that survived the sorting are firmed up to a fully-fledged service concept (conceptual design). As previously mentioned (see chapter 3.2.2.3), the service concept comprises the value proposition of the service. For rectification purposes the reason why this particular new service is under consideration to be offered is also attached to the service concept.

Having established the potential service concepts, the most appropriate ones are to be extracted. Under the label of concept testing in step 5 the service concepts are evaluated on the basis of buyers' responses. Potential buyers are asked, whether the service concept is conceivable for the prospective users, whether they appreciate the service, or, whether the service delivers a benefit that corresponds to unsatisfied needs. Service concepts that fail to convince the customers are subsequently eliminated. The step of concept testing actually poses a very high hurdle for the concepts. Only few concept proposals are intended to surpass the strict sorting out.

In the previous steps the service concepts are only analyzed from a customer-oriented point of view. In other words, the value proposition for the customers stands at the beginning of the development in center of attention. In step 6, the business analysis enriches the service concepts with business models. The attention shifts from the value proposition to the analysis whether the service company can earn a decent profit with the operation of the service concepts. As such, business analysis includes a market assessment, demand analysis, revenue and cost models. On the basis of this information, the top management of a service company can decide over the implementation of the service concepts.

The most critical decision along the development process occurs at the project authorization in step 7. The top management has finally to decide which service concept will be implemented. This decision coincides with the commitment to assign resources of the service company to the development process.

The steps 8-11 following the authorization decisions strive for converting the service concepts to operational practice. In terms of engineering design those steps are comparable with the embodiment design. The service procedure and system needs to be installed in a way that service procedure and system have the potential to implement the service concept. Apparently, this gives rise to a design approach, which is characterized by much iteration, revision, and redesigns. Step 8 is concerned with elaboration of a detailed service description. Basically, this description must convey how the new service differentiates itself from the competitors'. In step 9, the service procedure and the service system are planned and evaluated. This step is demanding, as several interdependent factors have to be taken into consideration. One major factor refers to the extent the customer is involvement in the service production process, as the encounter with the customer must precisely be planned. Another important factor is concerned with the design of the service system. The resolution of the questions what technical equipment and which personnel are needed for the service delivery is subject to conscious design. A useful tool supporting the service designer is a service blueprint. Basically, a service blueprint provides a "holistic" view on the service procedure, and can be compared with a definitive layout. Displaying all the activities involved with the service provision, it allows the evaluation – especially through value and failure mode analyses – before costly implementation (Shostack 1984). Having surpassed the evaluation, the service is implemented. Before the service is offered to public it is tested internally. Adaptations and step-backs are at this point of the service development process possible and, moreover, even most likely.
In step 10 the marketing program for the introduction and, if applicable, for the distribution of the service has to be planned. Simultaneously the circumstances of the sale have to be planned and arranged.
Before the service can go online, the employees must be familiarized with the new service. The designer must accordingly choose the appropriate personnel for delivering the services. Then, the selected personnel must be properly trained. Step 11 is – especially in people-based services – extremely important, as the introduction of a new service often fails because of the inadequate training of the personal (Scheuning and Johnson 1989).

Testing

The purpose of service live testing in a pilot-run (step 12) is twofold. Firstly, the service testing is intended to infer information about the customers' acceptance of the new service. A live testing procedure with few consumers allows the service company gathering information from first-hand. Necessary adjustments in the service concept, procedure, and systems can be undertaken. Secondly, live testing also demonstrates whether the service provision is smoothly functioning.
In step 13 test marketing examines the scalability of the new service by the use of field experiments. Those field experiments are larger-scaled than the live testing pilot run in the previous step. Test marketing allows the service company collecting information upon the market reaction upon the use of alternative marketing mix options. For example, the reaction of the test-customers on different prices can be evaluated. On the basis of the field experiment the service company can finalize its marketing program.

Service Introduction

Having completed all refinements and also the tests, the service is offered in step 14 to the entire market. Subsequently the service provision is subject to a post-launch review, which evaluates the degree to which the operating service meets the intended objectives. Refinements are even at this point possible.
This last step, however, is not meant to be the ultimately last step in the development process. Reviews should be regularly conducted opening the way for the service re-development process.

4.2.2.2.3 Comparison

The two systematic approaches taken from engineering design and service development obviously differ in many respects. Being phase-based models, the stages of the approaches are to a certain extent akin – but their emphasis is not: *"The design process and several of its stages are almost universally included, albeit with different accounts of the process"* (Devon, Bilén et al. 2003, 7). In the following, it will be investigated, which approach is more appropriate for market engineering.

The engineering design approach is basically a problem-oriented approach. In other words, the approach is focusing not on the product to be designed but on an abstraction of the product. The emphasis is thus on the problem, not on the analysis and evaluation of the initial product ideas. It is the utmost strength of the problem-oriented engineering design approach to offer a discursive process to gradually convert the problem into a concept. Different levels of abstraction (e.g. function, solution principle and form) help the designer in this challenging conversion task during the conceptual design phase. The conceptual design phase is unanimously among the most demanding steps in design work and indeed the whole engineering (Hubka and Eder 1988). As a matter of fact, some of the methods and tools that support the conversion of the problem into a concept are among those at least understood (Wallace and Blessing 2000).

The engineering design approach is also subject to discomfort, as the problem is always of abstract nature. Being a pure abstract-to-concrete process, it accordingly offers no reference to the original product idea.

The service development process constitutes itself as a product-oriented process. As such, it focuses on the analysis and evaluation of the generated ideas. Furthermore, it emphasizes the conversion of the product ideas into fully-fledged concepts by a systematic step-wise refinement process. The generation of the ideas is, however, not discursively supported but result of intuitive methods. The reason for this omission is not derogatory but the belief that the idea generation is not a problem (Easingwood 1986). Cowell summarizes this service development point of view representatively as follows: *"For most service companies generating new ideas is not a problem. Inside the business the most common source of ideas will be the marketing function. It has constant contact with competitors and with customers through the sales reports and market research receives regular information on changing customer environmental requirements"* (Cowell 1988, 300). The great strength of the service development approach is the omniscient reference to the product to be designed – the service. At any step of the process the peculiarities of services are directly addressed. Another advantage of the service development process is its inherent interweavement with marketing aspects. Alternative marketing mix options of how to offer the service are planned concurrently with the service concept, procedure, and system.

Compared to the problem-oriented approach of engineering design, the product-oriented service development process mirrors how designer actually design. This, however, makes this approach look inferior to problem-oriented approaches, as the latter have the potential to provide other than conservative ideas. In other words, product-oriented approach replicates current practice, while the more abstract problem-oriented approach can improve current design. This perception is also shared by service literature: *"Many ideas though are conservative. They often focus most on geographical extensions, "me too" ideas or upon minor modifications to the main service packaging"* (Cowell 1988, 300).

Both approaches are comprehensive, albeit two critical aspects may be easily overlooked. Firstly, both approaches focus primarily on the design of a new product. In practice service companies are rarely providing only a single electronic market service, instead they offer a variety of services. As such, the approaches have also to account for the interdependencies between the new service and the existing service portfolio. Secondly, service development has a strong social connotation. Not only are the needs and demands of the buyers and sellers on the electronic market relevant but also the needs and demands of all stakeholders.

The service development process is harmed by the fact that the levels of the design process model are mixed up. More precisely, the process lists phases and also activities. For example, "concept development" is a phase that corresponds with the conceptual design phase in the engineering design. With this phase many activities have to be performed, e.g. generation of alternatives and appraisal thereof. On the other hand, the service development process lists also activities such as "project authorization" or "post-launch review".

Overall, the engineering design approach suggests bearing the greater potential being a problem-oriented process. Furthermore, the engineering design process is assumed to be more mature providing many design methods and guidelines. The service development process is in contrast more descriptive as it gives rather scantily advice, what design methods to use. On the other hand, the service development process addresses service-specific insights into the domain "service" that are per-se missing in the engineering design context.

4.2.3 Towards Prescriptive Market Engineering

The discussion suggests adopting a blend of both approaches for market engineering. This blend is, however, asymmetric, as the engineering design approach gives structure to the process, stressing the *problem-oriented*, abstract-to-concrete character of the approach.[154] The choice of the engineering design approach allows the explicit anchoring of two fundamental desiderata in the market engineering process:

(1) utilization of economic models in the design process and
(2) the use of behavioral and cognitive models to determine the needs and requirements of the potential customers.

The first desideratum is very powerful, as it allows the integration of economic modeling in the market engineering process. Market engineering is hence not neglecting prior work on the field of economic design, but can incorporate it in the process. Recall that economic design is essentially concerned with social effects in markets derived from the analysis of abstract resource allocation mechanisms. Analogous to engineering design that deduces solution principles on the basis of physical effects, market engineering can make use of the social effects[155] to derive solution principles. The second desideratum is also of great importance in the design of electronic market services, as it primarily addresses social issues with many different customers involved. As such, the engineering design template is additionally enriched by elements of the service development process. Those elements peculiar for services are principally covered within the (domain-independent) engineering design process but they are refined such that they receive more attention.

[154] Being a phase-based model the service development process also embodies an abstract-to-concrete character but is this disguised by additional phases that often move marketing activities on the level of phases.

[155] Social effects are here defined very broadly as all regularities that depend on specific interpersonal interactions.

Figure 19 sketches the higher-level phases of the market engineering process (Weinhardt, Holtmann et al. 2003). At the outset of the market engineering process stands the new service objectives and the strategy that governs the market engineering approach. In the first stage – the "clarification of the task" – the requirements of the new electronic market service are deduced. This step is other than in engineering design dubbed environmental analysis, as it comprises the specification of the environment, i.e. who are the potential customers, what are their preferences, endowments and constraints? As a result of the environment analysis, the designer is given the information about the requirements of the potential customers and of the market firm. The design and implementation stage is more or less a container for several design phases. Following the engineering design process, the design stage is decomposed into four major phases being the conceptual design, embodiment design, detail design and implementation. The peculiarity of market engineering process is embedded in the stage "design & implementation", which embodies the phase-based engineering design approach. Having implemented the appropriate electronic market service, it is tested upon its economic properties and its operational functionality. Those services that surpass the testing are subsequently introduced into the market. At any stage of the market engineering process there is a decision, whether to proceed with the next step or better to repeat the prior one. The use of prototypes is again possible at any stage of the process, such that they are left out in the picture.

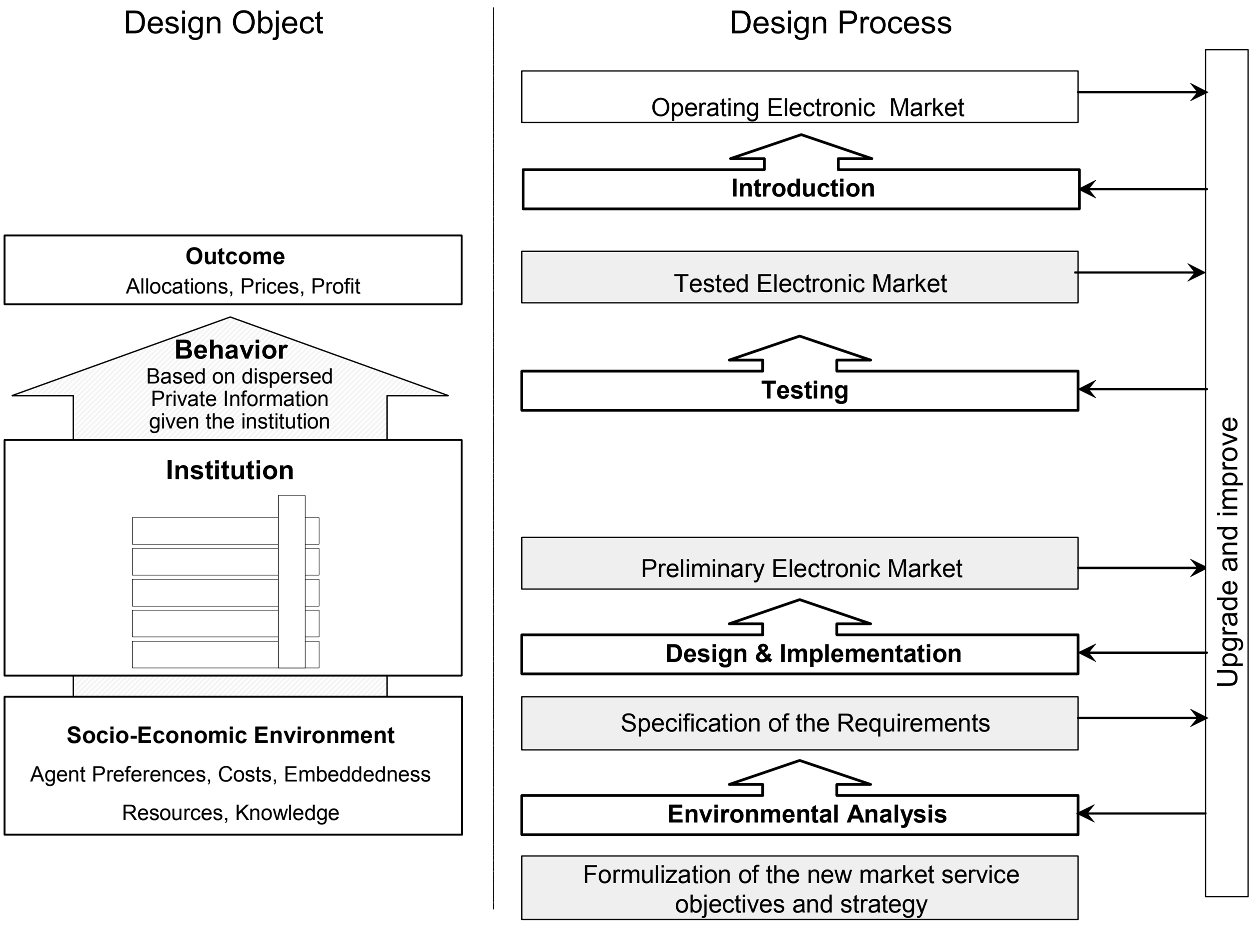

Figure 19: The Stages of the Market Engineering Process

Figure 19 also sketches the EMS framework in the right panel. Basically the EMS framework directly corresponds to the design process. Point of origin is the socio-economic environment, which is independent of the designer.

To set up an electronic market service, the conscious designer must be aware of the environment in which he wants to implement a new market service. After the environment analysis the design and implementation stage is triggered in which the designer has to set up

1. the service concept (what value proposition is the service to deliver?),
2. the service procedure (how do the institutional rules except the media rules look like?) and,
3. the service system (how do the media rules – the software system – looks like?).

As such, those three phases result in the design of the institutional rules. Finally, the newly developed electronic market service is evaluated in laboratory experiments or by numerical simulations. Testing simply verifies whether the agents are behaving as they were intended. Thus, the testing hypothesizes an outcome of the environment-institution combination.

Upon success the electronic market can be released to operation. Apparently, the market engineering process can be linked directly to the electronic market framework, i.e. engineering object.

4.3 A Design Process Model for Market Engineering

The short overview in the previous chapter is way too short to be helpful as prescriptive design process model. This shortcoming is remedied by a more thorough description of the process model. For simplification the prescriptive design process model for market engineering is in the sequel dubbed market-engineering process.

4.3.1 Elements of the Design Process Model

When design process models are developed the levels of analysis must be clarified. Phases are different than activities and likewise are their implications different. Activities can be supported by design methods that can be in turn distinguished into operations. For a better understanding, phases are furthermore aggregated into stages. Comprising, the design process model presented here defines stages, phases, activities and operations.

Stages

A stage describes one of a series of steps one above the other. In other words, a stage is an aggregate description of phases in the course of design. Stages are linearly surpassed. Having approved the finishing of one stage, the subsequent stage is initiated. Iterations between stages are possible, but principally costly, as they entail to discard the previous results of the downstream stage.

Phases

Phases are the main elements of the design process model. According to Merriam Webster's online dictionary a phase is defined as *"a distinguishable part in a course"* (Merriam-Webster 2002). Those phases are intended to give more structure to the rather general stages. Phases are also linearly passed one at a time. Having finished a sub-phase, it is determined, whether the next phase is or an iteration of previous sub-phase(s) is initiated. In turn, iterations are also costly, but, as the phases deal with different levels of abstraction, they are indispensable.[156]

[156] Note that the real creativity results from the *"zigzagging"* through different levels of abstraction (Tate 1999).

Activities
Phases are prescribing sequences of activities. Activities specify the operations that are recommended to pursue in order to solve specific design problem. For example, *"alternative generation"* denotes an activity that consists of one or more operations. Activities can be concurrently or linearly sequenced. Iterations and loops occur rather frequently. In contrast to phases, one a small number of participants are involved in activities. Activities can be supported by discursive or intuitive design methods.

Operations
Operations are the lowest level of abstraction. They denote atomic actions that are to be taken along the design process. Operations are principally interdependent and overlapping – iterations between operations are common.

As market engineering marks a complex design problem that requires numerous different operations, it is beyond the scope of this book to drill down to the operations level throughout the entire process. A design process model is, however, useless for prescription if it remains on the phase-level (see the Service Development Process). Accordingly, there is a trade-off between being superficial and too detailed. This book tries to follow a *"balanced"* way demonstrating the entire process down to the activities level (the remainder of this chapter) and selected aspects on the operations level (chapter 5).

4.3.2 Stage 1 – Environmental Analysis

The environmental analysis stands at the outset of the market-engineering process. This first stage is being triggered within the market firm by the formulization of the objectives and the strategy. Market engineering is not a stand-alone activity, but embedded in the market firm's corporate strategy. This deduction may enable the market firm to obtain a balanced fit between the new and the existing electronic market services.

Objective of the environmental analysis stage is twofold: Firstly, the identification of a promising market segment for which an electronic market service is considered. Secondly, the analysis of the requirements potential adopters may have regarding the electronic market service. Corresponding with the engineering design process, this stage comprises two different phases: the environment definition and the requirement analysis.

4.3.2.1 Environment Definition

The central intuition of the environment definition phase is to pinpoint the environment for which subsequently the electronic market service is offered. The environment definition is clearly a marketing action. To systematize the phase more thoroughly, the environment definition is divided into three subsequent activities:

1) Market Definition,
2) Market Segmentation, and
3) Market Targeting.

Firstly, the relevant market is being defined. In other words, the market firm is carving out the arena in which it is going to compete for business (Fennell and Allenby 2003a). The market definition thus comprises information about the potential market participants, their geographical positions, their specific needs, and so forth. In short, the market definition[157] characterizes

[157] The terms market definition, segmentation, and targeting have been established in marketing for a long time. As such, these terms are also used in this book, although the definition of the term "market" is not

the demand-side for the electronic market service that is eventually determined by the definition of the trading object.

Secondly – having defined the relevant market – the market firm divides the defined market into several segments. The division into segments is intended to disaggregate total demand into smaller pieces of demand. The smaller pieces of demand are ideally of homogenous nature such that it is easier to fine-tune the electronic market service to the needs of this market segment (Smith 1956; Fennell and Allenby 2003a).

Thirdly, the market segments are evaluated against each other. As a result, the target market consisting of one or more market segments is selected (Hlavacek and Reddy 1986).

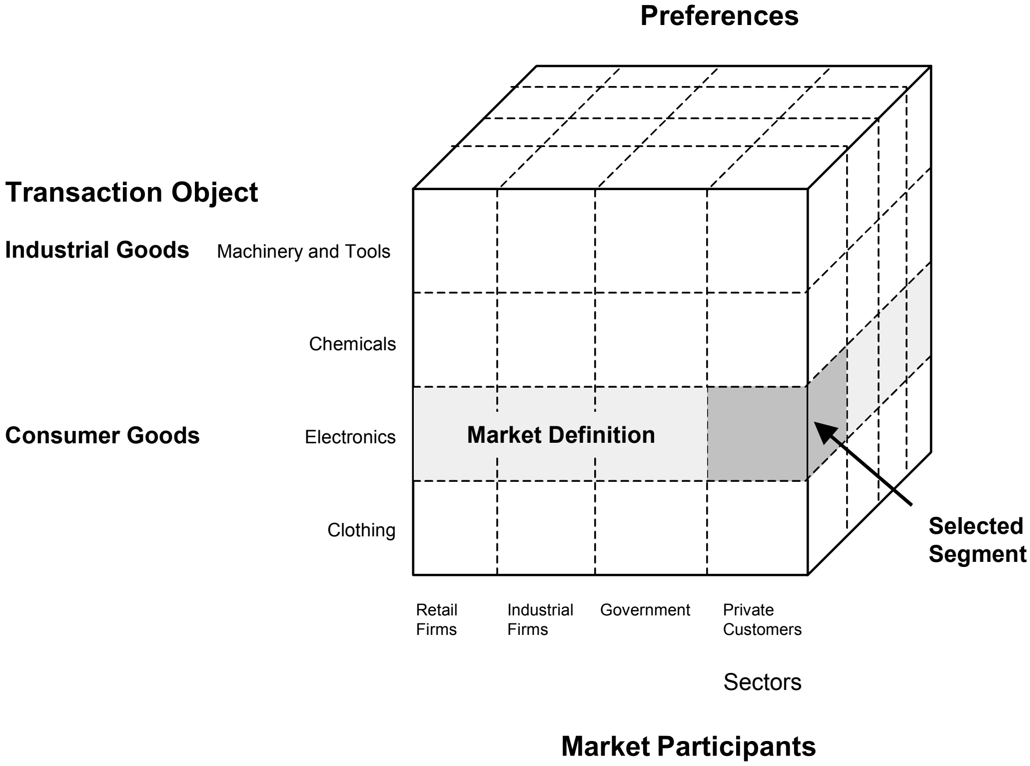

Figure 20: Environmental Definition

The intuition behind those three steps can be visualized by the means of the *"socio-economic environment cube"* (cf. Figure 20). The cube depicts the space of all conceivable environments by the three dimensions trading objects, market participants and their demands and needs (Budimir, Holtmann et al. 2001). For example, the environment (i.e. demand and supply situation) for electronics is different than for chemicals. Inside the segments – depicted by the mini-cubes – the preferences, i.e. the specific needs, are assumed to be homogeneous.[158] Depending on how the market is defined, the segments may either exhibit heterogeneous preferences or may not exist. For example, when the slice is made over the transaction object or the participants, it is obvious that the needs and desires are different: The needs concerning an electronic market for wastewater may be different than for stocks. Alternatively, when the slice is made over the preferences, then – per definition – needs and demands are alike for all electronic trading venue. However, it may happen that the cube is representing no agent. Via market segmentation the plane is divided into several segments. The market firm then selects

exactly corresponding with the institutional definition given here. What marketing literature addresses with the term "market" is the environment, whereas the institutions are left out.

[158] The granularity of the cubes depends on the referring analyst.

the desired target group with homogeneous demand, which reflects the identification of a mini-cube.

4.3.2.1.1 Market Definition

In market engineering the market definition is of eminent importance, as it describes the environment in which the market firm chooses to engage in (Brandt 1966; Fennell and Allenby 2003b). As such, the market definition provides the starting point for all analysis and planning activities concerning the trading, business and media rules – it is thus the foremost activity of market engineering.

Principally, there are various criteria that could be used to define the relevant market. For example, in the marketing literature usually geographical or product-oriented definitions are proposed. Geographical definitions, e.g. the European market, correspond to specific environments – in our example the "European" environment. Agents that live outside the specified region are not part of the environment and are consequently left out. Stated as a product market the market definition determines the environment, which consists of all firms and offerings that offer comparable products. Those criteria can, obviously, be combined for a more precise market definition (Fennell and Allenby 2003b; Fennell and Allenby 2003a). As an environment is defined over the three dimensions being products, participants, and preferences, there are the following strategies to perform the market definition:

(i) Market definition over the trading object definition

Commonly, in market engineering the trading object definition reasons the market definition. Any market definition corresponds to a specific environment, but this correspondence is initially unknown. The less specified the market definition is the more complex will be the corresponding environment. Defining the trading object is, however, a difficult endeavor *"selecting the commodities which will be traded is often the most difficult part of the design process. Sometimes a resource allocation problem has an obvious breakdown into commodities. Other times there are many ways to slice the resources into commodities, with no clearly superior treatment"* (Wellman and Wurman 1998**,** 119-120).

(ii) Market definition over the participants

Alternatively, the market definition can be determined by selecting potential participant groups. In other words, the market firm chooses a promising participant group and attains thereby the market definition. For example, the market firm may choose banks as their target customer groups. In many cases the selection of the participant group is too broad to be of any help. For example, the definition may comprise participants to be women between 20 and 25; the corresponding markets are unknown, as the information about the environment does not suffice to identify a market ad-hoc. As such, the market definition is often supplemented with a (more or less specific) definition of the trading object (i.e. blended market definition).

(iii) Market definition over the preferences

Thirdly, the market definition can be performed over the preferences. In other words, participants with equal needs and desires concerning the electronic market service are used for the market definition. This may be a relevant strategy for market firms who already have established a running electronic market and want to penetrate in a market with the same preference profile. But again trading object definitions often enriches market definitions over preferences (i.e. blended market definition).

(iv) Blended market definition
Lastly a combination of the above strategies is also possible.

Comprising, most market definitions comprise the trading object definition either in a clear way e.g. stocks or generically. For the market definition it is to note that it is definitely of advantage if the market firm has deep knowledge about the industry for which it intends to set up an electronic market service (Sawhney 1999a). In those cases the market firm has at least a rough idea about the real resource allocation problem and can appropriately react. On the other hand, it is also appealing to establish electronic market services for other unknown or even non-existent domains. For example, markets with innovative trading objects such as emission certificates may offer wide opportunities. It is, however, difficult to analyze the corresponding environment, as a "market" may not exist. Alternatively those markets with innovative trading objects such as wastewater or water can already exist but are (natural) monopolies (Beecher 2000; Seidenstat 2000).[159] Setting up electronic markets services to foster competition must not take the needs of the incumbent monopolist but also those of future entrants into consideration. As future entrants may not be aware of their needs, the premise of *"make what customers want to buy"* is extremely difficult to implement.

The market definition is certainly a decision task. The decision should be supported by discursive methods. However, as traditional marketing frequently omits this activity (which is astonishing, since marketing deals with markets but neither define them!) (Fennell and Allenby 2003b; Fennell and Allenby 2003a), it is referred to the methods that are used for segmentation market research analysis methods (Baker 2001; Dolan and Ayland 2001).

In summary, market definition plays a primary role in this early stage of the market engineering process. By explicitly imposing boundaries on the socio-economic environment it provides the context for succeeding activities. Market segmentation for example, simply requires an explicit definition of the underlying market.

4.3.2.1.2 Market Segmentation

The market definition only sketches a rough picture about the market, which the market firm intends to serve. Market segmentation divides the defined market into several segments. Marketing literature regards market segmentation as *the* key decision area (Wind 1978; Dibb 1999). The term market segmentation was coined by Wendell Smith's influential article, which introduced the concept of segmentation that *"[...] is based upon developments on the demand side of the market and represents a rational and more precise adjustment of product and marketing effort to consumer or users requirements"* (Smith 1956, 5). In other words, the fundamental benefit of market segmentation is that it allows the firm to tailor their marketing program to the needs of the customer segment (Nagle and Holden 1995; Kotler 1997; Dibb 1999).[160]

[159] Legal barriers in many times protect those natural monopolies. Setting up electronic market services in those markets, thus, requires beforehand liberalization. Those legal issues are, however, not covered.

[160] Particularly pricing is more effective if tailored to specific market segments. An easy example may illustrate this: A pricing strategy with only a single tariff bears an inefficient compromise, since customers with lower preferences may be excluded from buying the good if their willingness to pay is below this single tariff, while customers with higher preferences can attain a positive rent because their willingness to pay is above the tariff (Nagle and Holden 1995). By pricing over segments instead the group with the lower preferences can be served with a lower tariff while the group with the higher preferences can be charged at a higher tariff. Hence offering segmented pricing virtually diminishes the need for inefficient compromises and improves both sale and profit. Pricing is, however, not that easy for example because the individual membership to the market segments is not observable (Wilson 1992; Nagle and Holden 1995).

Basically the concept of market segmentation is intuitively simple, albeit its implementation is not. Unfortunately, there is no generally accepted approach to market segmenting (Beane and Ennis 1987). Table 6 summarizes the segmentation forms that are commonly suggested in literature (cf. Kotler and Armstrong 1998).[161]

Segmentation Techniques	*Description*
Geographic Segmentation	Descriptors for segmentation are geographic details of the customers, such as regions or countries.
Demographic Segmentation	Using demographic descriptors (e.g. gender, age, and so forth) is the most prevalent form of market segmentation. This segmentation theory has limitations when the segments do not clearly exist (Beane and Ennis 1987).
Psychographic Segmentation	Psychographic segmentation is concerned with less conspicuous characteristics of the customers focusing on social descriptors such as way of living or lifestyle. Those characteristics are difficult to operationalize; psychographic segmentation strives for the definition of clear quantitative measures to describe the lifestyle, *"[…] Psychographic research can be defined as quantitative research intended to place consumers on psychological – as distinguished from demographic dimensions"* (Wells 1975, 197). Psychographic segmentation is commonly combined with demographic descriptors.
Behavioral Segmentation	Behavioral segmentation involves behavior-centric descriptors such as purchase occasion, benefits sought, degree of usage etc. In other words, customers are segmented on the basis of knowledge about the product, attitude, or response to the product (Beane and Ennis 1987).
Benefit Segmentation	Segmenting with respect to perceived value or benefit is denoted as benefit segmentation (Haley 1995). The underlying premise of benefit segmentation is that the type of the benefit gives rise to the true market segments. Identifying market segments requires the development of an understanding of the customers' requirements. Experience with this segmentation strategy has shown that the benefits sought by the customers can much more accurately describe the customer behavior than demographic strategies can do (Elliott and Glynn 1998).

Table 6: Segmentation Forms

These segmentation techniques are heavily discussed in general marketing literature, not so in the service literature, as Elliott and Glynn notice *"The treatment of the central concept of market segmentation in the services literature is noticeably a lightweight"* (Elliott and Glynn 1998, 40). Hitherto researchers tend to briefly touch market segmentation and focus on subsequent activities such as targeting and positioning. If covered at all, mostly demographic or geographic variables are employed for segmentation. Taking into account that the customer is also co-producer of the service, it appears to be disappointing that market segmentation does not deserve a more thorough treatment in the service literature.

In market engineering it is principally possible to segment the defined markets using any of the five techniques given in Table 6. However, geographic, psychographic and behavioral segmentations have severe drawbacks that argue against their application. The inherent ubiquity of electronic markets can make a geographic segmentation in many times meaningless. Psychographic and behavioral techniques tend to be more appropriate for firms that offer goods instead of services. As such, market engineering typically relies on demographical or benefit segmentation:

[161] Literature also distinguishes a normative theory of segmentation that strives for optimal choices of segments. Models have been rarely implemented and are frequently ignored by marketing literature pointing at their inherent problems concerning its operationazability (Wind 1978).

- Demographic Segmentation
  The intuition behind the demographical segmentation is that certain customer groups have somewhat more homogeneous needs. For example, in financial trading retail investors have different needs than institutional investors. Nonetheless can the differences between customers of the same group still be significant. Demographic (and also geographic) segmentation techniques *alone* are apparently with respect to market engineering insufficient. Customers are not "using" the electronic market service because they belong to a certain demographic group that shares comparable habits. Instead, they use the electronic market service because it creates value for them. For example, buyers appreciate reverse auctions as these auctions create value for them in a way that the buy prices are gradually lowered due to the competition on the seller side. In this rather general example customers consume this electronic market service because of its perceived benefit.
- Benefit Segmentation
  Thus, for market engineering it appears to be promising to make use of benefit-oriented segmentation as well. Possible descriptors or requirements are for instance fast execution of offers, market impact, liquidity, amount of information disseminated, speed of information dissemination, and so forth (NYSE 2000; Budimir, Holtmann et al. 2001). Using benefit segmentation for customer retention is fairly straightforward if enough data about the customers is available to extract those needs. For market firms the segmentation of customers that already take part in ongoing electronic markets it is presumably easy to gather those data. However, this is different in situations where no ongoing (electronic) markets exist. In those cases the market firm has mainly to rely on demographical data. In this case it is, nevertheless, advisable to obtain more information about the benefits from potential customers.

Example 4.3-1: Traditional versus benefit segmenting

In financial markets it is usually distinguished between private and institutional investors. Broadly speaking institutional investors are characterized by the fact that they trade huge amounts of securities in a professional manner. Private investors are typically less informed and trade smaller packages of securities. If a market firm would traditionally segment into private and institutional investors the segmentation is of limited use, as the groups are still extremely heterogeneous. The so-called heavy traders are, for example, a sub-group of private investors who resemble in their trading behavior more institutional than private investors. A pure demographical segmentation is thus not decisive enough. Segmenting after their trading motive appears to be a better way. Heavy traders are, for example, interested in accruing profit following a *buying low and selling high strategy*. As such, they are concerned about fast execution and real time information dissemination. This brief example shows that customer needs are more appropriate criteria to reasonably segment markets.

In summary, the activity of market segmentation divides the environment that corresponds to the market definition into smaller parts according to some descriptors. In Figure 20 the doted lattice upon the cube schematically represents the result of the segmentation activity.

4.3.2.1.3 Market Targeting

Once identified, the potential segments must be evaluated concerning their validity and their relative attractiveness. Subsequently, the most attractive market segments are selected; this activity is usually dubbed market targeting (Hlavacek and Reddy 1986; Dibb 1999). The first step in market targeting is to check whether the market segments are considered qualifying.

The qualification of market segments is usually regarded as being valid, if the criteria compiled in Table 7 – originally presented by Kotler – are satisfied (Kotler 1997).

Criteria	*Description*
Measurability	Measurability is concerned with the measurability of the size of the market segment. This of course assumes that the market segment actually does exist (Beane and Ennis 1987).
Accessibility	A qualifying market segment must be accessible for the market firm.
Substantiality	The market segment must be sufficiently large and profitable
Actionability	Actionability checks whether the market segment can be effectively reached by marketing programmes.

Table 7: Criteria for Market Targeting

Additionally marketing literature also includes segment stability also as qualifying criteria. Only if the market segments will exist in that form for some time in the future, the market segments are promising for actions to be taken (Dibb 1999). As a matter of fact, many market segments satisfy those criteria and thus qualify for market segmentation. In other words, the qualification criteria are necessary but not sufficient conditions for service. The identification of the market segments that are potentially being served depends on the assessment of the market segments' attractiveness.

Unfortunately, marketing literature has been aiming at the evaluation of the different segmentation methods rather than aiming at the evaluation of the segments itself (Sarabia 1996). Attempts to assess the segments attractiveness guiding the targeting process can be roughly distinguished into three groups:

1. Profit-oriented methods
   The first group of methods seeks to trace (potential) sales revenues to market segments and relate these revenues to marketing costs that are necessary to exploit those revenues (Beik and Buzby 1973). The resulting profit gauge may, however, not be a comprehensive measure for attractiveness.
2. Multi-criteria methods
   The second group of methods can be subscribed as multi-dimensional measures, as they not only contain a single measure such as profit but also other criteria such as segment stability, relative responsive rates and segment size into account (McCann 1974; Sarabia 1996). The relevance of those multi-dimensional measures is, however, diminished by their static nature.
3. Dynamic methods
   The third group comprises all measures, which are not myopic in a sense that they are not only concerned with current but also with future value. For a market firm the customers of a market segment are not merely regarded as isolated transactions with only current value; rather are these customers representing a revenue stream of potential future value. Analogous to the financial concept of the net present value satisfies the need of gauging the market segments' value over time. This move from static to dynamic thinking also implements a long-term *relationship-building* behavior of the market firm (Grönroos 1994; Elliott and Glynn 1998).

As holistic market engineering (design & operation) is principally interested in sustaining success, the methods pertaining to the third group (i.e. dynamic methods) are – due to their dynamic nature – suggested as relevant method for the assessment of market segments.

Having identified substantially attractive segments, the further task of the market firm is to select the most appropriate segments. In fact, this selection constitutes the overall market-targeting task. The primary challenge of market targeting is to obtain a *balanced* customer portfolio (Elliott and Glynn 1998) . The underlying intuition of a balanced customer portfolio lies in the observation that not all customer relationships are worth keeping. Some customers may no longer fit under the current strategy of the market firm due to changes in their behavior and correspondingly in their needs. This may occur because the maintenance costs of these relationships exceed the revenues they generate. Now the goal of a market firm is to obtain a balanced customer portfolio, i.e. an optimal mixture of customers that promises sufficient current profit, adequate future profits and also decent growth perspectives. The selection of the market segment is intended to exactly attain such a balanced customer portfolio.

Finally, once the targeted market segments have been identified the environment definition phase closes initiating the requirement analysis phase.

4.3.2.2 Requirement Analysis

Basically, the target market segment reveals the environment for which the electronic market service is intended. In order to gain potential agents as customers, the electronic market service must match with the particular needs of the agents. The requirement analysis phase consists of a thorough extraction of the potential customers' needs concerning the resource allocation problem and the environmental side-constraints (Byrd, Cossick et al. 1992; Stanoevska-Slabeva and Schmid 2000). In other words, the requirement analysis seeks to describe the socio-economic environment consisting of the (potential) number of agents, their preference structure and risk attitude, the number of resources to be offered, their characteristics, and the agents' endowment. Cramton summarizes this as follows: *"Good market design begins with a thorough understanding of the market participants, their incentives, and the economic problem that the market is trying to solve"* (Cramton 2003**,** sec. 9)

Some of the information is straightforward to extract. For example, the physical consistency of the resources can be obtained simply by observation. However, other information cannot be observed such as the risk attitude of the participating agents. These pieces of unobservable information about the socio-economic environment are difficult to obtain. Unfortunately, this information is in many cases crucial for the design of the institutional rules. For example, trading rules have a diametrically different impact on the agent behavior if they are installed in a private instead of a common value situation (for a recapitulation see Example 2.1-2 and Example 2.1-3). It is thus generally recommended that the market firm knows the industry they want to serve very well, because this knowledge may help in determining the unobservable characteristics of the socio-economic environment. In the absence of own experiences the market firm can try to statistically deduce some missing (unobservable) information from real world data.

Remark 4.3-1: Deciding between Common and Private Value model

The implications of auction theory are very sensitive to the underlying assumptions. In fact, the assumption regarding the structure of the preferences determines in many cases the direction of the effects the trading rules (i.e. the auction rules) have on the agent behavior. Typically, researchers describe the structure of the preferences either by using an independent private (IPV) or the common value (CV) model formulization. Although both formulizations may apply in real world setting, typically researchers consider either the IPV or the CV to dominate.[162] The application of auction theory to real world problems

[162] Mostly researchers choose either the IPV or the CV model, although there is a possibility to include both aspects as the affiliated value model proposes. This is sometimes reasoned by the assumption that one of these effects is dominating (Paarsch 1992). The discussion will, however, not be further covered.

relies on the accurate identification of the dominating model (Paarsch 1992; Armantier 2002). Due to the lack of knowledge and to the fact that intuition may fail, researchers have started to statistically decide which specification is more accurate. Hitherto, three different approaches have been proposed: the first approach relies on structural econometrics and model validation (Paarsch 1992).

This first approach is, however, inaccurate if the structural model is incorrectly specified. Furthermore, the application of structural models is generally limited if only few small samples are available. Unfortunately, both limitations are not too far-fetched, as (1) the distributions of the private preferences are unknown but fundamental part of the specification and (2) the samples are in many times small.

The second approach basically comprises the running of several linear regressions in order to determine the empirical and the theoretical relationship between the number of bidders and the magnitude of the winning bid. If the number of bidders has a positive impact they conclude that the IPV model prevails, whereas a negative impact points at CV domination. In the former case additional bidders increase the competitive situation and drive the winning bids higher, whereas in the latter case the bidders are more cautious in order to avoid the so-called winners curse. Accordingly, they determine the underlying model by comparing the estimated regression (Giliberto and Varaiya 1989). This approach is, however, doubtful as the private values do not appear in their regression but are a fundamental explanatory variable. Omitting critical explanatory variables may diminish the explanatory power of the regression tremendously. Furthermore is the implicit assumption of a linear relationship between the number of bidders and the winning bid also very doubtful (Armantier 2002).

The third approach remedies those shortcomings by employing non-parametric estimations of the bid function. For a comprehensive overview of this matter see Armantier (Armantier 2002).

Typically, it is not possible to accurately specify all information, observable and unobservable, about the socio-economic environment. This incomplete specification naturally aggravates the subsequent design process. As a result of the requirement analysis step stands the specification of the socio-economic environment of the relevant market – in particular the demands and wishes of the market participants concerning the electronic market services.[163] Demands are a strong form of requirements, which necessarily must be met. Wishes are less stringent requirements as they are not necessary, but should also be taken into consideration. The specification of demands is important in order to determine valid design solutions whereas wishes affect the preferability of design solutions.

Common elicitation techniques for requirement analysis can be distinguished into three broad categories (Byrd, Cossick et al. 1992).[164]

- Observation techniques
  Observation techniques such as behavior analysis or protocol analysis elicit information about the customer by simply observing their behavior. In the context of practical designing electronic markets, observation techniques are very commonly used. It is however not that easy if a comparable (electronic) market does not yet exist. In those cases the use of prototypes appears to be promising, because the market firm can simulate the potential use of the electronic market service and study the behavior.

[163] Sometimes the requirement analysis step is more broadly defined also comprising the conceptual design phase and concept evaluation (Byrd, Cossick et al. 1992).

[164] Byrd, Cossick et al. also define two more categories that are, nonetheless, not as relevant for market engineering.

- Unstructured elicitation techniques
  Unstructured elicitation techniques such as open interviews are probably the easiest ways to obtain information (Hart 1987). Basically the analyst interviews the customers about their task. Along the interview – in an ideally relaxed atmosphere – the analyst gathers private information about the potential customer. As a disadvantage the obtained information are also unstructured and, moreover incomplete. Due to the simple conduct unstructured elicitation techniques are apt for – especially at the beginning – supporting market-engineering activities.
- Structured elicitation techniques.
  Structured elicitation techniques such as structured interviewing are very important instruments for the requirement analysis. In essence structured interviewing follows certain asking strategies. Structured interviews generally support the extraction of a great deal of information but are not as easy to implement as open interviews. Structured interviews can also universally be used.

In summary, the result of the requirement analysis ideally comprises the following aspects: a description of the socio-economic environment (agents, resources, and preferences), the legal framework, and a requirement list what objectives the electronic market service must attain, and lastly what properties it must have.

4.3.3 Stage 2 – Design and Implementation

The second stage – headlined as design and implementation – comprises the actual design process. It commences when the design problem has been sufficiently specified. The design problem thereby corresponds to the market-engineering problem stated in chapter 4.1.3.1. Accordingly, the specification of the problem consists of the properties of the electronic market service, the desired properties and the socio-economic environment reflecting the allocation problem.

The aim of stage two is twofold. Firstly, the conceptual design of an appropriate electronic market on the paper, and, secondly, its transformation into a running software system. As such, stage two is the core stage of market engineering.

4.3.3.1 Preliminary Considerations

As the name *"design and implementation"* already reveals, is this stage definitely a compound task. Before the phases of this compound task are depicted, a brief recapitulation of service development will be given. This recapitulation is deemed helpful, as service development already incorporates the intuition of engineering design but in more concrete terms.

Chapter 3.2.2.2 states that offering services means to offer the possibility of conducting a service. As such, it is necessary to establish the right service prerequisites. The right prerequisites comprise three components (1) the service concept, (2) the service procedure, and (3) the service system.

The service concept denotes in abstract terms the mission of the service. To be attractive for potential customers, the service concept accommodates to the customers needs and demands. As the service concept is of abstract nature, it must be translated into a (less abstract) process view. The service procedure thereby provides this process view conceptually. The last component of the service prerequisites is given by the service system, which is the infrastructure that conducts the service according to the service procedure. The service system accordingly represents those entities that conduct the service.

Figure 21 summarizes the prerequisites as a triangle, where the degree of abstraction increases from the basis to the tip. Accordingly, the service concept is at the tip of the triangle, whereas the service system is at the bottom. Principally, any service development process starts with the generation of the idea (step 2 of the service development process depicted in Figure 18). The idea addresses customer needs. As with any idea, they are of abstract nature. Subsequently, the idea is specified as abstract concept, which is later on refined into a more concrete model (step 4). Eventually the concrete model is finally even implemented (step 8 & 9).

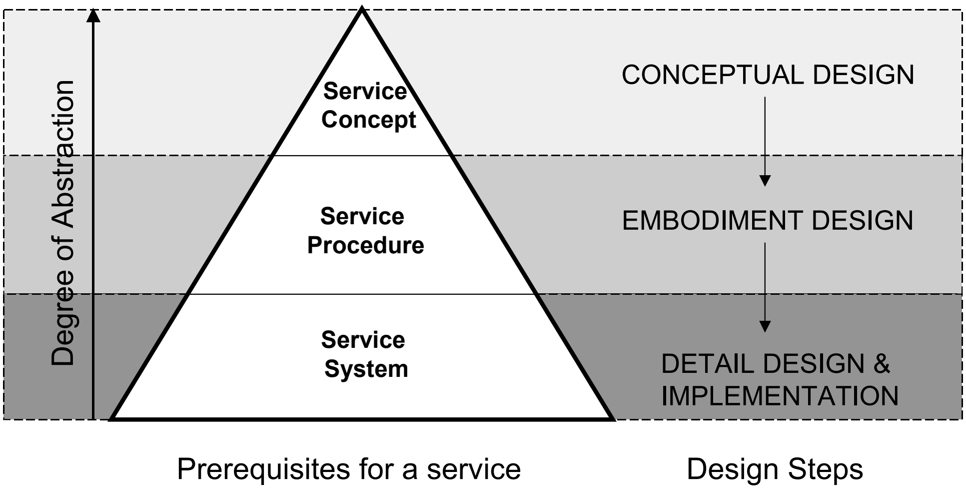

Figure 21: Design and Implementation Stage (cf. Figure 19)

The market engineering process (and engineering design process, respectively) exactly follows this intuition, as Figure 21 demonstrates. In the conceptual design phase the concept of the service is elaborated. Embodiment design refines the concept to the service procedure, which is substantiated in the detail design. Based upon the specification of the detail design the implementation as a last phase of this stage can be performed. As in the engineering design process, iterations are principally possible. Furthermore, it should be noted that the use of prototypes is possible at any time of the design process – as such they are left out in Figure 21.

The phases conceptual and embodiment design are only briefly covered, as a more thorough description is given in chapter 5.

4.3.3.2 Conceptual Design

The conceptual design step hallmarks the peculiarity that distinguishes the market engineering from the service development process. Essentially the design problem is abstracted in a way that the design object is abstracted to its functions. As the design object is the electronic market service it has the function to allocate resources, provide the customers with information, enforce the allocation, sue infringements and so on. The recourse to abstraction simply means *"ignoring what is particular or incidental and emphasizing what is general and essential"* (Pahl and Beitz 1984**,** 58).
Those functions are further divided into sub-functions reducing the overall complexity of the design problem. Then, the sub-functions are distinguished into important (i.e. main) or less important (i.e. auxiliary) functions. Important functions are tackled within the conceptual design phase, whereas the design of auxiliary functions is postponed to the embodiment phase.
The conceptual design itself follows the intuition of the methodology suggested by Pahl and Beitz (cf. chapter 5). Accordingly, effects in combination with the form design that cause

them fulfill functions. By combining effects and their form designs the desired overall functionality is achieved.

Transferred to market engineering, the functions are also solved by means of social effects (Oren 2001). Different than in engineering design, the entities that cause these effects are not form design, but institutional rules and/or complementary (information) services. For example, the market firm may have identified the function "allocate resources efficiently", then it is searched for possible social effects that attain this function. The corresponding trading rules that incite these effects can ideally work as solutions. By doing so, the market firm can generate alternative abstract descriptions of the institutional rules. The abstract descriptions will be combined into concepts that contain an overall abstract description of the institutional rules. The abstract descriptions are furthermore supplemented by a calculation of profitability predicting the chances of the envisioned service in the competition. Finally, it is decided upon which concept – including abstract descriptions of the service enriched by profitability estimates – is further adopted.

4.3.3.3 Embodiment Design

The concepts produced along the conceptual design phase are of abstract nature. For example, concepts define the trading rules in terms of the offer types available to the agents or the computation of offers into allocations and prices, but they do not exactly specify the flow of offers in detail. As such, different trading protocols can be used to implement the same conceptual representation of the trading rules. Embodiment design is thus primarily concerned with developing a layout that refines the concept into (semi-) formal descriptions of the institutional rules. The layout is thereby intended to allow an implementation, but is itself free of implementation details. Beside the layout development, embodiment design is also concerned with the search for conceptual solutions for the auxiliary functions.

4.3.3.4 Detail Design and Implementation

The detail design phase starts out with the layout, which describes the central aspects of the system, but is still at a level that is not implementable. Detail design further refines the layout into a fully-fledged system model that is subsequently implemented. Apparently, this phase accounts for the software engineering effort in market engineering.

From the software development point of view, the precedent design phases of the market engineering process can be subsumed under the term *requirement analysis*. Different than the traditional sequence of interviews, or the use of Joint Application Development (JAD) meetings conducted by professional modelers, the market engineering process provides the designers with a systematic approach to collect design information from the experts. In other words, the precedent design phases of the market design process converts the activities of gathering, figuring out, and communicating what to build (Holtzblatt and Beyer 1995) into a closed discursive approach.[165] By doing so, the market engineering process supports the arguably most important step in the requirement analysis (Dennis, Hayes et al. 1999).

Once the market firm has a clear idea how the electronic market service will look like (by means of the layout), an ordinary software development process can be started. State-of-the art approaches like the V-model (Tansley and Hayball 1993; Sommerville 2001) supplemented by methods such as the FUSION (Coleman, Arnold et al. 1994) or Coad/Yourdon (Coad and Yourdon 1991a; Coad and Yourdon 1991b) and tools such as UML (Odell and

[165] The market engineering process thereby follows the four phases of the requirement analysis, conceptual design, logical design, validation and formal specification proposed by Zmud (Zmud 1983; Byrd, Cossick et al. 1992).

Fowler 1999; Rumbaugh, Jacobson et al. 1999) are available such that the software engineering process will not further be elaborated.

Detail design is, however, more than software engineering – detail design phase is also concerned with the concretization of the business rules. Up to this point, only the key data concerning the business rules such as target costs and price ranges for the electronic market service exist. Once the properties of the electronic market services are clarified, reliable pricing schemes can be developed.

The end of the detail design and implementation is reached, when the electronic market service is fully implemented.

4.3.4 Stage 3 – Testing

Having implemented the electronic market service, it is tested. Stage 3 denotes, however, not testing in general but the final acceptance test before the electronic market service is rolled out. The inclusion of a separated testing stage may also account for the case that the market firm has sourced the implementation task out. The market firm will then only accept the software system if it passes their acceptance testing. Apparently, the inclusion of a testing stage does certainly not exclude testing along the entire design process; it rather provides the market firm with decision support whether or not the system can be launched in the field.

Nevertheless, the term acceptance testing is used here in a broad sense meaning all activities *"used in quality control operations to decide between acceptance and rejection of production lots based upon an inspection of selected items"* (Maxim, Cullen et al. 1975, 315). What is tested is the software quality, and the quality of the service. While the former testing checks the functionality of the service system, the latter refers to the outcome of the electronic market in economic terms (such as efficiency). Thus, the testing stage comprises two different testing phases before release: functionality and concerning economic performance testing.
Furthermore, having passed through these two tests a pilot run on a test market can be initiated as additional phase.

4.3.4.1 Functionality Testing

Before the economic performance testing is performed, the market firm has to assure that software implementing the electronic market service works as specified in the requirements (correctness). Actually, proofs can be used to show the correctness, but are costly and often error-prone. As such, testing is frequently applied in order to assure correctness. However, when it is talked about testing, one must keep in mind that it can never demonstrate the absence of errors in software, only their presence (Dijkstra 1970). Functionality testing can be structured along four activities (Whittaker 2000):

- Modeling the software's environment,
- Selecting test scenarios,
- Running and evaluating the test scenarios, and
- Measuring testing progress.

Firstly, the tester has to simulate the interaction between the software and its environment. As such, the tester has to identify and simulate the interfaces of software systems. Accordingly, the tester has to specify the inputs that can pass through the interfaces. Taking the numerous, different interfaces (e.g. human interfaces, API) into consideration, this can be difficult.

Secondly, as it is not possible to test all conceivable scenarios, the tester must select the test sets. Ideally, the tester thereby selects the minimal test sets satisfying some test criteria. The test criteria can for instance refer to the control flow of the source code, e.g. the test criteria may require choosing a set of tests in a way that any code statement is executed at least once. Other test criteria may concern the input possibilities. For example, the test criteria may prescribe to select a test set such that all likely paths of potential users are executed.

Having identified promising test scenarios, the testers seek to automate them. This is the case as manual testing is inherently error-prone and labor-intensive. The scenarios are subsequently evaluated in terms of the scenario and the expected outcomes.

Lastly, the testing is stopped when the errors have been sufficiently removed. As such, in the last activity, it is assessed, how many errors may be still in the source code and how likely it is that these errors will be discovered in the field. Concepts for measuring testing progress such as testability or reliability exist but are in their infancy (Whittaker 2000).

4.3.4.2 Economic Performance Testing

When the electronic market service passed through the functionality (acceptance) test, it is tested concerning its economic performance. Now the question arises, how economic performance can be evaluated? This question is extremely difficult, as the outcome is determined by the behavior of the agents and not by the institutional rules. Milgrom summarizes the problems with behavior as follows: *"Behavior is neither perfectly stable over time, nor the same across individuals, nor completely predictable for any single individual. Useful analyses must be cognizant of these realities"* (Milgrom 2004, 24). In the discipline of economic engineering there are two approaches to address the evaluation problem of institutions:

- Axiomatic Approach
- Experimental Approach

The axiomatic approach imposes a couple assumptions upon human behavior and calculates equilibrium strategies. With those equilibrium strategies, the performance of the institution can be calculated.

Alternatively, the experimental approach exposes humans to the institution, who will autonomously form their strategy. To make the laboratory experiment comparable, the demand and supply situation is induced to the participating human by means of a monetary incentive scheme. Hence, the performance of an institution depends on the real social interplay among the agents.

4.3.4.2.1 Axiomatic Approach

Standard economic theory has bred out two standard paradigms with different assumptions upon agent behavior pervading economic modeling:

1. The first paradigm is bolstered by welfare economics. Agents are in these models assumed to maximize their individual utility no matter what the others do. In a market context this implies that the buying agents are price-takers, as they take the announced price as given and act accordingly.
2. The second paradigm pertains to game theory. Agents are assumed to choose their optimal strategy conditional on the rival agents' reactions.

The first paradigm usually assumes a behavior that can be described as myopic-best response. In myopic-best response the agents behave such that their utility is maximized, taking the behavior of all other agents as unchanged. Apparently, it is assumed that the own action has no impact on the other agents' reaction. Equilibrium is reached when no agent can improve his utility (Kalagnanam and Parkes 2003).

The second paradigm stems from game theory. Accordingly, the agents choose their utility-maximizing strategy conditional on the rival agents' reaction. An equilibrium is characterized by the fact that all agents play their best-response strategy to each other. This implies that a single agent cannot increase his utility by a unilateral deviation from the equilibrium (Fudenberg and Tirole 2000). Those strategies are easy to compute, as it involves no anticipation of the other agents' strategies (Wellman, MacKie-Mason et al. 2003).

By the classification into game-theoretic and price taking behavior it implicitly raises the question, how complex a problem must be before the game-theoretic rationale loses its predictive power (Ledyard 1993; Kalagnanam and Parkes 2003). Accordingly, it is often assumed that the second paradigm is often used to reflect situation, where only a small number of agents are participating. The first paradigm may reflect agent behavior fairly well, when the number of agents is sufficiently large or when there is uncertainty concerning the preferences.

However, despite the nice properties of myopic-best response, this strategy has two major drawbacks. Firstly, myopic-best response is only meaningful for iterative auctions. Secondly, it is in many cases not rational[166], as there exists better strategies. Myopic-best response would thus neither maximize the agents' utilities nor attain allocative efficiency (MacKie-Mason, Osepayshvili et al. 2004). This suggests turning to the second paradigm of game-theoretic strategy description. Equilibria can be either analytically or computationally attained.

Analytical Models

It is principally possible to solve for these equilibria analytically. Analytical models rely on *"stark and exaggerated assumptions to reach theoretical conclusions"* (Milgrom 2004**,** 22). Typically, mechanism theory assumes that:

- Agents' valuations are well formed and describable in terms of probabilities,
- Differences in the valuations are fully reflected by differences in the information, and
- Agents maximize their utility and expect other agents to be utility maximizing entities as well.

Additionally, the models impose even more restrictive assumptions (such as symmetry of the agents etc.) upon the models to make them tractable (Milgrom 2004). The conclusions of the analytical models may *"fail miserably"* when the assumptions may not reflect reality. In reality the strategic behavior and the environment is more complex than in the models. In those cases optimal (i.e. utility-maximizing) strategies are rarely found. As a consequence, analytical models can be used for developing intuition but not for evaluation of institutional rules. Furthermore, as Milgrom noted, do state-of-the-art models only capture a very small subset of issues of the institutional rules, namely the trading rules (Milgrom 2004).[167]

[166] Straightforward bidding is rational in the case where a single unit is allocated (Peters and Severinov 2001; Wellman, MacKie-Mason et al. 2003).

[167] Milgrom adds that the remaining issues an auctioneer face can principally be incorporated in the mechanism theory framework (Roth 2000). This book supports this view by extending the microeconomic system framework to the EMS framework.

Apparently, economic performance testing has to cope with the problem that the analytical derivation of the optimal strategies is impossible due to the inherent complexity the models want to capture. Restricting attention to ad-hoc strategies and their impact on the economic performance may, however, entail false conclusions, as these ad-hoc strategies can be arbitrarily far from the optimal strategy (Reeves, Wellman et al. 2004).

Computational Methods

One direct way to evaluate the performance of institutional rules is simply to compute the Nash equilibria numerically. However, current computational game solver, such as Gambit, fail to compute even small problems in a reasonable amount of time (Kalagnanam and Parkes 2003). This failure stems from the size of the strategy space, which is simply huge.

Another possibility is to reduce the strategy space and compute the equilibrium based on this strategy space. It still can happen that the problem is computationally intractable, as Wellman et. al. report (Wellman, MacKie-Mason et al. 2003).

The search for equilibria in restricted strategy spaces for game-theoretic agents can principally performed in many ways. In the following three methods that have been proposed in literature are briefly discussed:

- Computational Game Solver
  As aforementioned, Gambit is computational game solver for solving finite games. In essence, it uses the full pay-off matrix and successively eliminates strongly dominated strategies. Then, it performs a simplicial subdivision algorithm for finding at least one mixed strategy equilibrium to any n-person game (McKelvey, McLennan et al. 2000). The major drawback of computational game solvers is, as aforementioned, that even small games cannot be processed within a reasonable timeframe (Kalagnanam and Parkes 2003).[168]
- Evolutionary Tournament
  Originally the interpretation of a Nash equilibrium aims at its evolutionary character. Accordingly, the Nash equilibrium denotes the end point of an evolutionary process, where the agents subsequently adjust their strategies. This evolutionary intuition can be formalized by replicator dynamics.[169] In replicator dynamics, it is the idea that not the individual agents learn but the society as a whole. Initially, a set of pure strategies and the proportion by how many agents of the population these strategies are adopted is given. A strategy that has proven its usefulness is replicated and thus stronger represented in the population. Once the proportions of the population playing a pure strategy remains constant and none of the strategies are extinct, a Nash equilibrium is reached (Fudenberg and Levine 1999). Reaching such a fixed point means that all pure strategies are equally performing well. Another, more plausible interpretation is that – in case the proportions converge – all agents are following mixed strategies according to the population proportions (Reeves, Wellman et al. 2004).[170]

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168 Kalagnanam and Parkes report about recent developments in the area of computational game solver (Kalagnanam and Parkes 2003).

169 Replicator dynamics originate in theoretical biology, *"where they were intended to model shifts in the proportions of genes or species of different fitness"* (Chattoe 1998).

170 In other words, a mixed strategy equilibrium is found. It can be verified whether this equilibrium is indeed a Nash equilibrium of the static game. In those cases the mixed strategy must be a best response to itself.

It is, however, not guaranteed that the evolutionary tournament indeed converges. This is the major drawback of the evolutionary tournament method.[171]

- Genetic Programming
  Another evolutionary technique proposed for simulation of social processes is genetic programming (Price 1997). Basically, agent behavior is modeled as a mental process. This mental process corresponds to an internal evolutionary algorithm. Not the entire strategies from the other agents (as in the replicator dynamics example) but their decision processes are replicated. Broadly speaking, when the decision process is conceived as a tree of operations, than this tree mutates. *"The motivation [...] is to discover which kinds of strategies can be maintained by a group in the face of any possibly strategy alternative. If a successful alternative strategy exists, it may be found by the "mutant" individual, through conscious deliberation, or through trial and error, or through just plain luck. If everyone is using a given strategy, and some other strategy can do better in the environment of the current population, then someone is sure to find this better strategy sooner or later…"* (Axelrod 1984, 57). As with the evolutionary tournament technique, it is also conceivable that evolutionary programming also fails to converge to a stable strategy.

Comprising, computational methods over restricted strategy spaces can provide a good estimate concerning the equilibria that may arise. However, there is guarantee that the methods converge. Whether the computed strategies are really good estimates for the generated strategies in the field depends on how well the restricted strategy space reflects the actual strategy space.

Computational methods are currently used in bolstering analytical models. Those analytical models typically warn that some problem may occur. What is missing is a *"sense of magnitude"*[172], how often those problems would arise and how severe they would be (Roth 2002). Computational methods can provide this information and thus help building a feeling about the dynamics of the system.

Another drawback that computational methods share with their analytical correspondents is their restriction towards trading rules. But in analogy to analytical methods is it possible to extend the computational methods as well.

4.3.4.2.2 Experimental Approach

The depiction of the axiomatic approach demonstrates that economic theory *"is endowed with numerous theories, which are judged on logical completeness"* (Duxbury 1995, 335). However, those (consistent) theories are developed in rather abstract scenarios. A check, whether those theories also hold in reality is a different question. Empirical tests and evidence can fill this gap by providing means to verify or reject those theories. However, there may be cases, where the available data are inadequate. This is where laboratory experiments can step in. Laboratory experiments are a fairly inexpensive method to generate data. The gist of laboratory experiments is their ability to create a test-bed, in which all relevant influencing factors of the environment can be controlled. In such a controlled environment it is possible to test theories or to discriminate between them (Smith 1994). Furthermore, by the use of experi-

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[171] From the theoretical point of view, replicator dynamics have been criticized as an inadequate representation of social processes. The main claim is that replicator dynamics reflect biological processes but *not* social processes. An overview over the criticism can be found at Chattoe (Chattoe 1998).

[172] Economists are sometimes offended that they ignore the size of the effects. "How big is big", remains often an unsolved mystery (McCloskey 1998).

ments also the effect of (new) mechanisms can be extracted, which are too complex to express them in a coherent formal model (McCabe, Rassenti et al. 1993).[173]
Tests of economic theories of individual choice can be traced back into the early thirties, when experimental techniques were used to test utility theory (Roth 1995). In essence, the questions were mainly concerned, whether utility theory can serve as an approximation of behavior. In 1950 Melvin Dresher and Merrill Flood firstly introduced game-theoretic experiments (Flood 1958), by studying the so-called Prisoner's Dilemma. Those games were fairly straightforward as they theoretically had just one equilibrium. When multiple equilibria exist the problem gets more complex as the players must co-ordinate their expectations and actions. Early experiments on co-ordination were reported by (Schelling 1960). The first experiment that studied the effects of different market institutions dates back to Chamberlin. Chamberlin (1948) introduced an experimental design to create a testbed for markets in which the economic environment can be directly controlled by the experimenter. By doing so, Chamberlin was able to compare the impact of different institutions on the outcome while holding the parameters of economic environment constant. Vernon Smith and Charles Plott expanded on the work of Chamberlin and established *"modern"* experimental economics (Roth 1995).

Apparently, there exists a tool not only for testing theory but also for economic performance testing: *"Testbed experiments involve the actual implementation of a process. The purposes of a testbed are to determine if the process can be implemented and how it works once it is implemented. […] More recently the terms "proof of principle" or "proof of concept" have been used to capture the motivation and interpretation of the research."* (Plott 1994**,** 4). The use of laboratory experiments as engineering tool is not undisputed, though. The dispute stems from the fact that experiments abstract from reality by sketching a simplified view upon the (socio-) economic environment. As such, *„[...] there is a question about the transferability of results from experiments"* (Loehman and Kilgour 1998**,** 18). Two popular streams of arguments have developed discussion the pros and cons of experiments.

1. The first stream assumes that the agent behavior in laboratory experiments resembles behavior in real settings. This implies that the results of experiments can be directly transferred to real settings (Easley and Ledyard 1993).
2. The second stream is a little bit more cautious, as it does not assume that behavior in experimental and real settings are alike. It basically perceives that a theory that does not hold even in a controlled environment of a laboratory experiment will also fail in more complex real settings. On the other hand, there is no guarantee that a theory that proves itself in an experimental setting will likewise do in real settings. That means negative results can automatically be transferred while positive ones cannot.

What is undisputed is the fact that testbed experiments can reveal information about the way institutions work on the performance. As such, experiments are an indispensable tool of market engineering. It provides the only method that can currently capture the effect of the entire institution. As such, the experimental approach is currently state-of-the art in testing innovative institutions (Milgrom 2004).

[173] Undoubtedly, there are many more reasons why experiments are important in economics. Smith for example mentions five additional arguments. For example experiments can help to explain the causes of theory's failure. Furthermore, experiments are adequate to distinguish the robustness of mechanisms. Last but not least experiments may serve as a source of empirical phenomena that needs explanation (Smith 1994). Further arguments for the method of laboratory experiments can be found under Davis and Holt (Davis and Holt 1992).

4.3.4.2.3 Automatic Testing

Experimental testing is – as aforementioned – a powerful tool for market engineering. The method has, however, some disadvantages. Experiments require a deliberate design of the economic environment(s), which will be tested and upon the incentive scheme. Subsequent conduct of the experiment is time-consuming, as the human agents require thorough prescriptions. Lastly, the agents obtain their monetary rewards. Comprising, experimental testing is an arduous task, as any experiment is unique.

In this context, computer scientists propose their vision of an automatic testing procedure (Kalagnanam and Parkes 2003). In essence, they demand for a black-box tool that requires information about the economic environment and the institution and renders the expected performance. The black-box tool thereby comprises software agents that represent the human agents on a market acting spontaneously. Embattled with evolutionary algorithms the agents are capable of learning better strategies dependent on the institution. Currently automatic testing is not more than a vision. However, if the representation of social learning processes is more thoroughly studied this black-box tool may not always remain a dream.

4.3.4.3 Pilot Runs

Having surpassed the two tiers of functionality and economic performance testing, it is advisable to conduct a pilot run. The purpose of a pilot-run is twofold: Firstly, the inference of information about the customers' acceptance of the new electronic market service. A live testing procedure with few consumers allows the market firm gathering information from the field. If necessary adjustments in the institutional rules can be undertaken, before the electronic market service goes live. Secondly, the pilot run also works as a stress test, validating whether the electronic market service provision is smoothly functioning.

4.3.5 Stage 4 – Electronic Market Introduction

After the pilot run, the electronic market service can be introduced on a full-scale. Market engineering understood as the design of the institutional rules ends with the post-launch review, which measures the customer acceptance right after rolling out the service. Holistic market engineering continues, however. With the introduction of the electronic market service the operation cycle will be initiated.

4.4 Chapter Summary

The institution of an electronic market can be conceived as a very complex construct, consisting of six different rule types that enfold interdependent effects upon the market they serve. Electronic markets are not just evolving, but they have to be carefully designed (Roth 2002). The reason why they need conscious design stems from the fact, that these rules must be implemented by the trading system. As such, the market firm is facing the problem of designing institutions.

The first lesson for designing institutions can be drawn from mechanism design theory. Mechanism design theory relies on the microeconomic system framework. The design problem is assumed to be well-defined, transforming the design into an optimization problem. When the assumption of perfect knowledge about the socio-economic environment is relaxed, the so-called market design problem is not just a computational problem. The designer must engineering-like determine aspects of the design, where theory is silent. As such, the institutional design shifts from pure science to engineering.

This shift is even magnified when the institution definition is revised in order to account for electronic market institutions. In those cases the engineering design of institutions – called market engineering – becomes much more complex. Not only are the trading rules subject to design but also all other rule types such as the business or media rules. Due to the huge design space and the limited information about how the institutional rules affect the outcome, the problem is inherently ill-structured.

Typically, for ill-structured problems only weak problem-solving methods exist. In design science ill-structured problems are successively decomposed into smaller problems with more structure. For those smaller problems stronger problem solving methods may exist. Apparently, this decomposition strategy is a way to cope with the complexities of the problem. For adopting such a strategy for market engineering two constituents are needed: an approach that guides the decomposition and methods that solve the smaller design problems.
The approach for market engineering is derived from the engineering design process, which essentially prescribes a *problem-oriented*, *abstract-to-the concrete* approach. Different than the related service development process, engineering design supports the important conceptual design. In this design the institutional rules are solved conceptually on the paper and further elaborated. The explicit recognition of the conceptual design allows the well-directed use of economic theory.

Lastly, the market engineering process is introduced in more detail. In essence, the process is divided into four stages:

- Stage 1 – Environmental Analysis
  The first stage can also be headlined as *"marketing"*, as it comprises the usual approach of new product development: market definition, segmentation and targeting. Having identified the relevant segment for which an electronic market institution is potentially being offered, the requirements of future participants are elicited.
- Stage 2 – Design and Implementation
  Based upon the requirements the actual design activity is triggered. Accordingly, the institution is decomposed into its components. Then, it is planned in which order these components are designed. The design is firstly conducted on a very abstract level and further on refined. At the end of the step the resulting rules are coded in software.
- Stage 3 - Testing
  The third stage comprises the testing of the newly implemented institution. The economic performance is thereby tested by means of experiments. Once the institution passed the experimental testing, the electronic market institution is released for a pilot run. Essentially last amendments can be made before the electronic market institution goes life.
- Stage 4 - Introduction
  The last stage is concerned with the roll out of the electronic market institution.

The market engineering process gives structure to the design activity. All activities are arranged in a way to reduce the number of unnecessary iterations.[174] The description of the market engineering process is, however, still at a very general level. The precise use of the design methods is not in the center of attention in this chapter. This shortcoming will be remedied in the next chapter, which discursively discusses the use of design methods along the design stage (stage 2).

[174] This does not rule out iterations per-se, as iterations are important to enfold creativity; it only rules out iterations that can be avoided.

5 Conceptual and Embodiment Design

"Ignore basic economic principles at your own risk. Technology changes. Economic laws do not" (Shapiro and Varian 1999).

In the previous chapter the *market engineering process* was motivated and presented. Accordingly, the market engineering process provides a good starting point, as it states (1) the elements that must be designed and (2) the order in which these elements must be tackled. The decomposition of the market-engineering problem can reduce the complexity involved in the design process considerably. Furthermore, the market engineering process provides general guidelines for designing the elements. These guidelines are typically coupled with the recommendation of design methods.

Although market engineering is a fairly new discipline, it can draw on numerous existing methods and tools. However, market engineering also comprises design tasks for which no methods yet exist. While the previous chapter was primarily concerned with the description of stages for which methods and tools can be borrowed from other disciplines such as marketing or software engineering, this chapter focuses on market engineering specific phases. More precisely, the emphasis of this chapter is on the original design of institutions, namely the conceptual and the embodiment design phase.

Both design phases can be conceived as the interface between the environmental analysis and software engineering. While the marketing-oriented environmental analysis suggests providing an electronic market service for one particular targeted market segment, the service concept is no more developed than a rough idea. Software engineering, on the other hand, requires a well-developed requirement specification about the system to be implemented. Apparently, there is a fundamental gap between the specification rendered by the environmental analysis and the informational requirements about the future system demanded by software engineering. The conceptual and embodiment phase aim at the connecting link between those stages.

From their degree of abstraction, conceptual design is closer to the environmental analysis, while embodiment design is more related to software engineering. In essence, the conceptual design attempts to develop a concept of the electronic market service that is perceived to create a value added for the targeted market segment. As this concept is still on a very abstract level it must be further refined along the embodiment design phase into a semi-formal description of the service procedure. Once this description exists, software engineering methods may help to transfer it to a running electronic market system.

The difficulty associated with the conceptual and embodiment design phase lies in the absence of methods and tools. Hitherto, there does not exist any method, technique, approach or tool that supports either of these phases. The absence is not astonishing as any attempt of *social engineering* is difficult.[175] As the EMS framework demonstrates, all institutional rules are determining the system performance. When designing institutional rules the reactions of agent

[175] Social engineering denotes the desire of controlling the whole society. Apparently, this attempt is difficult as any social change may entail other, unintended reactions. Thus, social engineering is rather difficult (Freeman 1975). For electronic markets the society is confined to the participants. Despite this confinement, it is still challenging to influence agent behavior into a desired direction.

behavior must be anticipated by the market engineer and subsequently be incorporated into the design. Anticipating the future agent behavior is extremely difficult, as such a goal-oriented social engineering is heavily impeded.

The objective of this chapter is to develop a discursive approach that supports the market engineer in the design phase starting from the idea that is further refined until a (semi-) formal description of the electronic market service is obtained. This implies that also a systematic method for designing institutional rules in a *social engineering* manner is attempted. Since the resulting concept is too abstract for implementation, it needs embodiment into a blueprint of the electronic market service.

Accordingly, this chapter is divided into three parts. In the first part (chapter 5.1) the conceptual design phase is decomposed into its primitive activities. In the second part (chapter 5.2), the embodiment design phase, the resulting concept is further refined into a model of sufficient detail that can be implemented. Chapter 5.3 concludes with a summary.

5.1 Conceptual Design

The conceptual design is potentially one of the most critical steps in the engineering process. Essentially, the conceptual design comprises a functional analysis, which investigates all functions the electronic market service has to provide. The functions can be further decomposed into sub-functions. This recourse to functions recognizes the need for solution neutrality. As such, the approach does not stipulate at this early stage what solution will satisfy the particular function (Pahl and Beitz 1984). Thus, the functional approach is widely *"ignoring what is particular or incidental and emphasizing what is general and essential"* (Pahl and Beitz 1984).[176]
In engineering design it is assumed that solutions can be found referring to the physical effects that realize the desired functions. Since one effect may not suffice more effects are combined to solution principles. In this context the term "principle" means assumption – a solution principle expresses the conjecture that the combined effects satisfy the function as solution. Those solution principles are provoked by certain entities or design objects. In engineering design those entities are typically referring to the arrangement of *surfaces* and *motions* (Pahl and Beitz 1984).

The approach of market engineering, as suggested here, follows the engineering design process, although the interpretation is different. As market engineering designs institutional rules, it cannot be referred to physical effects but to *social* effects. This change makes, however, the approach weaker than engineering design as will be discussed below (Little 1993). Social effects will be released by the setting of institutional rules; the design entities are thus not surfaces and motions but rules. Following this analogy, solution principles in the market-engineering context comprise social effects and rules that provoke them.

Subsequently the solution principles must be aggregated to fulfill all functions of the electronic market, which is expressed by the overall function. The aggregation of the solution principles is not yet considered as a *concept*. What is missing is an estimate, how well the proposed aggregation of solution principles will perform in the field. Apparently, the solution principles must be enriched by a business analysis. Having firmed up the solution principles into concept variants, they are evaluated against technical and economic criteria. At the end of

[176] This independence of the function structures and the particular solutions is typically considered desirable, but presumably an unobtainable ideal. It marks an ideal, as the function structures are rarely free of physical or formal presuppositions. As such, the design space is inevitably restricted to some extent (Tate 1999).

the conceptual design phase stands the decision to authorize further design. All activities of the conceptual design phase are summarized in Figure 22.[177]

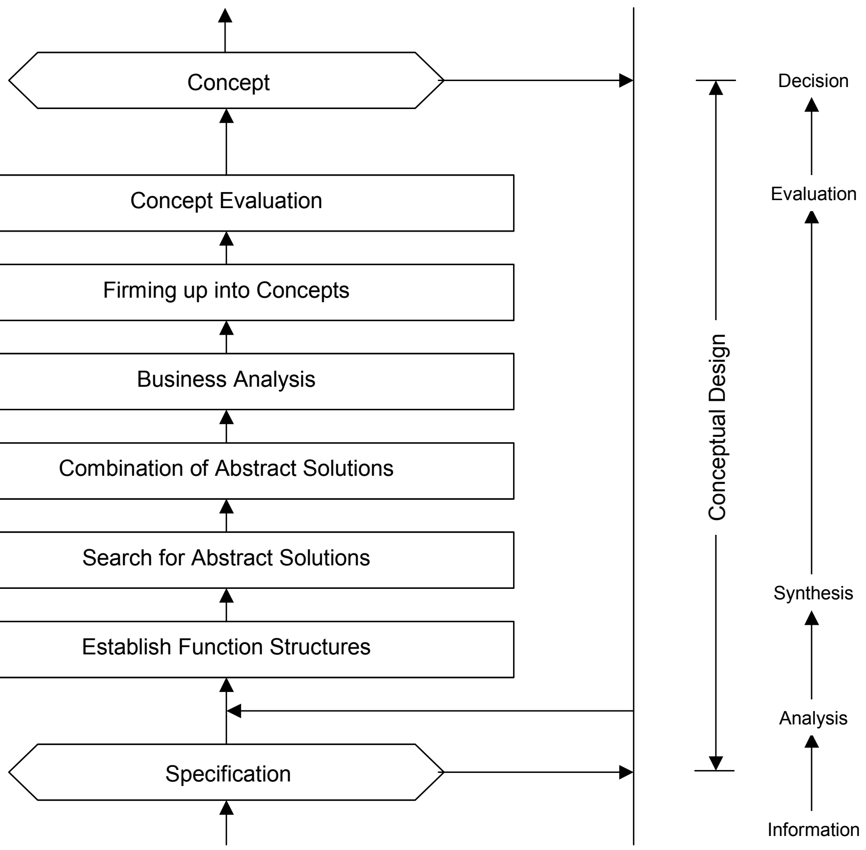

Figure 22: Activities of Conceptual Design

5.1.1 Establishing Function Structures

For the purpose of defining and solving the problem, the notion of a function is essential. Originally, the concept of functions was developed by the discipline of philosophy. Accordingly, a function *"explains the presence of an item (organ, mechanism, process or whatever) [...]"* (Cummins 1975, 741) that it represents. *"For something to perform its function is for it to have certain effects on a containing system, which effects contribute to the performance of some activity of, or the maintenance of some condition in that containing system*" (Cummins 1975**,** 741). In other words, a function explains the presence of an entity, which is part of a system by pointing out that the entity is necessary, because it has some specific effect on the system. From this it can be stated that a function is a black box describing the static input-output relationship of an entity (say for example, a machine, plant, assembly, or position). The entity receives inputs (e.g. signal, energy or material) and processes the inputs into a specific output (e.g. signal, energy or material). A functional description of an entity allows the abstract specification, independent of implementation details. The popularity of the functional approach in design[178] stems from at least three sources (Stone and Wood 2000):

[177] Note that the process proposed in Figure 22 is based on the approach defined by Pahl and Beitz, although some activities are different (e.g. business analysis). These changes reflect the peculiarities of the market engineering process. Nonetheless, the changes are not fundamental such that the character of the engineering design process remains unchanged.

[178] Not only the methodology suggested by Pahl and Beitz but also the Axiomatic Design and General Design theory proposed by Yosihikawa follow a functional approach (Kikuchi 2003)

- Fostering understanding
  The functional approach helps the designer to understand the design problem in its entirety. This understanding may prevent that the designer finds excellent solutions – but to the wrong problem (Cross 1994; Summers, Vargas-Hernández et al. 2001).
- Early design decisions
  By means of the functional approach the design object can be abstractly represented despite incomplete information. As such, it is possible to break the design problem down and make decisions early in the design process. Early decisions upon the concept are desirable, as the design process can abandon inadequate concepts right at the beginning.
- Creativity in concept generation
  The ability to abstract the design object grants the creativity of generating innovative design solutions (Ullman 1997). As the functional descriptions are independent of any particular solution, the designer is free to construct completely new solutions.

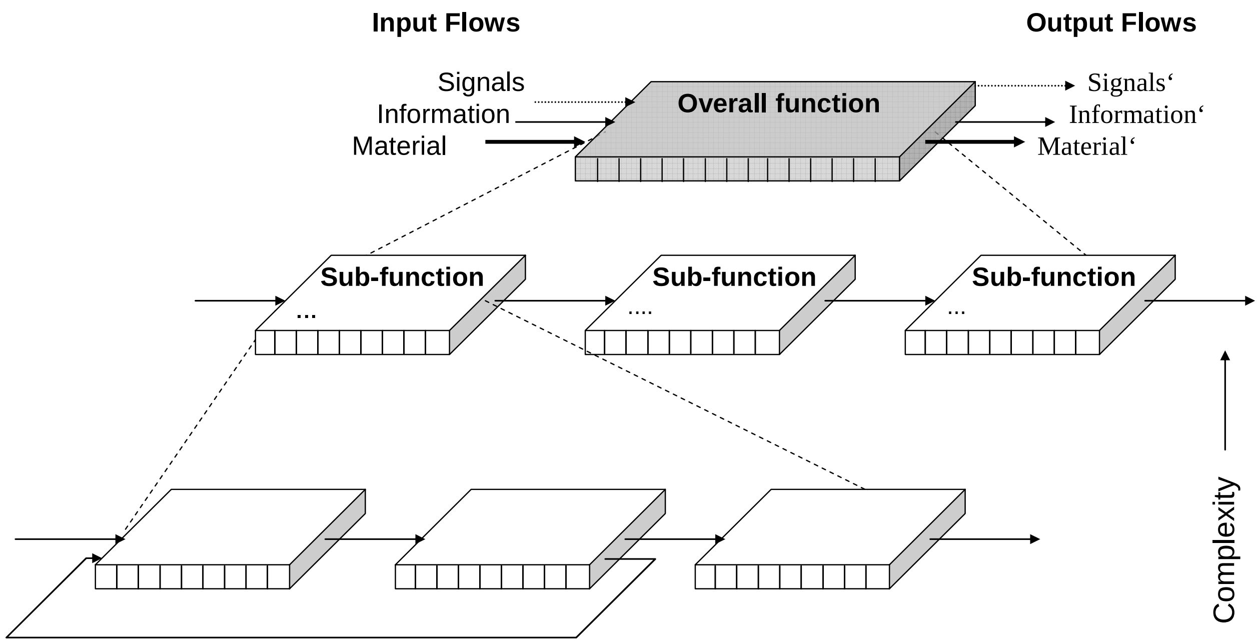

Figure 23: Function Structure (cf. Pahl and Beitz 1984)

Design methodologies use the notion of the *overall function* characterizing general input-output relationship of the design object (Stone and Wood 2000). Typically, the overall function is stated in verb-object form. When complex solutions are to be designed, the *overall function* can also be very complex. Hence, it is the idea of the functional analysis to decompose the overall function into sub-functions. The sub-functions thereby describe a part of the overall function representing a more elementary aspect of the design object. Aggregating over all sub-functions yields the function structure (see Figure 23). Apparently, the function structures reflect the "*meaningful and compatible combination of sub-functions into an overall function [...], which may be varied to satisfy the overall function*" (Pahl and Beitz 1984).

Setting up the function structure is thus a central task in conceptual design. The approaches discussed in literature vary considerably (Suh 1990; Stone and Wood 2000; Kurfman, Rajan et al. 2001; Stone, McAdams et al. 2004). In the sequel, the approach developed by Pahl and Beitz and refined by Stone and Wood is followed (Pahl and Beitz 1984; Stone and Wood

2000). Despite its drawbacks[179] it is easy to understand and, moreover, adequate for market engineering.
Accordingly, the establishment of the function structure follows three operations.

Operation 1 – Generate Black Box Model
The first operation is concerned with the establishment of the overall function as a black box model. Thereby, the operation of the function is described in natural language as well as the input and output flows associated with the function (c.f. Figure 23).
Flows, in general, represent the entities and quantities that are in- and output of the function. In engineering design it is referred to the flow of energy, material and information (Pahl and Beitz 1984). While energy and material is undisputed, engineering design understands information as signals that carry information for controlling purposes conveying either status or control information (Stone and Wood 2000). In market engineering, *information* becomes an input comparable with material that is processed along the market process. In such a case information is not only a (control) signal, but also the immaterial "matter" that is processed. As such, the information flow is introduced as counterpart to material.
The input-output flows of the overall function are straightforward to obtain, as they are part of the requirement analysis. Describing the internal processes as black box appears to be adequate, since the requirement analysis only rarely gives advice about how to achieve the overall function.

Operation 2 – Breaking up into sub-functions
Having stated the overall function, it must be broken up into simpler sub-functions. In principle, three design problems can be distinguished according to the relative degree of novelty of the problem (Pahl and Beitz 1984).

- Original design
  In the case of original design the problem is not fully understood, such that neither the sub-functions nor their ordering is generally known. Establishing the function structure of the problem denotes the most critical task in the conceptual phase.
- Adaptive design
  In the case of adaptive design the function structure of the problem is much better known. The sub-functions as well as their assembly can principally be acquired by a thorough analysis of previous, somewhat similar designs. As such, establishing the function structure of the problem comprises adaptations of the original-design by introducing, replacing, or omitting sub-functions.
- Variant design
  In the case of variant design the function structure of the problem is fully understood and known. This implies that the involved sub-functions used as building blocks and their assemblies are known. Design focuses on different solutions of the particular sub-functions.

As such, it is firstly checked whether the design problem resembles previous ones. If the new problem matches with a previous design problem, the precedent function structure can be used as a basis, where adaptations and variants are possible. If the problem is new, the derivation of the function structures is rather difficult. The systematic approach developed by Pahl and Beitz suggests the derivation of sub-functions along the input flows beginning *"with sub-functions whose inputs and outputs cross the assumed system boundary. From these we can determine the inputs and outputs for neighbouring functions, in other words, work from the*

[179] Two major drawbacks are frequently noted in literature: (1) the resulting function structure is not compelling, in a way that different designers establish different structures (Tate 1999), and (2) the resulting function structure is not precise, as the use of terminology can vary from designer to designer.

system boundary inward" (Pahl and Beitz 1984). For reducing the ambiguities associated with the sub-functions definitions, the sub-functions of the chain are expressed in the terminology proposed in Table 8, which relies on the work of Stone and Wood (Stone and Wood 2000).[180] The basic functions thereby denote the primitive tasks of sub-functions, which can be categorized according to the classes.

Class	*Basic Functions*	*Description*
Branch	*Separate*	Isolates material or information into distinct component
	Remove	Takes away a part of a material or information from its prefixed place
	Refine	Reduces material or information such that only the desired elements remain
	Distribute	Causes material or information to break up
Channel	*Import*	Brings in material or information from outside the system boundary
	Export	Sends material or information outside the system boundary
	Transport	Moves material from one place to another
	Transmit	Moves information from one place to another
Connect	*Couple*	Brings two or more materials or information together
	Mix	Combines two materials or information into a single component
Control Magnitude	*Actuate*	Commences the flow of material or information in response to an imported control signal
	Regulate	Adjusts the flow of material or information
	Change	Adjusts the flow of material or information in a predetermined and fixed manner
Convert	*Convert*	Changes from one form of material or information in another one
Provision	*Store*	Accumulates material or information
	Supply	Provides material or information from storage
	Extract	Draws a material or information
Signal	*Sense*	Perceives a signal
	Indicate	Makes something known to the user
	Display	Shows a visual effect
	Measure	Determines the magnitude of a material or information flow
Support	*Stop*	Ceases the transfer or material or information

Table 8: Basic Functions (cf. Stone and Wood 2000)[181]

The derivation of the sub-functions must be conducted for any input flow of the overall function. Aggregating over all sub-function chains leads to the function structures. Note that these sub-functions are at the same level of complexity. As those resulting sub-functions can be too high-level to find solutions for them, they are further decomposed into sub-functions of decreasing complexity, until the search for a solution seems promising (Hundal 1990).

Operation 3 – Distinction into Main and Auxiliary Functions

The last step of establishing the function structure distinguishes the sub-functions into main and auxiliary functions. Main functions directly affect the overall functions whereas auxiliary functions are complementary. While main functions are designed from the outset of conceptual design, auxiliary functions are left aside until the embodiment design.

[180] A conversion of the grammatical approach proposed here into a machine readable format is straightforwardly possible as Szykman et al. demonstrate (Szykman, Senfaute et al. 1999; Szykman, Bochenek et al. 2000)

[181] The list of basic functions is reduced in comparison to the original source. The reason stems from the fact that some mechanical engineering functions are inapplicable for market engineering. Furthermore, the energy flow has been substituted by information. This information does, however, not correspond to control information. The distinction into information and signals is still active.

The Function Structure of the Electronic Market Service
In market engineering the *design object* is the electronic market service. The function structure can be derived following the abovementioned operations:

Operation 1 – Generate Black Box Model
Firstly, the overall function of an electronic market service must be defined. The specification representing the overall function of the electronic market consists of at least a verb-object combination – quantitative or qualitative statements can enhance the specification. Basically the simple electronic market service, which is depicted in Figure 24, constitutes the function of providing an efficient resource allocation process.

The inputs from outside (i.e. from the participating agents) are either information or material. In our example case, it is assumed that the electronic market service accepts the physical transaction objects, and stores it until it is sold. Furthermore, the electronic market service requires information about the identity of the participating agents, their reputation and, of course their bids along the market process. Finally, the payment that the buyer pays to the seller is needed. As an output the service yields the allocation and prices, transfers the money to the seller, ships the transaction objects to their new owners, updates the reputation and renders information about the market process, e.g. the bidding history.

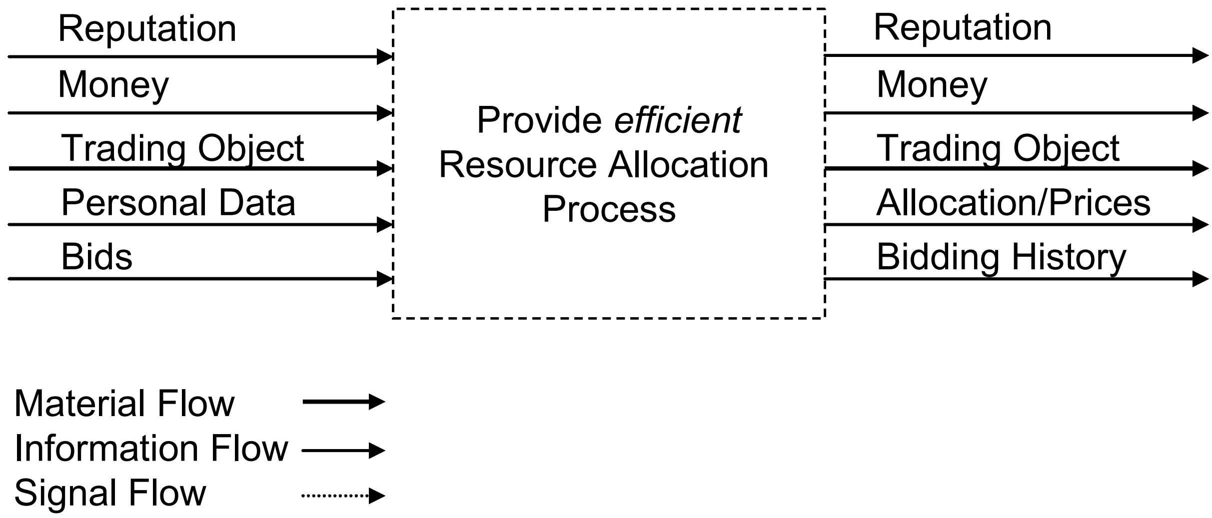

Figure 24: Black Box Model for an Electronic Market Service

Stated differently the overall function of the electronic market service describes on a high level the service concept.

Operation 2 – Breaking down into sub-functions
The black box model clearly sketches a very crude picture of the electronic market service. As such, the overall function must be decomposed into sub-functions. The decomposition develops for each input flow a chain of sub-functions that operate on that flow. For example, Figure 25 sketches the sub-function chain for the *"bids"* input flow. By analyzing the flow, the designer realizes that six operations are necessary before the bids are processed into allocations and prices and conveyed to the participating agents.

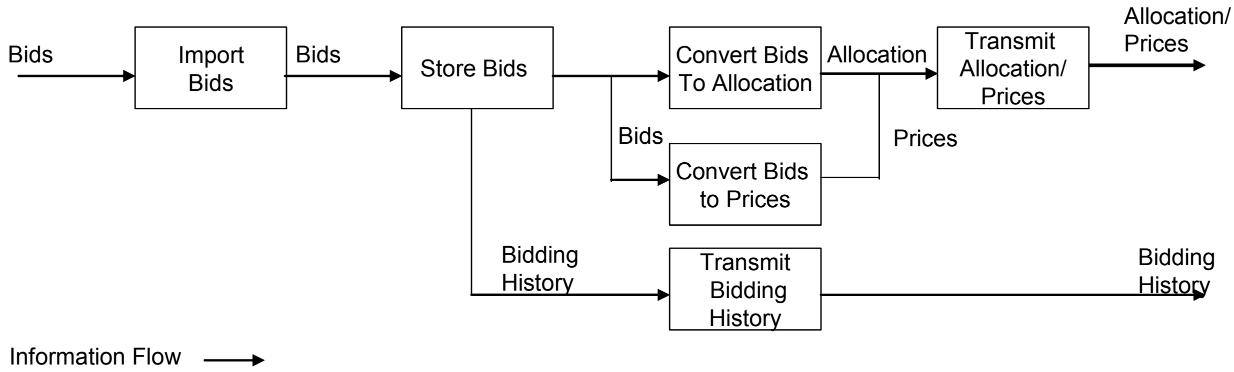

Figure 25: Sub-Function Chain for the Input Flow "Bids"

By aggregating over all input flows the designer yields the complete function structure (see Figure 26). If necessary the distinct sub-function chains must be connected. For example, in Figure 26 the sub-function chain pertaining to "bids" (marked by the shaded panel) is triggered by a control signal from the authentication.

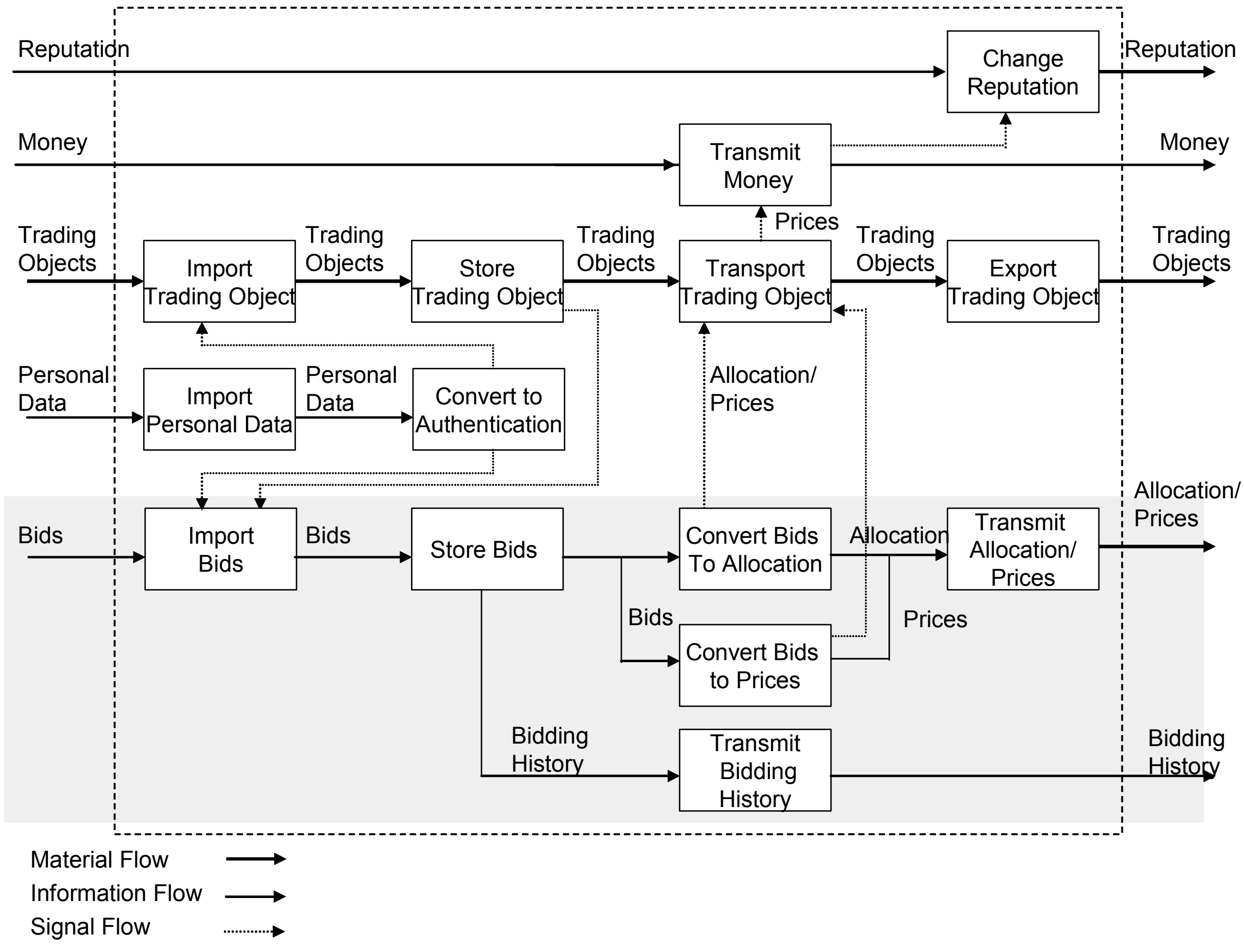

Figure 26: Examples of Sub-Function Chains

Now the function structure reads as follows: At the beginning of the process, the trading objects enter the electronic market service (i.e. import). Once the sender of the trading objects is authorized (according to the personal data), the trading objects are put on store. With the storing of the trading object the competitive bidding process is initiated. The bids are stored and subsequently converted into prices and allocations. This information triggers the transport of the trading objects to the new owner. Having exchanged the trading objects and the corresponding payments (money), the reputation is updated and the trading objects are exiting the electronic market service. Apparently, the development of the flow *“transaction object”* is connected with the flows *“bids”* and *“personal data”*.

The generation of the function structure requires the designer to decompose the overall function until solutions for the sub-functions can be found. In our simple example the function structure is still too high level. For example, the sub-function *“import bids”* may conceal various aspects such as bidding language or the transmission channel. For design it is important to further continue the decomposition process.

The further decomposition will be demonstrated by referring to the *“bid flow”* (c.f. Figure 25).[182] Figure 27 illustrates the deeper-level sub-function chain of the resource allocation process. Recall that the bidding process is started, once an agent indicates an intention to buy or sell.[183] On initiation of the process, the electronic market assigns the corresponding roles (e.g. buyer or seller) to the agents. Principally, these roles grant permissions (e.g. the right to submit a bid) and responsibilities (e.g. the obligation to always have an active bid). Furthermore, the electronic market disposes a bidding language. Having posted these two pieces of information, the bidding process is opened and bids will be accepted. Apparently, the former sub-function *“import bids”* is now decomposed into three sub-functions *“indicate roles”*, *“indicate language”,* and *“import bids”*.[184]

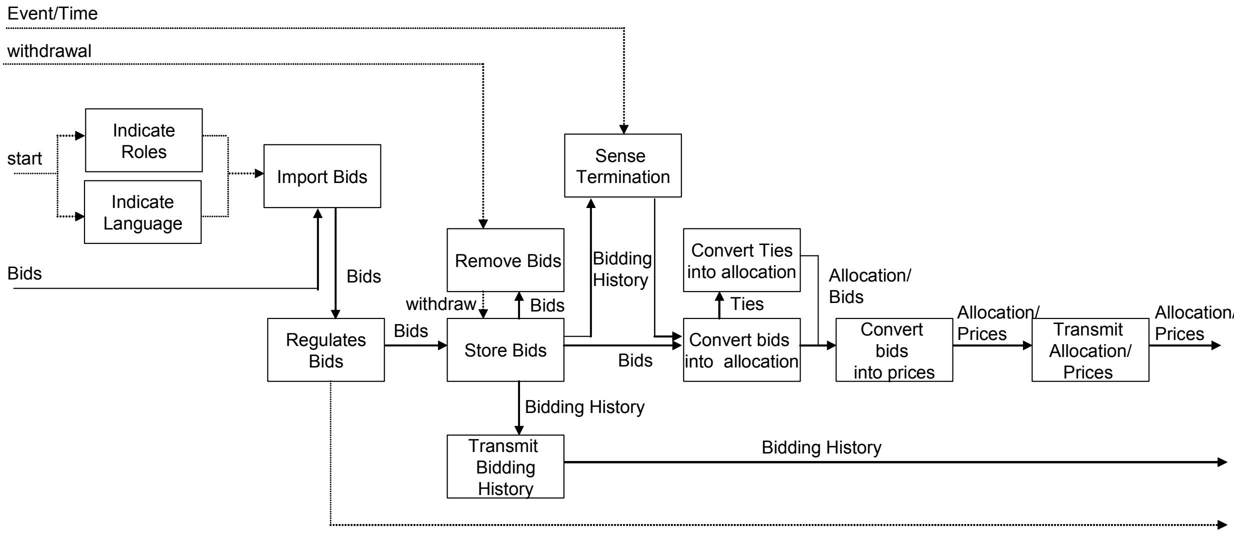

Figure 27: Sub-function Chain representing the Resource Allocation Process

After arrival, the bids will be validated along the sub-function *“regulate bids”*, while only valid bids will be stored as active. Invalid bids will be reject by informing the referring agent. Information about the stored bids (e.g. the bidding history or recommendations) can be conveyed at any time. If permitted the agents can withdraw bids from the store. Once the termination time or event is reached, the bids will be converted into allocations and corresponding prices.

[182] Without supporting the *“bid flow”* the (remaining) information system would not be considered as an electronic market (cf. chapter 2).
[183] In Figure 26 this intention was materialized by handing-over the transaction objects.
[184] Note that the new sub-function “import bids” comprises less functionality than the sub-function with the same name on an aggregate level.

Note that the sub-functions chain pertaining to the *"bid flow"* focuses on the functions that must be performed but not the chronological process. For example, the sub-function chain can also represent iterative market processes. Any new bid from an agent (outside the electronic market service) passes through this sub-function chain starting from *"import bid"*.

At this point there is no need to further decompose as to any of these sub-functions a corresponding design solution – a single rule or a rule package pertaining to the trading rules – can be found. For example, the sub-function *"sense termination"* can be conceptualized by a closing rule. Note that it is one of the major weaknesses of the functional approach by Pahl and Beitz that no precise stopping criteria for decomposition can be offered (Tate 1999). This stems from the fact that the connection between the sub-functions and the design elements is not very firm (Kikuchi 2003). However, this is a rather common phenomenon affecting all design approaches.

In the previous chapters designing electronic market coincided with the design of institutional rules. By means of the function structure the designer can determine, what particular functions the single institutional rules must regulate. As a matter of fact, the sub-function chain in Figure 27 reflects the stylized resource allocation process. Hence, it can be used as a template for resource allocation processes.[185] Establishing the function structure for the resource allocation process, thus, constitutes an adaptive and variant design problem. As such, it is possible to create variants of the electronic market service by linking the sub-functions in a different manner or by introducing new sub-functions in addition or as a replacement of existing sub-functions. Apparently, this part of the function structure is not the only possible. Rather are there many – albeit *akin* – function structures.

Operation 3 – Distinction into Main and Auxiliary Functions
The distinction into main and auxiliary functions basically concerns the sequencing of design tasks. Those functions that are regarded as main functions are designed at the beginning of the process, while less important functions can be left aside until a later time. This distinction cannot generically be given, as it depends on the service concept what is important and what is not. Typically, the resource allocation process is of considerable importance – as it constitutes the markets foremost objective. Hence, the functions pertaining to the resource allocation process are denoted as main functions.

5.1.2 Search for Abstract Solutions

The next step is to find solutions for each of the sub-functions. As a solution represents rather suggestions than fully-fledged recipes for solving the sub-functions, the term solution principles may be appropriate. In engineering design a solution principle reflects a physical effect, e.g. friction and the elementary form in which the effect is used. The abstract entity, which realizes the function through the exertion of physical effects, is thereby denoted as function

[185] This is, however, not the only conceivable template. The Montreal Taxonomy for electronic negotiations also provides the general structure of any electronic negotiation used in the context of trade (Ströbel and Weinhardt 2003). Basically, the Montreal Taxonomy introduces a list of characteristics for electronic negotiations and arranges them according to their function. The functions are taken out of a sequence of activities that all together describe the stylized electronic negotiation process. The functions comprise seven steps namely the offer specification, offer submission, offer analysis, offer matching, offer allocation, offer acceptance and information feedback (Neumann, Benyoucef et al. 2003; Ströbel and Weinhardt 2003). It appears to be reasonable to use those functions for setting up the function structure. The benefit of using the Montreal Taxonomy or any other classification scheme such as the resource allocation process introduced in this book lies in the provision of the design space. Not only are the functions and their sequence denoted but also how they can conceptually be solved.

carrier. For example, the function may demand to “convert torque into airwave”, which is realized by the function carrier “fan” (c.f. Figure 28).

In market engineering, the entities that solve the functions are typically neither referring to physical effects nor to form properties. Functions in market engineering are mainly concerned with the processing of information; function carriers, the entities that realize the function, are thus in most of the cases immaterial software programs. Functions can be distinguished whether or not (external) agents are actively involved (Chandrasekaran and Josephson 1997). On the one hand, when the function does not involve the participation of intentional agents, the function carrier can be characterized by a number of rules (say algorithms). For example, information delivery services have a function that can be solved by rules independent on how the agents behave. On the other hand, when the function does explicitly require the participation of intentional agents those rules alone do not suffice to attain the function.

The distinction will become clear referring to the overall function defined in the previous chapter. Basically the overall function requires *“providing an efficient resource allocation process”*. The demand for an efficient resource allocation process necessarily entails the participation of agents in the market process. The (calculation) rules alone that facilitate the market process are insufficient to solve the function. This arises from the fact that the result of the function *“efficient resource allocation”* depends on the behavior of the agents. As such, the rules have to incite social effects on the agent behavior. This is exactly what makes market engineering so difficult – the sub-functions typically aim at objectives that are not under complete control of the designer.

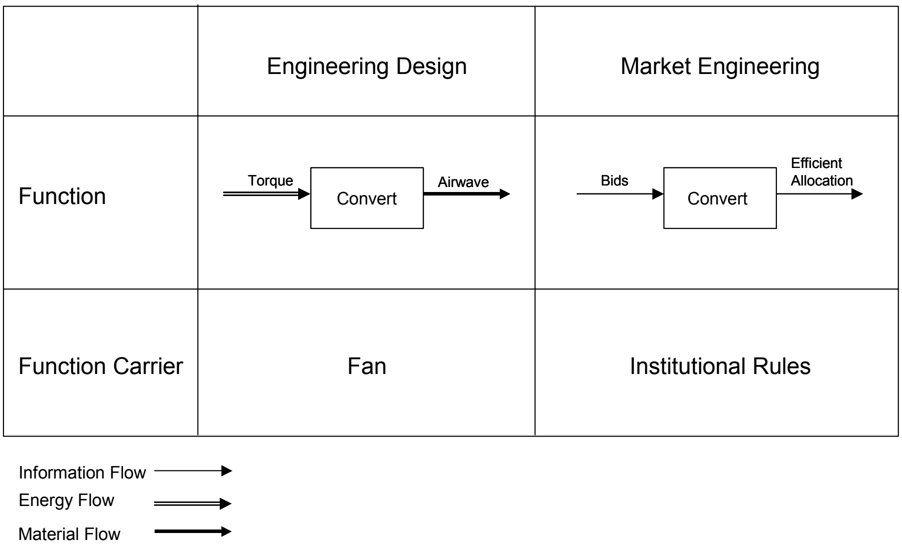

Figure 28: Function vs. Function Carrier

Now the analogy to engineering design may become apparent: the function carriers fulfill their function by entailing physical effects. The process of engineering thus concentrates on the study of physical effects and the design of entities that may enfold those effects. In market engineering the function carriers are institutional rules that incite social effects. As such, market engineering emphasizes the study of social effects and the design of institutional rules as entities that may enfold those social effects.

5.1.2.1 Social versus Physical Effects

Engineering design is founded on the solid fundament of physical processes. Physical processes are based on physical effects. Physical effects in turn can be described by means of a physical law. The existence of physical laws is generally accepted – making the discipline of engineering design that is spawned around physical effects very powerful. When the engineering design approach is transferred to market engineering the question arises, whether the social world is also law governed. Are there social laws analogous to physical laws that give rise to social phenomena? This question is crucial for market engineering, because a negative answer would make market-engineering efforts meaningless.

In this context, two different streams of thought have been emerged about the foundations of social sciences. The first stream – headlined as interpretivist school – argues that the generalization of social behavior into social laws is invalid (Somers 1998). Since all knowledge is historical, culturally specific, unique, particular and singular, it is claimed that there are no regularities among social phenomena. The second stream – headline as empiricist school – contradicts the interpretivist position by affirming the existence of social patterns (Kiser and Hechter 1998). Even more so, this stream conceives the search for prediction-supporting social regularities as the sole task of social science (Little 1993).

Both streams are presumably exaggerating in either the one or the other direction. In social sciences regularities can be found, which can be derived from the behavior of an individual agent in the context of a specific institution (or other social arrangement). However, those social regularities are not *governing regularities* in a sense that a specific behavior is generated according to a law. Instead social regularities are *phenomenal regularities* that emerge from the real casual characteristics of the agents. Thus, these regularities are not prescribing or constraining individual behavior.[186] *"Phenomenal regularities support counterfactuals, so they qualify as law-like, not accidental; but neither are they essential, determining, or regulatory"* (Little 1993). Physical effects clearly reflect governing regularities, whereas social effects are of weaker phenomenal nature. Apparently, social regularities exist, but they emerge not through *"[...] some mysterious social force inherent in the social entity itself"* (Little 1993), but from incentives, opportunities, powers, information and so forth. As such, those regularities are weak.

In engineering design, governing regularities are used to derive solution principles. Essentially, based upon physical laws it is predicted that a function carrier exerts a certain physical effect. The prediction is strong, as these regularities naturally exist. Market engineering, on the contrary, has to deal with phenomenal regularities. Apparently, it is crucial whether those phenomenal regularities are sufficient to make predictions.

Predictions in social science can be generated in two ways. Firstly, the regularities can be used for inferences. If it is a phenomenal regularity that low-income countries have a high infant mortality it can be predicted that particular low-income country has a high infant mortality. Secondly, it is possible to make predictions *"[...] in novel circumstances on the basis of an analysis of the causal mechanisms that we can identify in the circumstance, along with a model that permits us to attempt to estimate the aggregate effect of these causal mechanisms"* (Little 1993). In the first case, the phenomenal effects can be used for prediction. However, those regularities typically assume *ceteris paribus* assumption and are thus weak. It is accordingly essential to study the causal models why this phenomenal effect occurs, which would improve the precision of these regularities (Kiser and Hechter 1998). The second case addresses this, as the phenomenal regularities are derived from causal explanations.[187] As in the first case, predictions also rely on ceteris paribus assumptions, which may be not satisfied in

[186] The distinction between governing and phenomenal regularities basically follows the lines of Cartwright, who distinguishes between fundamental and phenomenological laws (Cartwright 1983; Little 1993).

[187] The types of explanations will be described in more detail in chapter 5.1.2.2.1.3.

the field. Moreover, causal explanations frequently make use of simplification, which diminishes the predictive power considerably. As such, the prediction can be understood as representing tendencies rather than probable outcomes (Little 1993).

At the bottom line, social effects exist but they are of phenomenal nature. They can be used for prediction and thus for market engineering, but their predictive power is limited and should be more used for tendencies than for probable forecasts.

5.1.2.2 Design of the Institutional Rules

As the previous discussion shows, social effects can be used in a market engineering sense to design the electronic market service. The results are, however, weaker than those from engineering design. Now the question arises, how can social effects be used to design the electronic market service?

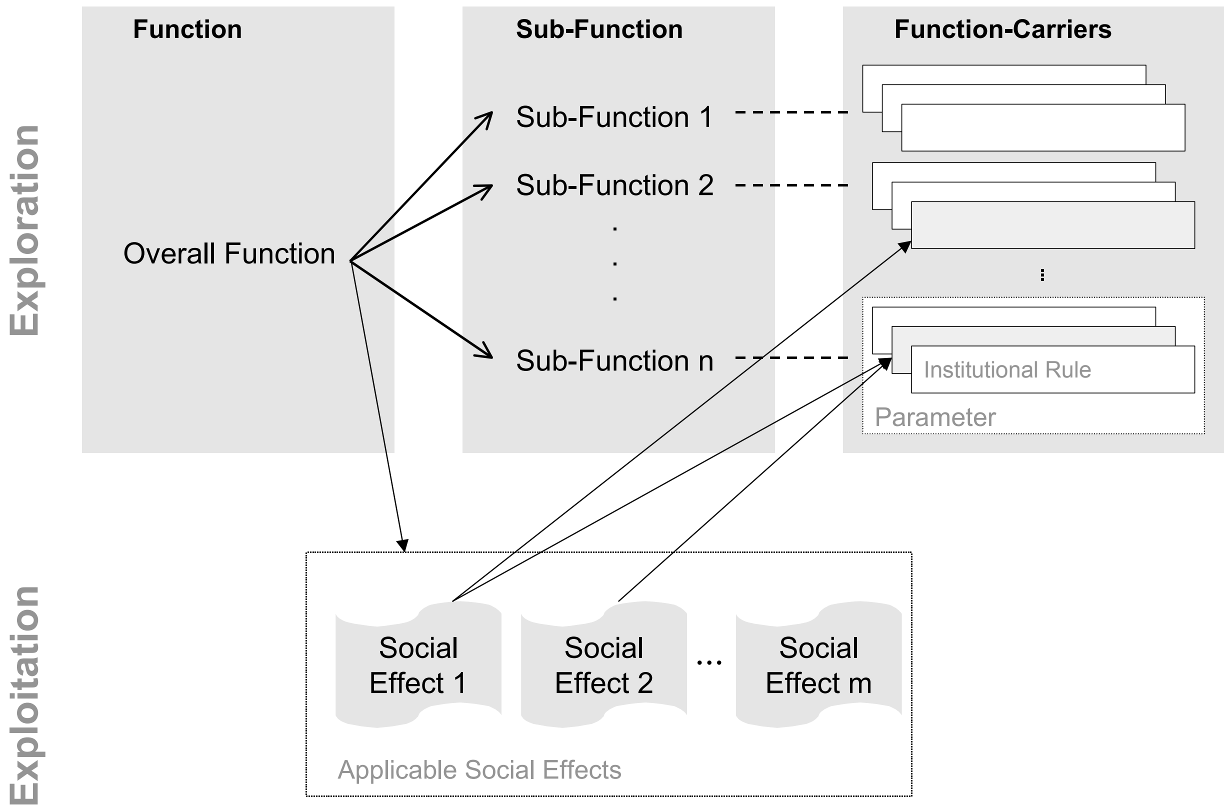

Figure 29: Search for Solutions

At this point a short review of the previous process may be helpful. Principally, the overall function of the electronic market service was stated in terms of a verb-object pair in combination with qualitative criteria concerning the resulting outcome of the electronic market service. In our example the verb-object pair is *"allocate resources"*, whereas the qualitative criteria *"efficiency"*. Whilst the former describes the demanded functionality, the latter refers to the performance of the resource allocation. The overall function is then decomposed into its sub-functions. This decomposition is, however, only guided by the verb-object pair and *not* by the qualitative criteria. This omission stems from the fact that these criteria cannot be determined by any of those sub-functions alone – it is the interplay of the agents within the bounds of the functionality given by the sub-functions that determines them. The sub-functions are further decomposed until a function carrier can be identified. As shown in Figure 29 the function carriers represent institutional rules. Typically, there are possibilities how to design the institutional rules such that they meet the sub-functions.

Which of the institutional rules will be selected (i.e. the shaded boxes in Figure 29), depends on the qualitative criteria of the overall function. Basically, the overall function requires the resulting resource allocation to satisfy some desiderata. All what the designer can do is to design the institutional rules such that (1) they realize the sub-functions and (2) incite a social effect in a way that the resulting outcomes tend to have desirable outcomes. For example, an open bidding procedure as part of the institutional rules tends to produce a more aggressive bidding behavior by the agents, which implies higher revenue. Based upon this social effect the designer can choose from those institutional rules that qualify as function carrier.
From this perspective, the two steps decomposition into sub-functions and search for abstract solutions can be interpreted as follows: The decomposition into sub-functions imposes a specific structure upon the institutional rules. By doing so, the huge design space is reduced to a smaller space consisting of institutional rules that are apt to meet the overall function (exploration). In the subsequent step it is searched for configurations that meet the desiderata based on the available social effects (exploitation). As before, iterations between those two steps are likely to occur.

Principally, all institutional rules must be designed with respect to social effects at a time. However, designing all institutional rules (e.g. trading rules, business rules, enforcement machinery) simultaneously is too difficult due to the interdependencies among the rules. Hence, the design is decomposed according to their input flows. The design of trading rules essentially pertains to the "bid flow" (see Figure 27). Due to the importance of the trading rules their design is exemplarily demonstrated in the following, especially how social effects can be utilized for design.

Parametrization of the Trading rules
As depicted in Figure 29, to each sub-function there potentially exist several possible institutional rules as function carrier. For example, there is more than just one possible institutional rule that satisfies the sub-function *"sense termination"*. The corresponding institutional rule, denoted as closing rule, may for example determine a time- or event-based closing of the bidding process. The term closing rule thus denotes a container for a class of institutional rules that meets the sub-function *"sense termination"*. In other words, the sub-function chain defines generic types or parameters of institutional rules. Subsequently, the design problem reduces to the assignment of one specific institutional rule to each of the parameters. This problem is usually called parametric design or parametrization problems.
More abstractly, it implies that the solution template embodies a fixed assembly of abstract parameters. In Figure 30, the boxes labeled I_1 to I_{15} represent the assembly of parameters. For each parameter a set of possible attributes is known that potentially specifies the parameter. As such, design reduces to the assignment of attributes to the corresponding parameters. The shaded boxes underlying the attributes denote the solution to a parameterization problem (Finger and Dixon 1989; Wielinga and Schreiber 1997).

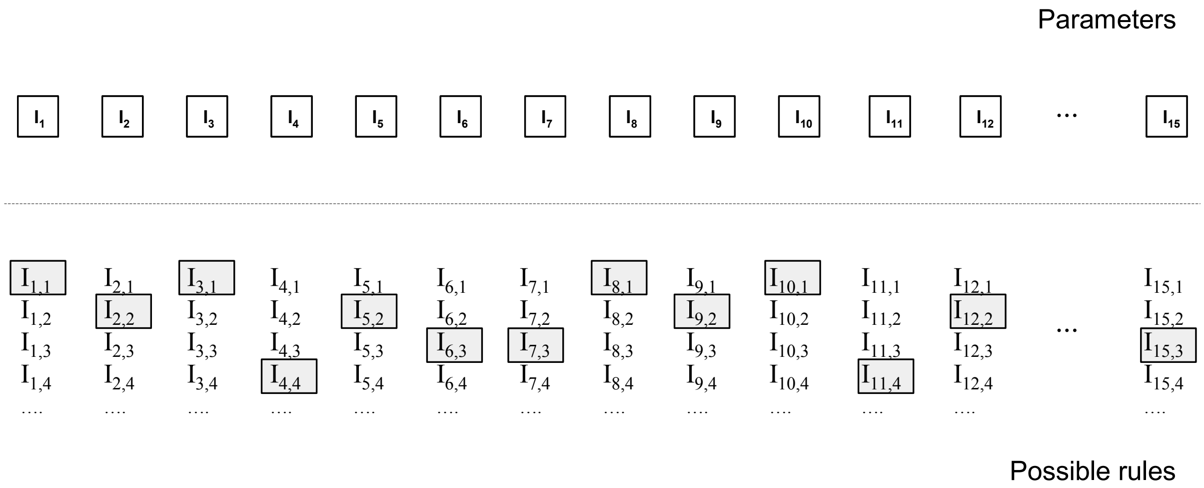

Figure 30: Parametrization Problem

Apparently, the design of the trading rules gives rise to a parametrization problem (Wurman, Wellman et al. 1998; Neumann, Holtmann et al. 2002c). The sub-function chain Figure 27 is translated into the parameter structure given in Table 9.

Sub-Function	*Parameter as generic Function Carrier*	*Notation*	*Description*
Indicate Role	Participation Rule	I_1	Determines what roles are possible
Indicate Language	Bidding Language	I_2	Determines what bids are feasible
Import Bids	Opening Rule	I_3	Schedules the beginning of the bidding process
Sense Activity	Activity Rule	I_4	Checks whether the agent is allowed to place bids.
Sense Internal Dominance - Buy	Internal Dominance Rule – Buyer	I_5	Checks whether the buyer is allowed to make a bid dependent on his own previous bids
Sense Internal Dominance – Sell	Internal Dominance Rule – Seller	I_6	Checks whether the seller is allowed to make a bid dependent on his own previous bids
Sense External Dominance – Buy	External Dominance Rule	I_7	Checks whether the bid is feasible
Remove Bids	Withdrawal Rule	I_8	Determines whether withdrawals are possible
Transmit Provisional Winning bid	Information Revelation Rule – Bidding History	I_9	Determines whether the provisional winning bid is revealed
Sense Timing	Information Revelation Rule – Timing	I_{10}	Sets the time when information is revealed
Transmit Bidding History	Information Revelation Rule – Other Information	I_{11}	Specifies what information about the bidding history is revealed.
Sense Termination	Closing Rule	I_{12}	Determines the time or event when the bidding process terminates.
Convert Ties into allocation	Rationing Rule	I_{13}	Defines the way ties are resolved.
Convert bids into allocation	Choice Rule	I_{14}	Defines the allocation
Convert bids into prices	Transfer Rule	I_{15}	Determines the prices

Table 9: Sub-Functions and Parameters

The fifteen parameters need specification, and hence, give rise to a parametrization problem that is sketched in Figure 30. Example 5.1-1 demonstrates how the parametrization can be used to describe an English auction.

Example 5.1-1: Parametric design of trading rules – English Auction

No	Parameter	Attribute	Description
I_1	Participation Rule	1 – many	A single seller faces many bidders
I_2	Bidding Language	price-bids	All bidders may submit single-unit price bids
I_3	Opening Rule	time triggered	Bidding process starts at a given time
I_4	Activity Rule	Not defined	The English auction does not require this parameter.
I_5	Internal Dominance Rule – Buyer	Not defined	The English auction does not require this parameter.
I_6	Internal Dominance Rule – Seller	Not defined	The English auction does not require this parameter.
I_7	External Dominance Rule	Best buyer price	Buyer must beat the current highest buying bid
I_8	Withdrawal Rule	Forbidden	Repudiation of bids is never allowed
I_9	Information Revelation Rule – Bidding History	Price	The price of the standing highest bid is revealed
I_{10}	Information Revelation Rule – Timing	Activity	Once a new bid becomes provisional winner, the content of the "reveal provisional winning bid" rule is posted
I_{11}	Information Revelation Rule – Other Information	Disclosed	The number of participating agents is disclosed
I_{12}	Closing Rule	Inactivity	Bidding stops when no new bids have been introduced for a while
I_{13}	Rationing Rule	Not defined	The English auction does not require this parameter.
I_{14}	Choice Rule	$h^{English}$	The choice rule of the English auction determines the winning bid
I_{15}	Transfer Rule	$t^{English}$	The transfer rule of the English auction charges from the winner the price of the winning bid (Pay as you bid)

Table 10: A Conceptual Description of an English Auction

Owing to its parametric structure, the design problem reduces to an assignment problem. To any parameter one rule must be assigned to obtain a complete set of trading rules. The process of parametric design is a search process through the space of possible attribute assignments (Wielinga, Akkermans et al. 1995). As the design space can be extremely large, a simple search strategy can become computationally intractable. Parametric design methods have been developed that propose a smart search for solutions (Marcus 1988; Chandrasekaran 1990; Schreiber and Birmingham 1996). Although designing the trading rules is frequently represented either explicitly or implicitly as parametric design problem (Wurman, Wellman et al. 1998; Neumann, Holtmann et al. 2002c; Ströbel and Weinhardt 2003), there does not exist a discursive method that applies general parametric design strategies to the problem of trading rule design (Neumann and Weinhardt 2002).

The reason why there has not yet been developed a discursive approach for designing the trading rules stems from the inherent context sensitivity of trading rules. The difficulty concerned lies in designing the trading rules *such that a desired outcome is achieved*. Principally, the trading rules define an incentive scheme that incurs social effects. Setting the right incentives such that the desired outcome is achieved is extremely difficult, since the social effects trading rules have on the predicted outcome are ultimately dependent on the socio-economic environment. Due to this context sensitivity simple heuristics (e.g. morphological analysis) to classify the trading rules are condemned to fail. Even small changes in the socio-economic environment description exert different incentives that can have unpredicted consequences. In short context-sensitivity massively exacerbates the development of discursive methods.[188]

However, relying on intuitive methods only bears the great danger that market engineering could not attain its objectives of producing electronic markets of reliable quality if its funda-

[188] General classification manuals for trading rules, for example, are difficult to derive because the socio-economic environment decides over the impact on the performance the trading rules have.

mental task of designing the trading rules is not systematically supported. This does not rule out intuitive methods, on the contrary. Intuitive methods are extremely important – nonetheless should they be embedded in a systematic approach. In the following sub-chapters such a discursive approach is attempted.

5.1.2.2.1 Making Economic Design Knowledge Work

In chapter 2.2 an introduction into mechanism theory was given – now this knowledge will be needed for engineering the trading rules. In essence, this sub-chapter attempts to make economic design knowledge accessible for the discursive design process. Hence, the economic design knowledge must be formalized such that it can be stored, retrieved and applied for the design. This is an extremely difficult task due to the inherent context sensitivity and the inherent complexity.

5.1.2.2.1.1 Overview

As suggested by the EMS and the microeconomic system framework in unison, there are five basic concepts that characterize markets:

- The socio-economic environment describes all factors determining demand and supply,
- the institution defining the rules of the game,
- agent behavior describing the bidding behavior of the agents and
- an outcome, which is
- measured in terms of a performance measure.

Those elements are also needed in the formalization of economic design knowledge. But how does this knowledge look like?

This question can be best explained referring to the metaphor of the *mechanism*. In mechanism design the mechanism shows participants what behavior is feasible and, furthermore, with which behavior of the other participating agents they most likely have to deal. Using a game-theoretic equilibrium concept it can be analyzed what outcome, consisting of resource allocation and payments, can be implemented in equilibrium. Comparable with the mechanism the market engineer would require a function that reveals an interpreted statement of the overall system performance given a specified socio-economic environment. This function must show the market engineer what system performance is most likely to occur, given a behavior assumption.

In other words, the function must map the description of the socio-economic environment and institution into an interpreted outcome under the premise that agents follow the behavior assumption. This function would make the trading rule design simple, as the right trading rules can be computed. However, this function is not known and will never be known due to the problems associated with social effects. However, the function need not fully be known – for some environment-institution combinations, it can be inferred from previous theories, experiments, simulations or empirical cases. Those techniques principally extract specific values of the function (i.e. system performance) for special cases (i.e. given socio-economic environment-institution combinations).

In a case-based reasoning manner it is assumed that these cases can be reproduced in a way that the previous system performance is the best guess for the new case. Note that it is a guess that the same system performance is achieved – not a law. But again the context sensitivity aggravates a systematic application of case-based reasoning. Only a very small number of cases compared to the huge number of the possible cases have been explored. The art in engineering the trading rules lies in developing a strategy how current cases can be subsumed under precedent cases. In other words, for new environment-institution combinations – although never been analyzed – it must be possible to make a good guess concerning the future system performance.

As aforementioned, the strategy of subsuming cases relies on social effects or, more precisely, on economic effects.[189] Economic effects in essence create the link between socio-economic environment, institution, and outcome. Basically, economic effects isolate the impact of one element, either from the environment or from the institution, on the outcome. By studying all economic effects that may apply in a certain situation the market engineer gets an understanding what can happen in the new case.

5.1.2.2.1.2 Definitions

As described by the EMS and the microeconomic framework the market engineer needs to know the elements of the institution *I*, the socio-economic environment *EC*, and the outcome *O*. The available knowledge of the market engineer can be denoted as the background *BG*.

Background $BG = (I, EC, O)$

The institution space *I* can be defined as the Cartesian product of *m* institutional rules $I_{i \cdot}$, $i = 1,\dots,m$

$$I = I_1 \times I_2 \times \dots \times I_m \qquad (1)$$

That is an institution *i'* is defined as a specific set of institutional rules.

$$i' \in I : I' = (i'_1, i'_2, \dots, i'_m)^T \qquad (2)$$

This reflects the aforementioned parametric design description. On an abstract level an institution consists of a set of rules specifying the parameters I_i.

Example 5.1-2: Parameter description I

The parameters I_1 to I_{15} denote the rules pertaining to a trading institution.[190] In Table 10 the parameters necessary for describing a resource allocation process span out the institution space *I*. An institution *i'* specifies all parameters with rules. In the English auction example the institution $i^{English}$ is as follows:

[189] In essence economic effects *are* inherently social effects. The difference between these two terms is that economic effects only refer to economic decision problems such as trading, while social effects also take patterns into account that are not economically motivated such as cultural customs.

[190] Throughout this chapter the institution is reduced to trading rules only. This is not necessarily the case, it, however, reduces the complexity considerably. Designing the trading rules is already difficult enough such that the other components of the institution will not be regarded – in subsequent research this simplification may be relaxed.

I_1 = *Participation Rules*
I_2 = *Bidding Languages*
I_3 = *Opening Rules*
I_4 = *Activity Rules*
I_5 = *Internal Dominance Rules – Buyer*
I_6 = *Internal Dominance Rules – Seller*
I_7 = *External Dominance Rules*
I_8 = *Withdrawal Rules*
I_9 = *Information Revelation Rules – Bidding History*
I_{10} = *Information Revelation Rules – Timing*
I_{11} = *Information Revelation Rules – Other Information*
I_{12} = *Closing Rules*
I_{13} = *Rationing Rules*
I_{14} = *Choice Rules*
I_{15} = *Transfer Rules*

$$i^{English} = \begin{pmatrix} \textit{1 - many} \\ \textit{price - bids} \\ \textit{time triggered} \\ \textit{not defined} \\ \textit{not defined} \\ \textit{not defined} \\ \textit{best buyer price} \\ \textit{forbidden} \\ \textit{price} \\ \textit{activity} \\ \textit{disclosed} \\ \textit{inactivity} \\ \textit{not defined} \\ h^{English} \\ t^{English} \end{pmatrix}$$

Institutions are not arbitrarily set but issued in order to attain a certain goal. For example, the institution of an electronic market is intended to assure a good quality of the market outcome.

The outcome O can comprise many objectives.

$$O = \{O_1, O_2, ..., O_{|O|}\} \qquad (3)$$

where

$$o' \in O$$

Example 5.1-3: Outcome

The outcome O denotes the *system performance* of an institution. Originally the outcome was defined as allocation and prices. For a market engineer these are not the relevant measures, as he is interested in the interpretation of these allocations and prices for the market. Thus, he is interested in the total revenue or efficiency the institution achieves. As such, the outcome can for example comprise the following:

O_1 = *Allocative efficiency*
O_2 = *Informational efficiency*
O_3 = *Stability*
O_4 = *Revenue*
O_5 = *Budget balance*
O_6 = *Fairness*
O_7 = *Computational Tractability*
O_8 = *Liquidity*

An explanation of these objectives can be found in sub-chapters 2.1.6, and 3.1.3. For any of those objectives the market engineer knows the values those objectives can take on. For example for the objective *Revenue* $\in O$ there might be four possible values *{low, medium, high, very high}* defined. Principally, the objectives could take on continuous values – nonetheless a discretization of the values is preferred. The reason stems from the fact that economic design knowledge can only produce vague predictions due to the involved uncertainties. A qualitative description of the outcomes is thus preferred.

Institutions enfold their potential to achieve a certain outcome within the boundaries of a socio-economic environment. Depending on the underlying exogenous factors of the economy institutions lead to different outcomes. The socio-economic environment EC is assumed to consist of two different components:

$$EC = E \times U \qquad \text{Socio-Economic Environment} \qquad (4)$$

E denotes those elements of the economic environment that are directly observable. For example, the physical appearance of the traded resource can be obtained by observation. U denotes the other elements of the socio-economic environment that are, in contrast, unobservable. This distinction relies on practical considerations that will follow when the parametric design of institutions is explained.

The observable socio-economic environment E is assumed to be the Cartesian product of the elements of an economic environment, which are observable. The elements of the economic environment are denoted *"observable"*, if their magnitude can principally be observed. It is not necessary that the market engineer can observe them at the moment of design. For example, the number of participating agents is observable, though at the design time, this is not known.

$$E = E_1 \times E_2 \times \ldots \times E_n \qquad \text{Observable Socio-Economic Environment} \quad (5)$$

A particular observable economic environment is then the set of attributes that specify the economic environment.

$$e' \in E : e' = \left(e'_1, e'_2, \ldots, e'_n\right)^T \quad \text{Observable Environment Description}$$

Example 5.1-4: Observable Socio-Economic Environment

An example may clarify the notion of the observable economic environment.

$$\begin{aligned} E_1 &= \textit{Number of Buyers} \\ E_2 &= \textit{Number of Sellers} \\ E_3 &= \textit{Market Power} \\ E_4 &= \textit{Number of Units} \\ E_5 &= \textit{Degree of Homogeneity} \\ E_6 &= \textit{Discreetness} \\ E_7 &= \textit{Perishability} \end{aligned} \qquad e' = \begin{pmatrix} \textit{many} \\ 1 \\ \textit{symmetric} \\ 1 \\ \textit{not defined} \\ \textit{not defined} \\ \textit{no} \end{pmatrix}$$

Apparently, the observable economic environment refers to attributes of the participating agents and the traded resource. For instance, the first two elements specify the number of participating agents. *"Market power"* refers to the heterogeneity of the agents concerning their endowment. The elements *"Number of Units", "Degree of Homogeneity"*, and *"Discreetness"* specify the traded objects. *"Perishability"* is concerned with the durability of the trading object. Apparently, perishability hints at the time-dependence of preferences: if a good is perishable it is conceivable that the preferences decrease as time elapses. For example, the element *"Number of Buyers"* can take on the following values *{many, average, low}*. Again the discretization accounts for the inherent uncertainty.

The unobservable socio-economic environment U is assumed to be the Cartesian product of the elements of an economic environment, which are unobservable. The elements of the economic environment are denoted *"unobservable"*, if their magnitude cannot be observed. In fact, the unobservable economic environment tries to capture all factors that are of abstract nature. For example, the structuring of the preferences or the risk aversion is unobservable.

$$U = U_1 \times U_2 \times \ldots \times U_p \qquad \text{Unobservable Socio-Economic Environment (6)}$$

A particular unobservable socio-economic environment is then the set of attributes that specify the economic environment.

$$u' \in U : u' = \left(u'_1, u'_2, \ldots, u'_p\right)^T \qquad \text{Unobservable Environment Description}$$

Example 5.1-5: Unobservable Socio-Economic Environment

Again, it is easier to explain the unobservable economic environment using an example:

$$\begin{array}{l} U_1 = \textit{Risk Attitude} \\ U_2 = \textit{Preference over Allocations} \\ U_3 = \textit{Preferences over Mechanisms} \\ U_4 = \textit{Time-Dependency} \\ U_5 = \textit{Embeddedness} \\ U_6 = \textit{Substitutability} \\ U_7 = \textit{Arrival Time} \end{array} \qquad u' = \begin{pmatrix} \textit{neutral} \\ \textit{independent private value} \\ \textit{no} \\ \textit{no} \\ \textit{not embedded} \\ \textit{no} \\ \textit{simultaneous at the beginning} \end{pmatrix}$$

Apparently, the unobservable socio-economic environment contains all elements presented in chapter 2.1.2 and 3.1.1, which have not yet been explained. The unobservable economic environment usually comprises those elements that belong to the decision-making process. For example, the risk attitude may explain how aggressive agents place their bids in the market. The way preferences are modeled is in auction theory essential for the conclusions. Without this information hardly any prediction can be made. This makes designing institutions difficult but also challenging. For instance, the parameter *"Risk Attitude"* can take on the values *{risk taking, neutral, averse}*.

With those components (i.e. institution, socio-economic environment, and outcomes) at hand the background $BG = (I, EC, O)$ is defined. Those components, however, do not reveal how some institution affects the outcome given a certain institution.

5.1.2.2.1.3 Modeling Economic Design Knowledge

The definitions of the (1) institution, (2) socio-economic environment, and (3) the outcome basically describe the relevant concepts that are needed. The market engineer faces a given socio-economic environment and designs the institution in a way that a specific outcome is realized. To design institutions, the market engineer needs a good idea how the institution will affect the outcome within a socio-economic environment. Apparently, the market engineer has to make predictions about the reaction of institutions that may have not yet been observed. Meaningful predictions can be based either on causal or on functional explanations (Durkheimer 1982; Jackson 2002b).

- Causal Explanation
  The central idea of causal explanation is the explanatory power of causal mechanisms (Little 1993). Causal mechanisms typically contain references to some forces that are causing a phenomenon. A causal explanation of an event or state X consists of an earlier event or state Y and a set of initial conditions Z, such that there is a causal relation stating that X is implied by the conditions Z and the earlier state Y (Tate 1999).
  Causal explanations are often used for analyzing institutions. More precisely, institutional-logic explanation as instance of causal explanation tries to determine the effect of institutions, i.e. incentives and constraints, on the outcome. Principally, institutional logic is solely grounded in the intentionality of the individual agents whose behavior is confined by the institutions under scrutiny (Little 1993). By means of setting incentives, by changing preferences and by providing opportunities institutions enfold a causal influence on the agent behavior and thus on the outcome. This induced behavior gives rise to a social regularity, *"The mechanisms through which social causation is mediated turn on the structured circumstances of choice of intentional agents, and nothing else"* (Little 1993).

- Functional Explanation
  "There is no consensus on what constitutes functional explanation or how it relates to other types of explanation in social science" (Jackson 2002b). Typically, two models of functional explanations are distinguished (Brandon 1999).

  In the etiological model functional explanation is derived from biology. Basically functional explanations are the opposites of causal explanations. Accordingly, a social phenomenon is not explained by what has caused it, but what it causes. A functional method explains an institution by pointing out the function that the institution performs within a systemic context.

  An institution X is accordingly expressed by its function Y for society Z if and only if (Elster 1979):

  (1) Y is an effect of X
  (2) Y is beneficial for Z
  (3) Y is unintended by the agents producing X
  (4) Y is unrecognized by the society Z
  (5) Y maintains X by a causal feedback loop passing through Z.

  Usually the etiological model is used in the following way: If it can be shown that an institution has unintended, unrecognized, beneficial effects (1)-(4) then, it is (functionally) explained, why it exists and persists (5) (Elster 1979).[191] Functional explanations in this tradition have received major criticisms because the analogy to biology may not hold for institutions. Originally the functional approach referred to living organisms whose internal organs function as a part of the system. The functions basically permit the organism to survive. Any systemic failure would condemn the organism to die (5). Now the analogy to institutions is very vague: once an institution attains undesirable outcomes for the society, the institution must collapse. As *"institutional deaths"* are only rarely to observe, the survival of the fittest explanation underlying (5) may not hold (Jackson 2002b). The etiologi-

[191] Hence, functions can be conceived *as "[...] those observed consequences, which make for the adaptation or adjustment of a given system"*(Merton 1964), p. 51.

cal functional approach has thus largely been shunned in Economics in science and engineering and will be thus neglected in the following.

The causal role model can provide a remedy of functional explanations: The causal role model is founded on the work of Cummins who shifted the focus away from explaining institutions towards explaining the system that surrounds the institution (Cummins 1975). It is an analysis of *"function without purpose"* (Amundson and Lauder 1994): Not the institution is explained but instead how parts of the institution react on the outcome. *"The basic idea behind the causal role analysis of function is that the function of a trait within a complex system is the effect of the trait that helps to explain the behavior of the complex system"* (Brandon 1999). Transferred to institutions, it can be asserted that a part of the institution (i.e. the trait) has a certain effect (performs a function) on the outcome within a specific socio-economic environment. If the socio-economic environment is changed, that part of the institution can lose its function, as it no longer incites the previous effect. Or stated differently, if the socio-economic environment is changed the behavior that led to the previous outcome is no longer reproduced. As such, the institution can no longer maintain its function. The causal role model apparently assumes causal relations to exist, but its explanation *"can shed light on social behavior without delving into a detailed analysis of causality"* (Jackson 2002b).

Modern economic theory has widely been devoted to causal explanations. It is the foremost idea of economic theory to reveal causality based on the study of individual behavior. The functional approach (causal role model) is, in contrast, more descriptive in nature as it concentrates on surface phenomena rather than on the underlying causality. Thus, for economics as a science, causal explanations are appropriate and superior to functional explanations.

When turning the attention to market engineering, this does not hold any more. In market engineering the socio-economic environment is very complex and incompletely known by the designer. As such, it is very doubtful, whether it is possible to specify the precise causal mechanism of individual behavior. Note that economic theory typically explains individual behavior in very restricted environments where the causal influence stems from a unique source only (cf. chapter 2.2). This does not mean that it is impossible to give any explanations about the working of institutions. It is still possible *" [...] to give partial account of how an economic or social system operates [...]"* (Jackson 2002b, 182) – however this theory presumably has a functional notion. In other words, causal explanations enable the market engineer to understand causal mechanisms of individual behavior in reduced, (over-) simplified settings. When statements are given concerning the working of a complex socio-economic environment in the field, those statements are likely to have functional cast (Jackson 2002b).

Apparently, functional explanations are very helpful for engineering, as they allow indeterminacy in its causal mechanisms. As such, functional explanations can accommodate more chains of causality. For example, traditional economics offers causal explanations, how auctions work within a certain environment – say the independent private value model. If assumptions of the causal model are changed, the previous results cannot be maintained, as the causal chain cannot be maintained. Relying on functional explanations those transfers of results are possible, as functional explanations are not restricted to causality. As such, solely causal explanations are inadequate for market engineering, as the workings of the causal mechanisms in real world environments may be too complex to deal with them satisfactorily. Functional explanations may step in providing more open forms of reasoning.
Hence, functional and causal explanations are not contradicting but rather complementary. Causal explanations provide the engineer with theories that can be used for functional expla-

nations. When causal explanations may fail due to the complexity of the socio-economic environment in the field, functional explanations can be used reconciling several causal chains.

Hanson puts it as follows: *"A scientist [...] insists on saying »I do not know« about a theory until it has robust empirical support, or has clear theoretical support from some other empirically-supported theory. A scientist thus bases policy recommendations only on relatively direct data, or on well-supported theory. A scientist who studies social or biological systems also tends to assume that existing systems are functional, and uses that as data to refine theory. A scientist therefore stays quiet about radical new forms of government, which cannot possibly have direct empirical support, and which are too complex for our theories to make direct predictions. An engineer, on the other hand, is more interested in improving systems than in improving theory. An engineer is thus willing to make cruder judgments, farther removed from theory. An engineer is happy to work on a concept with a five percent chance of success, if the payoff from success would be thirty times the cost of trying. An engineer uses theory explicitly as far as it will go, but also uses theory-informed intuitions to more informally think about a wide range of design issues"* (Hanson 2003).

In summary of the previous discussion, market engineering adopts functional explanations that are grounded on causal explanations derived by economic theory. In the following two approaches are discussed, how to realize the functional approach for market engineering. The first approach treats the institution as a monolithic piece. Although rather intuitive, the approach lacks the advantages of functional explanations as will be shown. Subsequently, the approach dubbed *"effect-based"* approach is demonstrated, which has the potential of guiding the design of institutions beyond the boundaries of existing (causal) theory.

A Naïve Approach

A naïve approach would be to find a function F that maps the institution I, and the socio-economic environment $EC = E \times U$ into possible outcomes O.[192] That is

$$F : I \times E \times U \to O \qquad (7)$$

If it is assumed that function F is fully specified, the problem of designing the institution is straightforward. For any complete description of the microeconomic system $I \times E \times U$ (that is every element of the institution and economic environment is defined) the function would provide an estimation of the outcome. Apparently, for the mapping the function requires assumptions about agent behavior. Implicitly, the function must translate agent behavior into outcomes, which will be assessed. Such a function, if existent, would make the design problem straightforward, as the institution proposals can objectively be compared with each other.

[192] Note that some causal mechanism underlies function F, which is not specified. As such function F cannot provide any causal explanation.

Example 5.1-6: A Naïve Approach

According to the naïve approach, the function would require the full description of the institution *I* and the socio-economic environment $EC = E \times U$:

$$i^{English} = \begin{pmatrix} \textit{1 - many} \\ \textit{price - bids} \\ \textit{time - triggered} \\ \textit{not defined} \\ \textit{not defined} \\ \textit{not defined} \\ \textit{best buyer price} \\ \textit{forbidden} \\ \textit{price} \\ \textit{activity} \\ \textit{disclosed} \\ \textit{inactivity} \\ \textit{not defined} \\ h^{English} \\ t^{English} \end{pmatrix} \quad e' = \begin{pmatrix} \textit{many} \\ \textit{1} \\ \textit{symmetric} \\ \textit{1} \\ \textit{not defined} \\ \textit{not defined} \\ \textit{no} \end{pmatrix} \quad u' = \begin{pmatrix} \textit{neutral} \\ \textit{independent private value} \\ \textit{no} \\ \textit{no} \\ \textit{not embedded} \\ \textit{no} \\ \textit{simultaneous at the beginning} \end{pmatrix}$$

As a matter of fact, this example sketches an English auction in the symmetric, independent private value model with many bidders in a single unit case. For this problem, it is commonly known that the outcome amounts to a decent expected revenue. Thus, the function yields *{high}* Revenue as interpreted output *o'*.

This approach is as abovementioned naïve, as the function *F* is not known. The function *F* can hardly be conceived as being mathematically formulized, as it tries to capture the effect of human interaction along the market process. Rather is the function more a theoretical construct, which can be described by its discrete function values $F((i,e,u)) \in O$ with $(i,e,u) \in I \times E \times U$.

Even the extraction of the function values is difficult, as presumably no formal model will ever exist that can capture the complexity of the economic environment without imposing on a special functional form. The conclusions from models probably hinge upon those special functional forms, diminishing the value of those complex models (McAfee and McMillan 1996). This argument vigorously contradicts against the naïve approach, since it is not possible to generate the function values.

Principally, it is possible to empirically observe the outcomes of the institution in certain environments. However, those observations are not facts but interpretations. The economic observations must be interpreted, which is particularly difficult for elements of the unobservable environment *U*. Furthermore, by observation only already existing institutions can be tested.

Suppose for a moment the interpretation problem is solved, then, the extraction of the function values would be possible. Nonetheless, it is still unlikely that the function can ever be completely described: The example demonstrates that the input space of the function – the specification of the microeconomic system $I \times E \times U$ – is huge. As such, the numbers of feasible variations is also extremely high. Apparently, the observed function values are extremely small in comparison to the space the institution and economic environment span out.

By treating the institution as a monolith, the potential of the functional approach cannot be extracted. The naïve approach is rather limited, as only the results of the causal models can be codified without their reasoning. This is unsatisfactory, as the shift to the functional approach was reasoned by the increase in the explanatory power.

Effect-based Approach

Consequently, the naïve approach is no longer pursued. Instead an effect-based approach is suggested. The intuition of an effect-based approach follows the causal role model. That is to concentrate the reasoning on pure effects rather than on causality. In essence, pure effects describe the changes of the outcome dependent on a single variable. Those pure effects can be studied by means of simple models, which require fewer assumptions than (all-comprehensive) complex models. Since the simple models may not rely on special functional forms, their findings tend to be more reliable. Instead of concentrating on one complex model of controversial explanatory power, the effect-based approach depends on several models each capturing a part of the original problem. The total effect of the complex model is the combination of pure effects. For example, some models capture the effect simultaneous bidding has on multiple goods while other models analyze the impact of ascending bidding formats on the bidding strategy. When those two elements, simultaneous bidding and ascending bidding, are combined into a simultaneous ascending auction the total effect can be constructed from the combination of the pure effects (McAfee and McMillan 1996; Roth 2002). McMillan and McAfee summarize the role of effects and simple models as follows:

"A lesson from this experience of theorists in policy-making is that the real value of the theory is in developing intuition. The role of theory, in any policy application, is to show how people behave in various circumstances, and to identify the tradeoffs involved in altering those circumstances. What the theorists found to be the most useful in designing the auction and advising the bidders was not complicated models that try to capture a lot of reality at the costs of relying on special functional forms. Such theorizing fails to develop intuition, as it confounds the effects of the functional forms with the essential elements of the model. A focused model that isolates a particular effect and assumes few or no special functional forms is more helpful in building understanding" (McAfee and McMillan 1996, 172).

Following this intuition, an effect-based approach is suggested. Basically, economic effects bridge the gap between the economic environment and the institution on the one hand and the outcome on the other hand.

Economic Effects

Economic effects describe the impact of one or more elements of the institution and economic environment on the outcome.

Definition 15: Economic Effect

An economic effect F is defined as the stable mapping of a set defined on the institution-environment combination into an outcome. That is

$$F : I \times E \times U \rightarrow O \qquad (8)$$

Different than the naïve function, an economic effect does not require a complete specification of the economic environment and the institution. Principally, an economic effect is already defined on *parts* of the economic environment and the institution. The domain on which the economic effect is defined is rather limited. Recall that an economic effect isolates the impact of a single variable on the outcome given a specific institution and economic institution. For example, an economic effect can describe the impact that the bidding language has when the auction is ascending in an independent private value model. Since not only elements of the institution can be subject to change but also the elements from the observable and unobservable environment, three different types of economic effects can generically be distinguished:

(i) Institution-based effects,
(ii) Observable socio-economic-environment-based effects,
(iii) Unobservable socio-economic-environment-based effects.

(i) Institution-based effect

An institution-based effect isolates the effect of changing institution element $i_l \in I_l, l \in \{1,...,m\}$ on an outcome $o' \in O$. This effect, however, only occurs when some elements of the institution and the socio-economic environment are present. In other words, an effect is dependent on the occurrence of other, required parameters. Before the institution-based effect is defined, three simplifications will be introduced:

First of all, the observable socio-economic environment E will be separated into two parts. The first part contains the required elements of the observable socio-economic environment that are required for the effect, while the second part contains the elements that are arbitrary. For this purpose two index sets K and J characterizing all elements of the observable socio-economic environment are introduced.

$$\exists K \wedge J : K \subseteq \{1,...,n\}, J = \{1,...,n\} \setminus K$$

Without loss of generality it can be written that

$$K=\{1,...,k\} \wedge J = \{k+1,...,n\}$$

Let the index set K contain all elements that are required by the effect and the index set J contain all elements that are arbitrary for the effect to occur. Then, any observable economic environment e can be described as follows:

$$e \in E : e = (\underbrace{e_1, e_2, ..., e_k}_{\text{required elements}}, \underbrace{e_{k+1}, e_{k+2}, ..., e_n}_{\text{arbitrary elements}})$$

Apparently, the effect is no longer dependent on the entire space E but on a partial space determined by the required elements. For instance, if an effect is robust with respect to the number of units E_4 that are auctioned off, then the element $e_4 \in E_4$ is arbitrary.
Hence, in this example $J = \{4\}$, and $K = \{1,2,3,5,6,7\}$

For the unobservable socio-economic environment, it can be preceded in the same manner. Accordingly, there are also two index sets P and Q:

$$\exists P \wedge Q : P \subseteq \{1,..., p\}, Q = \{1,..., p\} \setminus P$$

Again, without loss of generality it can be stated that

$$P=\{1,\ldots,h\} \wedge Q=\{h+1,\ldots,p\}$$

In analogy to the observable part of the socio-economic environment, let the index set P contain all elements that are required by the effect and the index set Q contain all elements that are arbitrary for the effect to occur. Then, any unobservable economic environment u can be described as follows:

$$u \in U : u = (\underbrace{u_1, u_2, \ldots, u_h}_{\text{required elements}}, \underbrace{u_{h+1}, u_{h+2}, \ldots, u_p}_{\text{arbitrary elements}})$$

Lastly, the institution will be separated into three different parts. Firstly, into the element that is varied, secondly into required elements and thirdly, into arbitrary elements. In other words, the effect also requires certain elements of the institution to be fixed. For the separation three index sets will be defined. Two index sets, V and W, may contain all elements of the institution except one. This element l denotes the element that is subject to change. As such l belongs to a third index set, which is a singleton.

$$\exists V \wedge W \wedge \{l\} : V \subseteq \{1,\ldots,m\} \setminus \{l\}, W = \{1,\ldots,m\} \setminus (V \cup \{l\})$$

Element l denotes the designated element of the institution that is variable. Without loss of generality it can be written that

$$V=\{1,\ldots,j\} \wedge W=\{j+1,\ldots,m\} \wedge l \notin V \wedge l \notin W$$

Let V contain all the elements that are required, and W contain all elements that are arbitrary for the effect to occur. Then, any institution i can be written as follows:

$$\forall i \in I : i = (\underbrace{i_1, i_2, \ldots, i_j}_{\text{required elements}}, \underbrace{i_{j+1}, i_{j+2}, \ldots, i_{l-1}}_{\text{arbitrary elements}}, \underset{\substack{\uparrow \\ \text{designated element} \\ \text{that is subject to} \\ \text{change}}}{i_l}, \underbrace{i_{l+1}, \ldots, i_m}_{\text{arbitrary elements}})$$

For those institution-environment combinations that satisfy the required elements the effect applies. The effect of element i_l on the outcome $o' \in O$ can now be stated as $F(i_l, i_{-l}, e', u') = o'$, where i_{l-1} denotes all elements of the institution except the varying element. Note that $i=(i_l, i_{-l})$ with $i_{-l}=(i_1,\ldots,i_{l-1},i_{l+1},\ldots,i_m)$

Example 5.1-7: Institution-based effect

Effects can be best understood by means of an example. The economic effect that will be demonstrated is taken from auction theory and headlined here as *"number uncertainty"* (cf. chapter 2.2.1.2.1.1). Suppose the socio-economic environment is given by an independent private value setting with risk aversive agents and many agents taking part: The employed institution is basically a First-Price-Sealed-Bid auction in its simplest form.

That is:

$$i^{FPSB} = \begin{pmatrix} 1-many \\ single\ price-bid \\ time-triggerd \\ i_4 \\ i_5 \\ i_6 \\ sealed \\ forbidden \\ i_9 \\ i_{10} \\ \boxed{i_l} \\ All\ bids\ submitted \\ h^{English} \\ t^{English} \end{pmatrix} \quad e' = \begin{pmatrix} many \\ 1 \\ symmetric \\ 1 \\ homogeneous \\ discrete \\ not\ perishable \end{pmatrix} \quad u' = \begin{pmatrix} averse \\ independent\ private\ values \\ not\ time-dependent \\ not\ embedded \\ no \\ u_6 \\ simultaneous \end{pmatrix}$$

Accordingly, in this example is
$i^{FPSB} \in I$ with the index sets $V = \{1,2,3,7,8,12,13,14,15\}$, $W = \{4,5,6,9,10\}$, and $l = \{11\}$
$u' \in U$ with the index sets $P = \{1,2,3,4,5,6,7\}$ and $Q = \varnothing$
$e' \in E$ with the index sets $K = \{1,2,3,4,5,7\}$ and $J = \{6\}$

Not all elements of the socio-economic environment and institution are required by the effect: Basically, the observable socio-economic environment is fully required, whereas the unobservable socio-economic environment is almost fully required. Only the institution leaves several elements open. [193]

Apparently, the number of required elements is very long, exhibiting the context sensitivity for that respective effect. Principally, economic effects should specify as few as possible elements to be *required*. The fewer elements are required, the more universal the effect is. Unfortunately, in many cases effects are very context dependent, leaving only few arbitrary elements.

Now, the varying element of the effect *"number uncertainty"* is the degree of information feedback about the participating agents $i_{11} \in I_{11}$. For example, suppose there are two possibilities either $i_{11} = no\ information$ or $i_{11} = full\ information$. In the latter case *"full information"* the auction format reveals the exact number of participating agents to the agents, while in the former this information is concealed. What is searched for is the impact of the information feedback concerning the revenue. Stated differently, the effect basically describes the relationship that the revenue increases in a First-Price-Sealed-Bid auction, when information about the number of participating agents is disclosed. The

[193] Note that the institution description is a subset of the complete description. This illustrates that the first-price sealed bid auction is rather a class of auctions.

functional approach alone just describes what happens as an aggregate, but does not provide a causal explanation why it is so. However, the functional approach basically relies on causal models from auction theory, which can give reason for this effect: when the information is disclosed the agents bid more aggressively. Since the First-Price-Sealed-Bid auction employs a discriminative transfer function, more aggressive bidding ceteris paribus results in higher revenue. As the standard First-Price-Sealed-Bid auction is assumed to attain *"average"* revenue when bidders are risk-neutral[194], the revenue is higher when the bidders are risk averse. Thus, alternative *"no information"* is predicted to receive *"high"* revenue, while the other alternative *"full information"* yields *"very high"* revenue (cf. Figure 31).

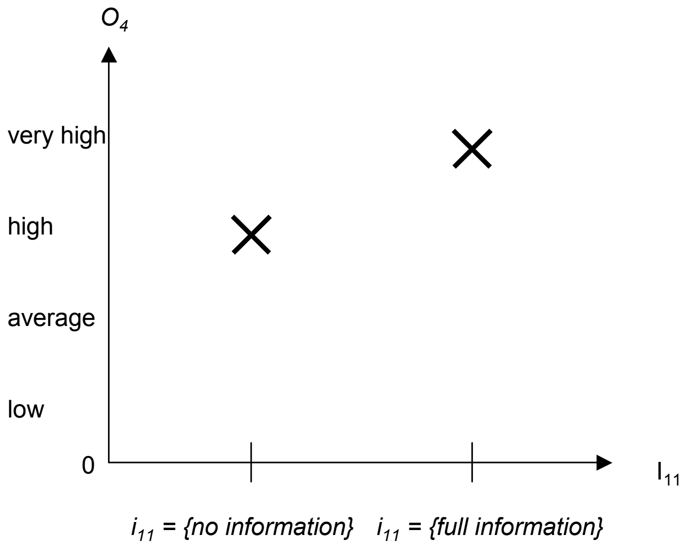

Figure 31: Number uncertainty

(ii) Observable socio-economic-environment-based effect

An observable socio-economic-environment-based effect (henceforth, OEE effect) isolates the effect of a changing element e_l of the observable socio-economic environment on an outcome *o'*. In analogy to institution-based effects, OEE effects only occur when some elements of the institution and the socio-economic environment are present.

OEE effects are completely identical to institution-based effects only the designated element e_l subject to change is part of the socio-economic environment: $F(i', e'_l, e'_{-l}, u') = o'$.

Example 5.1-8: OEE effect

The OEE effect denoted *"changing numbers of bidders"* captures the effect that in Dutch auctions under an independent private value setting a higher number of participating agents yields higher expected revenue (cf. chapter 2.2.1.2.1.1). This basic economic effect stems from the fact that agents must bid higher to attain the same probability of winning if the number of agents is successively increased.

(iii) Unobservable socio-economic-environment-based effect

Lastly, unobservable socio-economic-environment-based effects (henceforth UEE effects) are defined as the previous effects, only that the changing element u_l is element of unobservable socio-economic environment. As before, the effects are context-sensitive in a way that the

[194] For the determination of the outcome it is necessary to define a benchmark. In auction theory it is quite common to denote the symmetric independent private value model as benchmark. As such, the First-Price-Sealed-Bid auction in the benchmark model is assumed to yield "average" revenues.

UEE effect requires certain elements of the institution-environment combination in order to enfold. Furthermore, the effect is identical to the previous ones; only the changing element is part of the unobservable socio-economic environment. That is, $F(i', e', u'_l, u'_{-l}) = o'$.

> **Special case: Impossibility theorems**
> The main contribution of mechanism design theory was the derivation of impossibility theorems. The impossibility theorems state in rather general terms, what outcome is impossible (cf. chapter 2.2.1). For example, the Green-Laffont impossibility theorem rules out that the outcome is allocative efficient, when the preferences are quasi-linear and single-units of the same resource are allocated. Impossibility theorems thus have the form $F(i', e', u') \neq o'$ where almost all elements of the institution are arbitrary[195], whereas elements of the socio-economic environment can be required.
> Note that possibility theorems – on the contrary – cannot be used, as these theorems only show the possibility. However, as there may exist multiple outcomes it is not a social regularity that these desirable outcomes will occur. For instance, the Generalized Vickrey auction implements an efficient allocation even if complementarities among the resources exist. Due to empirical and theoretical concerns (Rothkopf, Teisberg et al. 1990; Lucking-Reiley 2000; Milgrom 2004) it is impossible to construct a reliable social effect from this theorem.

The notion of economic effects is extremely difficult to perceive, as Figure 32 demonstrates. In essence, Figure 32 sketches idealized in a three-dimensional graph an economic effect F_1, which maps points from the institution-environment plane into an outcome.[196] Any point in the institution-environment plane represents a particular state of the economy. What is needed is a prediction how this institution-environment combination will perform in terms of the outcome O. The two ovals in the plane denote the area for which the economic effect F_1 is defined. While the institution-environment combinations in the shaded oval are mapped into the higher outcome o_1, the white oval is mapped into the lower outcome o_2. Both ovals share common elements of the environment and/or institution.[197] For instance, both ovals may contain all conceivable environments that are characterized by *"independent private"* values and institutions with *"ascending bidding"*. The two ovals differ with respect to one single variable either from the environment or from the institution. For example, the shaded oval may contain *"full information"* as information revelation rule –other information, while the curtailed white may contain *"no information"*. Dependent on this distinction in the information revelation rule the effect either predicts a higher or lower outcome. As there are many environment-institution combinations that share those characteristics the effects are defined over a cloud of points captured by the ovals.

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[195] More precisely, for Groves mechanisms the impossibility does not hold (cf. chapter 2.2.1.1.1).

[196] Essentially Figure 31 and Figure 32 are alike. What is differing is that Figure 31 holds the environment-institution combination constant. Figure 32 shows the effect with respect to all institution-environment combinations.

[197] Note that Figure 32 is merely a figure for deliberation. Basically the environment-institution space is a multidimensional space. The two ovals can thus share common elements without intersecting each other.

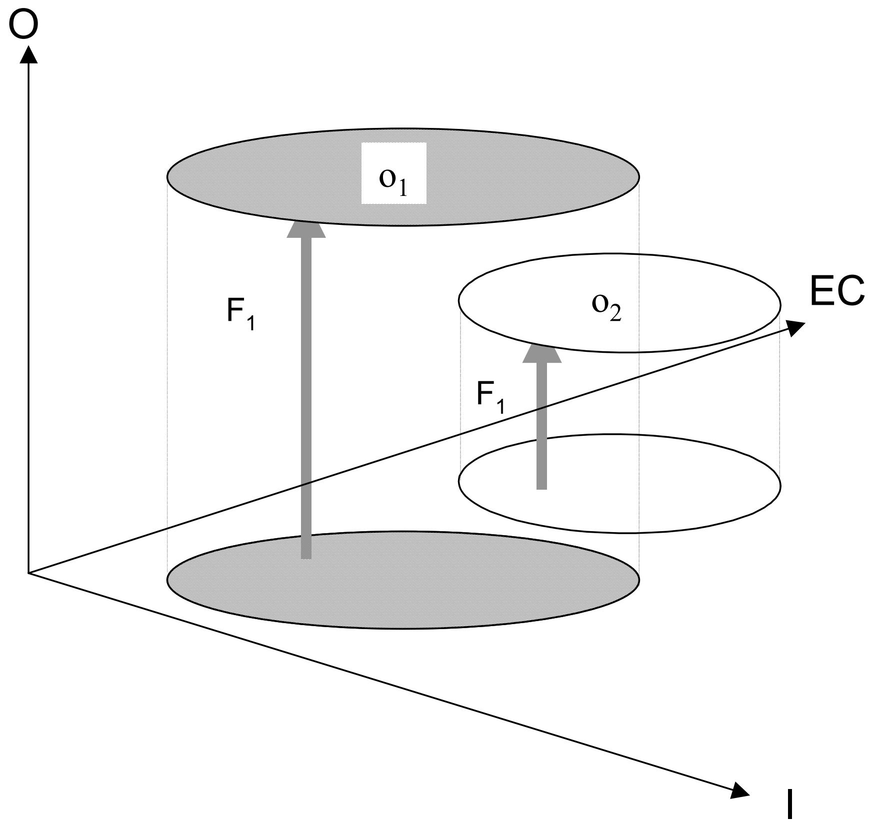

Figure 32: Representing Economic Effects

The set of all economic effects that are known is finite and given by :

$$F_{Possible} = \{F_1, F_2, ..., F_{|F_{Possible}|}\} \qquad \text{Set of all Economic Effects}$$

5.1.2.2.1.4 Domain Theory of Economic Design

Embattled with those effects, it is possible to construct a domain theory based on functional explanations. In essence, the effects are defined on a space of institution-environment combinations. Figure 33 illustrates the effects by the arrows mapping the institution-environment combinations to the outcome. The ovals in the institution-environment space represent the applicability of the corresponding effects.[198] By referring to an area it is accounted for the fact that the effects require only a subset of the institution and environment parameters.

In order to predict the impact on the outcome, it is necessary to identify the exact location within the institution-environment space, and thereby, all applicable effects.[199] Figure 33 demonstrates, however, the drawbacks of this approach. It can happen that for an institution-environment combination two effects are applicable that are contradicting each other (see the intersection of the ovals in Figure 33). The domain theory has thus to offer a construct how to resolve those contradictions.

[198] Note that the effect description $ED(F_1)$ of effect F_1 also comprehends the second oval which is represented by the dashed line. Since point ED* is captured by the shaded oval the other –for this point irrelevant – oval is only schematically shown.

[199] This deviates from causal economic theory, which specifies an economic environment and a concrete institution and derives by game-theoretic reasoning the equilibrium outcome.

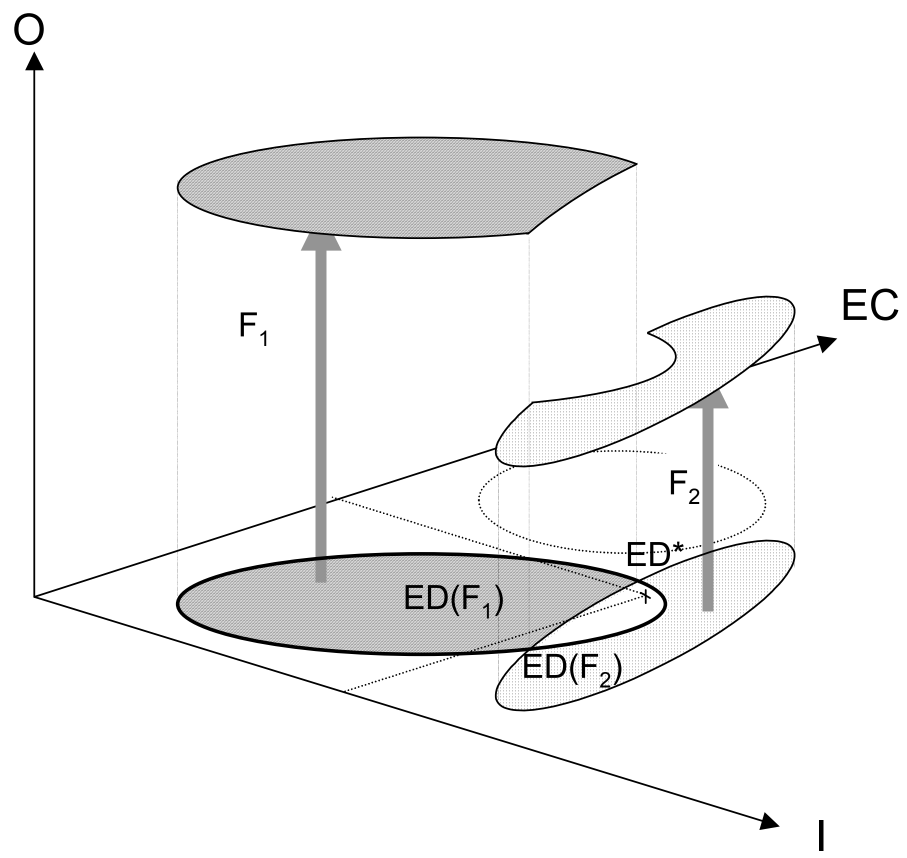

Figure 33: Representing the Domain Theory

Apparently, the effects alone are insufficient to represent the entire domain theory. The following definitions are intended to provide the remaining elements of the domain theory.

Firstly, let the function *ED(F)* – the state of the economy – return the effect description, consisting of the institution-economic environment description on which the effect is defined

$$ED(F) \subseteq I \times E \times U \qquad \text{Effect Description} \qquad (9)$$

In other words, *ED* yields for any effect, say F_1, all institution-economic environment combinations for which the required elements of the effect are given. Those required elements span out a space on which the effect may occur. This space is represented by the ovals in Figure 33.[200]

Now it is possible to demonstrate how functional explanations can be constructed. For example, ED^* denotes the institution-economic environment combination for which the outcome $o \in O$ is unknown (see Figure 33). First of all, the applicable economic effects can be identified. The applicable economic effects are basically those effects for which ED^* is part of the effect description *ED(F)*.

Definition 16: Applicable Economic Effect

$$\overline{F}^{ED} := \left\{ F \in F_{Possible} \mid ED(F) \supseteq ED^* \right\}$$

[200] Note that the variable of the effect is <u>*not*</u> included in the environment description.

The set of all applicable economic effects for state ED^* is given

$$\overline{F}^{ED} = \{F_1, F_2, \ldots, F_{|\overline{F}|}\}$$

which is finite.

That is, effect F is said to be applicable for a given description ED^* if and only if the used effect description is part of the given effect description ED. In Figure 33 the given effect description ED^* is captured by the effect description of F_1 and F_2.

Example 5.1-9: Applicable Economic Effect

Suppose the state of the economy is determined by the economic environment that is characterized by an independent private value setting with risk-averse agents, many agents participating, and by a First-Price Sealed Bid auction as institution: For this state ED^* the economic effect *"number uncertainty"* applies.

Two economic effects that are applicable for the same state ED^* and predicting a different outcome are contradicting. For example, in Figure 33 the two applicable effects, F_1 and F_2, suggest contradictory outcomes. While F_1 predicts a higher outcome F_2 suggests a lower outcome.

Definition 17: Contradict

An effect F_1 contradicts F_2 if, and only if,

(i) $F_1, F_2 \in \overline{F}^{ED}$,

(ii) $F_1(i^1, e^1, u^1) = o'_1 \neq o'_2 = F_2(i^2, e^2, u^2)$ and $o'_1, o'_2 \in O'$, $(i^1, e^1, u^1) \in ED(F_1)$, $(i^2, e^2, u^2) \in ED(F_2)$

Example 5.1-10: Contradiction

Suppose the state of the economy specifies an ascending auction in an environment, which is characterized by independent private values, one unit to sell, one seller, and many buyers. Then, two effects are applicable. Firstly, the OEE-effect observational learning applies in this setting owing to its iterative bidding procedure with open bids. The agents learn by observing the bids of the other agents. A higher number of bidders increase real competition in this auction. In independent private value settings rational agents bid up to their valuation and then drop out. As such, an increasing number of agents leads ceteris paribus to higher bids and thus to higher expected revenue. When many buyers are present, observational learning entails revenue of *"high"* on a four-scale. However, there is also another OEE-effect countering observational learning. This OEE-effect, *entry deterrence* also applies to this state of the economy. Principally, the agents can forgo the chance of bidding, since only the agent with the highest valuation will eventually win the auction. Agents with slightly lower valuation will not have a chance to obtain the unit and, thus forgo the chance of bidding, resulting in lower competition (Klemperer 2002). Apparently, the predicted revenue will not be *"high"*. As such, the effects are contradicting.

Apparently, these competing effects must be resolved. The overrule function returns the composite effect of two or more competing effects.

Definition 18: Overrule Function

The total effect $F^* \in \overline{F}^{ED}$ of contradicting effects $F_1, F_2, ..., F_n \in \overline{F}^{ED}$ can be written as by the overrule function r for ED.

$$r^{ED} : pow(\overline{F}^{ED}) \rightarrow F^* \in \overline{F}^{ED}$$

Note that *pow* stands for the power set.

That is

$$r^{ED} \in R^{ED} : r^{ED}\left(\widetilde{F}\right) = F^* \in \overline{F}^{ED} .$$

where $\widetilde{F} \in pow\left(\overline{F}^{ED}\right)$

F^* overrules the contradicting effects and determines the outcome prediction.

Definition 19: Set of Overrule Function

$$R^{ED} = \left\{r_1^{ED}, r_2^{ED}, ..., r_m^{ED}\right\}$$

R^{ED} denotes for a given ED^* the set of all applicable overrule functions.

In Figure 33 effects F_1 and F_2 are contradicting. The overrule function may for instance reveal that effect F_2 is totally dominated by F_1. Hence, if both effects occur together F_2 looses its predictive power. The overrule function is not only defined over a pair of effects but on the power set of applicable effects.

Example 5.1-11: Overrule contradiction

Example 5.1-10 sketched the contradiction between the effects *"entry deterrence"* and *"observational learning"*. While the former effect tends to favor lower revenue the latter promotes higher revenue. This contradiction is difficult to resolve, but it is possible. Recall that the state of the economy denoted many buyers potentially taking part in the auction. As such, it is likely that the effect of observational learning will prevail. The ascending auction will thus achieve high revenues as a composite effect.

Overruling functions are difficult to obtain, as economic theory (causal explanations) has limits: "*Theory sometimes shows that there are effects that work in opposite directions from each other, and data are needed to establish which effect is likely to be dominant"* (McMillan 1994, 151). Facing grounds where economic theory is silent, the market engineer must – as aforementioned – make crude judgments beyond the borders of economic theory (Hanson 2003). Apparently, it is very likely that domain theory cannot resolve the conflict. In such a case the outcome is unpredictable. Either the effects are irresolvable in a way that there is no stable behavior – the one or the other effect arbitrarily dominates. Alternatively, it may be the case that those effects have never been studied before and guesses are very vague. This would suggest for a new laboratory experiment extracting the composite effect, where the experimental design is tentatively given by the effect descriptions.[201]

As previously mentioned, there is no guarantee that a stable overruling effect really exists. A stable overruling function would suggest that the institution could indeed incite a social regu-

[201] Other forms of knowledge acquisition such as simulations or models are certainly also applicable.

larity within a certain environment. In many cases it will, however, not exist such that no predictions can be made.

Principally, if more economic effects, say $\{F_1, F_2\} \in pow(\overline{F}^{ED})$ and $\{F_1, F_2, F_3\} \in pow(\overline{F}^{ED})$ are contradicting, it is possible that the conflict cannot be resolved. For example, $r_1^{ED}(\{F_1, F_2\}) = F_1$ and $r_2^{ED}(\{F_1, F_2, F_3\}) = F_2$. In those cases it is assumed that the overrule function defined on more effects overrules the overrule function on less effects.

Thus, the assumption can be formalized as follows:
$r(\widetilde{F})$ overrules $r(\widetilde{F}')$ if and only if $|\widetilde{F}'| < |\widetilde{F}|$. With this assumption in mind, $r_2^{ED}(\{F_1, F_2, F_3\})$ overrules $r_1^{ED}(\{F_1, F_2\})$.[202]

By means of the overrule function a defeat can be defined:

Definition 20: Defeat

F_1 defeats F_2 if and only if $r^{ED}(\{F_1, F_2\}) = F_1 \in \overline{F}^{ED}$ and $r^{ED} \in R^{ED}$

Now, an economic theory can be formulated, which explains for a given economic environment-institution combination a resulting outcome.

Definition 21: Effect-dominated Economic Theory

An effect-dominated economic theory is a tupel $M = (ED, \hat{F}^{ED}, \hat{R}^{ED})$

- $\hat{F}^{ED} \subseteq \overline{F}^{ED}$ with $F_i \in \hat{F}^{ED}$
- $\hat{R}^{ED} \subseteq R^{ED}$
- There is no effect $F_j \in \hat{F}^{ED}$ that defeats F_i

In other words, in this socio-economic environment it can be predicted that the outcome associated with effect F_i will be attained, as there is no contradictory effect that overrules this effect. Note that this theory gives, however, no causal but a functional explanation of a social regularity.

202 It is still possible that the overrule functions $r_1^{ED}(\{F_1, F_2\}) = o'_1$ and $r_2^{ED}(\{F_2, F_3\}) = o'_2$ where $o'_1 \neq o'_2, o'_1, o'_2 \in O$ contradict one other. If no further overrule function is available the contradiction cannot be resolved. Again this can mean that no stable composite effect exists or that this effect is unknown – calling for a laboratory experiment,

5.1.2.2.2 Parametric Design

Having specified the peculiarities of the domain knowledge, the corresponding design method can be sketched. In essence the presented method can be subsumed under the roof of propose and revise: [203]

<u>Problem Formulation</u>

At the outset of the design problem the market engineer has two pieces of information, being the observable socio-economic environment *e'* and the desired outcome $\bar{o} \in O$ (e.g. high revenue), which is for simplicity assumed to be single-valued.[204] Now the problem is to define an institution $i*$, which implements the desired outcome $\bar{o}$ within the context of the socio-economic environment *e'*. Apparently, the socio-economic environment is hopelessly under-specified. This is inevitable since the unobservables of the socio-economic environment *u'* are simply unknown and cannot be obtained, which hinders the design tremendously, as McMillan summarizes: *"[...] implementing a recommendation of the theory may require knowledge that is unavailable. In particular, some of what auction theory identifies as optimal seller strategies depend on the distribution of bidders' valuations, which were not known"* (McMillan 1994, 151).

The idea used here to parametrically design the trading rules is the following: Firstly, all effects that pertain to the observable socio-economic environment are extracted. These effects denote all possible reactions that are known with respect to that observable environment. Then, only those effects are selected that yield the desired outcome. Since any of those effects is associated with parts (elements) of the institution the market engineer becomes an idea what institution elements to use. Ideally, these effects together render an entire description of the institution – this will, however, not be the case. Some elements of the institution will not be specified at all, as the effects do not consider them. Other elements will – on the contrary – be specified in different ways by different effects. Now the market engineer has to select as many institution elements as possible. Since those elements are not fully specifying the institution, the market engineer has to complete the institution in a way that all parameters are

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[203] For parametric design problems a number of methods have been developed that provide heuristic search strategies. Those methods can be distinguished into three classes: (1) *Generate-and-test* methods are two-stepped comprising at the beginning a generation of a solution that is subsequently verified. Once a generated solution is negatively tested a completely new attribute assignment is generated. Thus, the new attribute assignment is independent of the previous, faulty attribute assignment, as the reason why the previous attribute assignment failed is not further pursued (ten Teije-Koppen 1997). (2) Broadly speaking are *propose-critique-modify* methods also generating solutions, which are subsequently being tested. What distinguishes those methods from generate-and-test methods is that they use the previous faulty solution and modify it to a new solution (Wielinga, Akkermans et al. 1995). (3) *Propose-and-revise* methods are simplifications of the propose-critique-modify class, where the critique operation is curtailed.
Generate-and-test methods are the easiest conceivable methods, as they spend no time on repair actions. On the other hand, small changes are more preferable than starting the design from scratch again. The intuition of preferring repair actions to complete new designs is that the initial proposals are not too far away from being a solution to the design problem. *Propose-critique-modify* methods specify the complete critique and repair step. However the problem in designing the trading rules is that the knowledge necessary for a sophisticated critique and repair step is presumably not available. Hence the simplified *propose-and-revise* method may suffice to give a frame to the conceptual trading rule design and is thus adopted.

[204] Principally it is more realistic to assume multi-valued objectives. The design is extremely difficult, "*[...] because we don't know how to weigh the importance of various elements in an institutional design. For example, the Dutch auction allocations have been shown to be less efficient than other auctions (English, sealed bid), but Dutch flower auctions are enormously faster than other auction forms and thereby offer lower transactions' cost, which helps to account for their use in the sale of small ticket (and perishable) items like cut flowers and plants"* (McCabe, Rassenti et al. 1993). In this tradition it will be referred to single-valued objectives only.

assigned to a corresponding institutional rule. Subsequently, the verification of this generated institutional rule starts.

With the complete institution at hand and the description of the observable environment the market engineer can extract all effects that may occur. Subsequently, it can be checked whether these effects contradict the desired effect entailing the outcome $\overline{o}$. Typically, contradictions occur, as the socio-economic environment is underdetermined (recall that the unobservable environment information is missing). Underdetermined socio-economic environments entail that more effects principally occur. As especially the unobservable part is missing, the effects are more than likely contradicting.

These contradictions can be classified into two categories. In the first category, the contradictions occur within the same environment. By means of laboratory experiments those contradictions can be removed. In many times the contradictions may stem from variations in the unobservable socio-economic environment. Laboratory experiments can only resolve the robustness of these effects in different environments – they do, however, not help in the particular engineering problem, as laboratory experiments require the induction of the environment. However, the market engineer simply does not know the unobservable environment.

In this situation forming the second category of contradictions it is necessary to conduct field experiments. In field experiments agents are taken from the industry the electronic market service wants to serve. Those agents are familiar with their industry and have implicit information about the unobservable economic environment the market engineer lacks. By letting them trade in the field experiment without controlled environment, the market engineer can infer the unobservable environment by the composite effect, which is obtained.

Step 1 – Problem Specification

In the first step, two specifications are necessary. Firstly, the desired outcome $\overline{o} \in O$ and secondly a reduced effect description *ED** which only contains information about the observable socio-economic environment.[205] That is, $ED^*(F)$ puts only requirements on the observable socio-economic environment, when no information about the unobservable socio-economic environment is present. In case the market engineer has this information, it can also be included in *ED**. Furthermore, if the potential market participants have strong preferences concerning one or more institutional rules, these desired institutional rules can also be captured by *ED**.

Step 2 – Effect Extraction

For this reduced effect description *ED**, it is possible to extract all known effects that can occur. That is, select all effects that are applicable for *ED**:

$$\overline{F}^{ED} := \left\{ F \in F_{Possible} \mid ED(F) \supseteq ED^* \right\}$$

The set of all applicable known economic effects for the given state ED^* is

$$\overline{F}^{ED} = \left\{ F_1, F_2, \ldots, F_{|\overline{F}^{ED}|} \right\}$$

[205] It is assumed that the requirement analysis renders the information about the observable socio-economic environment.

Step 3 – Effect Selection
From this set of applicable effects only those are relevant that lead to the desired outcome. In other words, the market engineer has to select those effects that help to attain the outcome:
$\breve{F} := \{F \in \overline{F}^{ED} \mid F(ED^*) = \overline{o}\}$

Step 4 – Institution Selection
Having selected all applicable effects that are deemed to realize the desired outcome, the market engineer has to extract the institution that incites the necessary effect in *ED**. Ideally, the institution will be filled without a problem. This is very unlikely, as many effects are defined over the same institution parameters but with different attributes. For example, effect F_1 requires *"open bids"* while effect F_2 *"sealed bids"*. As the parameter *"information revelation rule- bidding history"* allows just one attribute these two effects are incompatible with each other. The strategy suggested here is to choose those effects such that the number of assigned elements of the institution is maximized, provided that the used effects are not contradicting each other.

Choose $F_i \in \breve{F}$ and extract all $j \in V$ institution elements $i_j \in I_j$ that are required for the effect to occur,[206]
and set $i_j^{new} = i_j$ such that the number of uniquely, specified elements is maximized.

Step 5- Complete Institution
As aforementioned, the effects will not provide all elements of the institution. Step 5 requires the assignment of the remaining elements of the institution. Lack of domain knowledge[207] makes it necessary to assign arbitrary rules to the institution.[208] As such, designing trading rules *"[...] also uses ad hoc methods to resolve issues about which theory is silent"* (Milgrom 2000).

Step 6 - Validate
Ideally, the proposed institution and the given environment can together explain the desired outcome according to the domain theory.[209] In other words, the institution is verified when there is no applicable effect that contradicts or even overrules the desired composite effect that in turn entails the desired outcome.

If the validation yields

(1) an overruling, then the proposed institution is inadequate to attain the desired outcome
(2) a contradiction that cannot be resolved due to the missing overruling function, then experiments are necessary.

In the former case the proposed institution can be dismissed, while in the latter case the proposed institution must be closer analyzed. Firstly, the effect descriptions pertaining to all effects that are applicable to the selected institution in combination with *ED** are needed. These

[206] Remember that the index set *V* comprises all elements of the institution that are required for the effect to occur (cf. chapter 5.1.2.2.1.3).
[207] The domain knowledge was used via the effects to design the institution in the first hand. Remaining elements are not covered by the domain theory.
[208] The two steps, selection and completion of the institution can also be interpreted as follows: Firstly, classification is used to design the skeleton of the institution. Secondly, the remaining elements are configured to this skeleton (Weinhardt 1995).
[209] This does not mean that the institution can really enfold the desired effects.

effect descriptions can only differ with respect to the unobservable environment and the institution. Say for instance two effects are contradicting. The effects are based upon the same effect description except the unobservable environment. In such a case, the contradictions may stem from the unobservable environment *U*. If the pure effects in the different environments (*E* and *U*) are known, it is reasonable to perform a field experiment. Since real agents are supposed to take part in a field experiment, the composite effect can give advice about the underlying unobservable environment. If the pure effects of the institution in different environments are not known, laboratory experiments should be performed in order to obtain these information.

Step 7 - Revise
If contradictions cannot be removed, the institution definition must be modified. Principally, it can be searched for the effects that contradicted the desired outcome. Once this faulty effect is identified, its effect description may give insight in how to modify the institution.

Once the institution is released as appropriate it is advisable to launch a field experiment in any case.

Example 5.1-12: Parametric Design

A brief example may clarify the parametric design problem. Suppose the market firm wants to auction related telecommunication licenses to firms. The market firm intends to set up an auction that achieves an efficient allocation of the licenses. The observable socio-economic environment is characterized by few buyers and multiple and heterogeneous objects, and the presence of market power (step 1).
Facing such an environment all effects that are associated with single-sided multi unit auctions principally apply (step 2). In step 3 the market engineer has to extract all effects that are firstly applicable and secondly promise to achieve allocative efficiency. For example, one of those effects can be denoted as *"truthful bidding"*, *"ascending bidding"* another as *"simultaneous bidding"*. The effect description associated with the first effect prescribes in essence the Generalized Vickrey auction. The second effect description demands: open bids on any of the licenses until no bidder is willing to bid higher on any of the licenses. The third effect description is associated with *"simultaneous bidding"*.

Maximizing the number of institution elements suggests the use of *"truthful bidding"* as the Generalized Vickrey auction is the institution that is most comprehensively required (step 4). Step 5 can be skipped, as the institution is fully specified. Subsequently, the validation (step 6) can take place. As a matter of fact for the GVA another negative effect can apply called *"shill bidding"*. This contradiction cannot be ruled out. In the case the licenses are not for all bidders substitutions and an overrule function exists that predicts an inefficient allocation as outcome, since the effect *"shill bidding"* is assumed to dominate. Step 7 revises the current institution. Basically, the effect description of the effect that created the contradiction is reviewed.[210] As there was only one effect used in the first hand, the corresponding institution cannot be used at all. Thus, the market engineer turns to the remaining effect *"ascending bidding"* and *"simultaneous bidding"*. Putting the institutions of these effects together yields an institution that can be described as follows: "All the licenses are on the block at the same time. The auction proceeds in a number of rounds with prices on each license ascending in response to bids. In each round, bidders can bid on any of the licenses. The auction ends when no bidder is willing to bid higher on any of

[210] Principally there are more revisions possible. For example, the market engineer could create a mechanism such that the undesired effect is not occurring. In this example, it is conceivable to fight *"shill bidding"* by a personal registration procedure.

the licenses. Again all elements are specified turning to the validation. Since there is no contradicting effect on the revenue the auction is predicted to achieve the desired outcome. This example is intended to give a rough idea about the parametric design method. It is leant on the FCC auction design (cf. Cramton 1997; Milgrom 2004) but uses functional explanations in order to show that comparable results could have been achieved by referring to the effect-based explanations presented here – provided the used effects had been known.

5.1.2.3 Critical Review

The presented discursive method shows, how difficult the design of trading rules is such that a certain desired outcome is achieved. The design of trading rules will ever be an exciting object to study due to the tremendous context sensitivity of institutions. Apparently, social effects are extremely difficult to use, as they do not depend on natural laws. Nonetheless, it is the claim of this book that they can be used for predicting tendencies. Moreover, the method can make the proposal of an institution explicit. By doing so, this difficult step in market engineering can be made reproducible. Furthermore, the method is capable of pinpointing the experimental set-ups – either laboratory or field experiments – that are necessary to make more precise predictions. The method thereby tries to combine experimental and theoretical economics in a discursive approach.[211] Beside those advantages there are also severe disadvantages.

Firstly, the approach contains many sources of ambiguities such as the fuzzification of the parameters, and in particular of the outcome. Those ambiguities are, however, inevitable being in the nature of social effects. Causal explanations of human behavior can only be precise when several assumptions are being made. If those assumptions are relaxed – which is necessary for generalization – the statements are being blurred.

Secondly, the approach needs many effects to function. At the moment there are not enough effects accessible.[212] The difficulty stems from the fact that these effects require thorough interpretations. Nonetheless, it is necessary to acquire more knowledge about social regularities.

Thirdly, the approach cannot give the market engineer a causal explanation why the effects apply. This disadvantage is indeed there, but it can be referred to laboratory experiments, which have the same problem.

Fourthly, the presented approach only incorporates one single objective into consideration. Typically are trading rules facing basic tradeoffs (Cramton 2003). While they perform well with respect to one objective, they fail with respect to another. This is certainly true and could easily be remedied by permitting multiple objectives. However, the weighting problem what objective is more important than another cannot be solved (McCabe, Rassenti et al. 1993).

In summary, the design method has several drawbacks, but it is the first attempt to model the design of trading rules. It can assist the market engineer in the difficult design process, but the results of the method must be treated with care. As such, the method gives only tendential predictions – in combination with experiments, though, the statements can become much stronger.

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[211] The claim is clear that theoretical economists also argue on the functional explanation level, *before* they incorporate it into a formal, causal model. It is the idea of this chapter to make this preliminary approach explicit.

[212] There are many effects already described in literature, but they are currently not in the form used here.

5.1.3 Combination of Abstract Solutions

Electronic markets are more than facilities for resource allocation. Although resource allocation is the main constituting sub-function of a market, other sub-functions may be as or even more important than resource allocation. In particular information services that for instance assist the search for corresponding offers, often constitute in combination with the resource allocation *the* unique-selling proposition of a market (e.g. information services provide the market participants with the information necessary to make full use of the resource allocation mechanism). Furthermore can information services themselves exert positive network effects on the participants: if the relevant information service is due to the large customer base so powerful (e.g. precise recommendations) it can happen that the market participants choose to participate in the corresponding electronic market regardless of the trading rules.

Apparently, all sub-functions that were classified as main function tremendously influence the value market participants can draw from the electronic market service. As such, it is important to include them into the conceptual design. The conceptual design of these main functions follows the intuition of the engineering design approach. In essence, the task of conceptual design implies the identification of solution principles on an abstract level. This requires either the description of some algorithm or of some institutional rule.

Having specified all solution principles for any sub-function identified in chapter 5.1.1, they must be morphologically combined to single concept proposals (Pahl and Beitz 1984; Finger and Dixon 1989). A concept proposal thus contains several documents with institutional rules or algorithm descriptions as solution principles.

5.1.4 Business Analysis

The business analysis augments the concept proposal (i.e. the combinations of solution principles enriched by drafts about the technical infrastructure) with the possible business model. The business analysis is intended to give a rough idea about profitability the market firm can expect from the concept proposal if implemented (Haksever, Render et al. 2000). At this early stage of the design process it is not advisable to develop a fully-fledged business model for any concept. This stems from the fact that conceptual design strives for developing many different concepts that are subsequently evaluated. Elaborating a complete business model is inadequate, as it requires substantial resources and time. Since only a single concept is chosen at the end of the conceptual design phase much of the work would have been in vain. However, without business model at hand the question arises, how reliable estimations about the profitability of concepts can be drawn?

5.1.4.1 Strategic Pricing

The environmental analysis already examined the proposed market segment concerning size and growth. As the size and growth of the market segment does not directly create revenues, the market firm has to develop a pricing scheme for their offered service(s) in order to capture some of the created value. The 's' in brackets hints at the point that not only the main service *price determination and allocation* (i.e. allocate resources) can be priced but also other (complementary) services such as information services. In the following the emphasis is on revenues (and correspondingly pricing) of the main service.

When it is referred to pricing, usually one has physical goods in mind. The price is then associated with exchanging the property rights of the good. Pricing services is, however, different, as there is no exchange of property rights. What is priced is the successful fulfillment of the service. Recall that the electronic market service is first successfully fulfilled once corresponding wishes of buyers and sellers are executed against each other. In other words, the service entails a transaction, i.e. an exchange of resources. Pricing this service therefore refers to *transaction-based pricing*.[213] Apparently, the market firm has to develop a pricing scheme for transactions that generate sufficient profit. Sufficient profit can be interpreted either as balancing revenues and costs or as maximizing profits.[214]

Management literature offers two major extreme approaches for pricing. The first – sometimes called traditional – pricing approach refers to cost orientation. Basically, this approach stems from cost accounting that determines the price level dependent on the costs that originate from the provision of the product. Serious concerns against cost-based pricing pertain to the way costs are used. Cost-based pricing approaches first determine the quantities of products (i.e. the product program) the firm will sell and the group of buyers the firm wants to serve and calculates then the costs necessary to provide this product program. Then, the price level is determined, which is necessary to sell the product program and, likewise, to assure a decent profit rate. In other words, traditional pricing takes *"sales goals as given before allocating costs, thus precluding the ability to incorporate market forces into the pricing decision"* (Nagle and Holden 1995, 36). As a consequence cost-based pricing strategies are suspected to both overestimate the price levels in weak markets and understate the price levels in strong markets.

In contrast to cost-based pricing marketing provides a second extreme pricing approach that refers to customer-driven pricing. Customer-driven pricing determines the price level as the level that customers would be willing to pay. As such, the prices reflect more the market condition but widely ignore costs. By doing so customer-driven pricing has the potential to capture more of the value the product generates to its customers. In many times the goal of capturing value is misinterpreted with sell as much as possible. This misinterpretation is not astonishing as the costs are ignored. A major ramification of such a misinterpretation is to price at *"whatever buyers are willing to pay, rather than at what the product is really worth"* (Nagle and Holden 1995, 7). Apparently, both practical approaches are afflicted with inconveniences.

Economic analysis dictates to take both aspects value (e.g. demand) and costs (e.g. supply) for optimal price determination into consideration. In practice neither is the demand curve known nor do the assumptions apply. As consequence optimal pricing behavior prescribed by theory is not directly applicable. Nevertheless, the intuition of incorporating the blend of costs and value is still promising, as it also combines the two management approaches. In this context the approach proposed in this book for estimating the profitability of a concept without having a fully developed business model comprises at least three elements: demand, costs and revenues.

5.1.4.2 Demand Analysis

Customer-driven pricing requires knowledge about the value the product accrues to the customer. Once this value is known, the price can be set so that it exactly reflects this value (minus a discount). But what exactly is this value for a customer? This is, in fact, the critical point of customer-driven pricing. Due to possible misunderstandings the term value is closer

[213] Principally, the market firm can also charge access fees. In the electronic market context this will become more impossible, as the marginal costs of participation tends to 0. This implies that an additional participant generates no additional costs for the market firm. Competition among various electronic markets will entail that the access costs eventually drop to zero. This price drop marks the endpoint of a process of mutual undercutting. Collusion is unlikely as participation directly affects the utility of the corresponding electronic market.

[214] Recall the market-engineering problem in chapter 4.1.3.1.

defined. Economics usually define value as use-value or utility gained from the product. The utility can be measured by the amount the agents are willing to pay. Ideally for the seller prices should match this willingness to pay. Competition coupled with experiences from past trades, however, impedes the extraction of the consumer rent:[215] As consumers maximize their accrued value (utility) they always search for cheaper opportunities. Except in those cases, where the seller is a monopolist, it is rather difficult for a seller to capture the entire consumer rent.

In the absence of market power this use-value definition is less helpful. Marketing suggests in those cases a different value concept, which is called economic value-to-the-customer or short *"economic value"*. Basically, this value definition is entwined around alternative, competing products. The total economic value of a product consists of two components:

- Reference value
  The reference value is the price of a customers' best alternative.
- Differentiation value
  The differentiation value captures the value that differentiates the offering from alternatives.

For electronic markets the reference value amounts to the lowest fees of competing electronic markets that offer comparable services. In the absence of such markets the transaction costs of traditional trade can be estimated. For the product "electronic market service" the differentiation value contains three major components. The first component refers to the value differences that stems from deviating trading rules. As trading rules determine the way, how the trade takes place, it affects the transaction costs of the participating agents. Thus, trading rules can create value by reducing transaction costs of the agents, if the market firm would hand the reductions over to them. The second component refers to differences in the configuration of the other rules (except the business rules). Differences in the degree of automation for example can create value, as it accelerates the trading process. The third component pertains to differences in the customer base. The more agents are participating as customer in the electronic market, the more attractive the electronic market becomes due to demand-sided network effects. As previously mentioned the probability of finding an adequate matching offer quickly raises the more agents are participating.

The economic value analysis seeks to extract the economic value as the sum of the reference and differentiation value numerically (Nagle and Holden 1995; Smith 2002). It is to note that the determination of the economic value requires profound knowledge about the competition situation within the market.

Figure 34 illustrates the total economic value of the electronic market service consisting of a reference value and a differential value. The example in Figure 34 may exhibit the economic value of an electronic market with innovative trading rules and powerful IT support that enters as a newcomer an existing market. The reference value mirrors the fee level of the best competing electronic market service. Additionally, the newly introduced electronic market offers added value owing to their institutional rules (except the business rules). As such, the differential value of those components is positive – nonetheless, the incumbent electronic markets may have a higher customer base decreasing the differentiation value of the newly entering service (negative differentiation value). It results the total economic value, which

[215] Consumer rent is an economic concept, which measures the difference between the price the consumer has actually to pay and his willingness to pay.

measures the service's *value-to-their-customers*. This ways the economic value analysis yields a straightforward estimation of the value the electronic market accrues to its customers and is thus a good starting point for strategic pricing decisions.

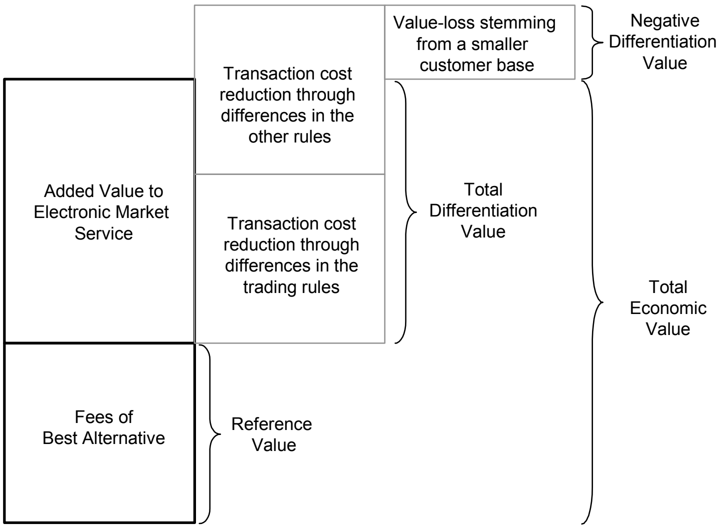

Figure 34: Economic Value Analysis (cf. Nagle and Holden 1995, 75)

The economic value gives a good idea about how high the prices can principally be set. The economic value analysis is hence a reference point of the demand analysis, because it provides an upper bound of the price. It should be noted that the determination of the economic value may suffice for evaluating the concepts. The business analysis is then quite simple but it omits the relevant question, whether the concept can ever expect positive revenues.

The fact that economic value is not sufficient is reasoned by its inability to fully capture the role prices have in the individual buying process. Assuming a fully informed *"homo oeconomicus"*, the concept of economic value would suffice to determine the demand. Then, reference and difference value were known to anyone. Forfeiting the chance to buy the service at a price below the economic value would mean to sacrifice a net value gain. In general, this state of being fully informed is, however, more of a theoretical concept. The customers are rather influenced by perceptions concerning the value. These perceptions are in turn heavily affected by the product price.[216] For demand analysis it is commonly insufficient to just identify the "objective" economic value. Instead, it is also important to determine the price sensitivity of the customers or in economic terms the *price-elasticity of demand*. The unit price-elasticity states the percentage change in the quantity demanded (i.e. unit sales) in reaction of a given percentage change in price. The magnitude of this trade-off between price and quantity demanded is necessary for pricing, as both components affect the revenue.

In essence price sensitivity analysis are mostly of quantitative nature. Quantitative methods collect data from direct questioning, buy-response surveys, field or laboratory experiments and extract the price sensitivity as result of linear regressions. The former methods are inherently exacerbated by the fact that many customers will not truthfully answer the questions. This is especially true for questions concerning the price. A survey over commonly used techniques can be found in Nagle and Reed chapter 13 (Nagle and Holden 1995).

[216] Clearly, the price is not the only determinant; others are endowment effects or the social embeddedness of the customers.

5.1.4.3 Cost Projection

Generally the price level determines the quantity a firm can sell. Normally, lower prices allow the firm to sell more of a product, while reversely higher prices quantity will be less. The total costs certainly will vary with the price decision, as producing more products will increase the costs. But not all costs will vary with prices and quantities – those are not relevant for pricing. All other costs are subsumed as *incremental costs* comprising all costs that results from implementing a price change. This definition captures all variable costs such as the costs of raw material in the production process and even parts of the fixed costs. For fixed costs to be incremental it must be possible to relate those costs directly to price changes. For example, a sharp drop in fees for the electronic market service may cause incremental costs in a way that processing capacity may be extended (e.g. purchase of new servers) in order to assure the same quality (e.g. reliability) of the electronic market service.

Meaningful price decisions require solid information about the incremental costs. Business analysis thus needs an estimation of the incremental costs. As the setting up of a useful managerial accounting system exceeds the scope of this book it is referred to the pertinent literature of *activity-based costing* (Cooper and Kaplan 1991; Nagle and Holden 1995; Ruhl and Hartman 1998).

By means of incremental costs the market firm can calculate so-called breakeven sales curves. Those breakeven sales curves basically state for any conceivable price the required volume in order to keep the profit at a constant (no loss) level. In other words, breakeven sales curves are a simple but powerful tool, which reveal the tradeoff between price and volume required for a constant profit. If demand is accommodated at point below the breakeven sales curve the market firm incurs a loss, while vice versa it attains a gain.

5.1.4.4 Revenue Projections

The two components costs and demand can be put together in order to obtain reliable information about the profitability of pricing schemes. Figure 35 demonstrates the interplay between demand and costs. The breakeven sales curve shows all price-quantity combinations that yield a constant profitability. This reflects, however, only the supply side. A price drop must be compensated by a higher number of transactions in order to keep the level of profitability constant. As such, the curve is falling as depicted in Figure 35. Furthermore, from the price elasticity of demand, it is possible to draw the demand curve. The demand curve basically shows how the quantity demand varies on a change in price. Apparently, the demand curve will presumably intersect the price-axis below the upper bound determined by total economic value. Setting a price below the intersect of breakeven sales and demand curve results in total gains; as the demand expands more than the additional costs this price setting produces a total gain. Setting a price above the intersect will vice versa result in a total loss. In summary, the combination of breakeven sales and demand curves allow the market firm to get a good idea about the potential revenues.[217]

[217] This simple estimate uses exclusively a linear pricing schedule, i.e. all customers pay for any transaction the same price. In many times, it can maximize the market firm's profit to offer two-part price schedules, i.e. linear price schedule combined with access fees, or even multi-part (non-linear) price schedules, e.g. price discounts (Wilson 1992). Additionally, the market firm can offer different pricing schedules to different customer groups in order to skim customer rent. In those cases a cross-subsidization is conceivable in a way that one customer group is given a competitive advantage on the expense of another group. In short, the possibilities of designing price schedules are manifold. Principally, once the demand and cost curves are known one could set up a theoretically adequate pricing scheme. At the concept level, however, only a rough estimate of the profitability is required. As such, the development of the concrete pricing scheme is postponed to the embodiment design.

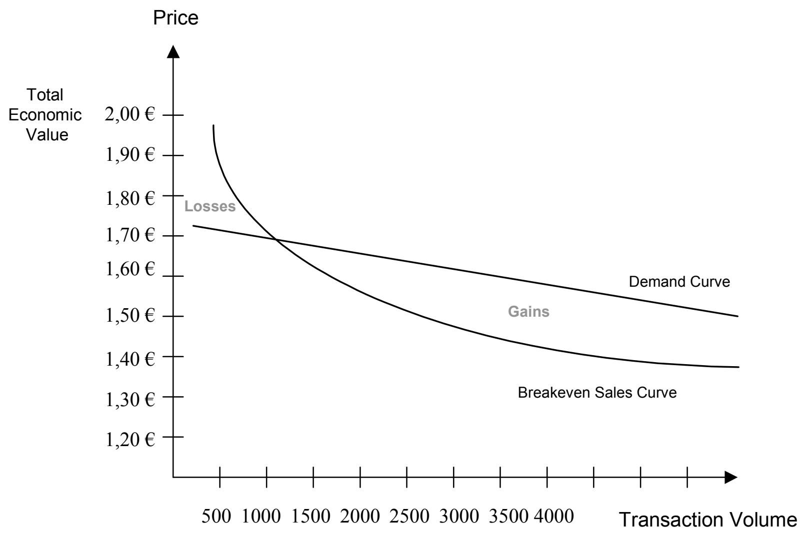

Figure 35: Relationship between Breakeven Sales and Demand Curve

For the evaluation of the revenues concepts may accrue, the abovementioned tools appear to be appropriate. The determination of the economic value a concept provides can be the first step in the demand analysis, as it provides a more or less objective value. Demand analysis can stop with the economic value or even acquire information about the potential demand schedule. With this demand schedule and the cost projections the market firm can assess the future revenue a concept may accrue.

5.1.5 Firming up into Concepts and Concept Evaluation

The concept proposals are often not concrete enough to be adopted as a concept variant. Where needed the concept proposals are refined such that it becomes apparent, whether the concept proposal is feasible at all. Likewise considerations concerning the reliability and safety of the envisioned information system are added to the concept proposal.

Now the concept proposals being firmed up to fully-fledged concept variants must be evaluated in order to provide an objective basis for the decision, which concludes the conceptual design phase. An evaluation thereby means to determine a ranking of all concept variants. The ranking is developed with respect to the given set of objectives. For concept evaluation the set of objectives is not a singleton, as there are even three different objective categories: The first objective category refers to the trading rules and specifies the given trading rules are supposed to affect the market performance. Commonly, the market performance is not described by a single criterion (e.g. revenue, efficiency, budget-balance). The second category of objectives includes economic objectives such as value creation expressed by the economic value or revenue and cost projections. The third category reflects technical objectives concerned with scalability, response time or reliability. Any of these categories can have one or more objectives. Comprising, the ranking of the concepts needs to take several objectives into consideration.

Apparently, there is a need for a method that allows for a comprehensive evaluation covering a variety of objectives. During the conceptual design phase the variant properties are often of qualitative nature. As such, it is necessary that the method can elaborate beside quantitative also qualitative properties. The results of the method, i.e. the evaluations, must be reliable, easily understood and replicable. A simple scoring model – sometimes called cost-benefit analysis – is such a method that can be used for the step of the concept evaluation (Dean and Nishry 1965; Pugh 1981; Pahl and Beitz 1984).

5.2 Embodiment Design

While the conceptual design phase is concerned with the formulization of the problem and the search for abstract solutions, the embodiment design refines the abstract solution principles to layouts. Layouts in general refer to a plan or arrangement of something that is laid out. In market engineering the *layout* denotes a model of the function carriers that is more concrete than in the concept but still independent of implementation details. In other words, the solution principles of the conceptual design phase comprise at most a verbal description of the institutional rules or algorithms as function carrier. As such, many different layouts can be found that realize the same conceptual solutions. During the embodiment design this verbal descriptions are transformed into a model with sufficiently low level of abstraction that traditional design techniques may be applied in order to implement it: the concept becomes form (Pahl and Beitz 1984).

Figure 36 illustrates the activities of embodiment design. Basically, the phase of embodiment design starts with the concept that is firstly analyzed. After analysis, the concept is refined into a preliminary layout, which translates the abstract models gained along the conceptual design phase into a more precise model. Then, the sub-functions that have been classified as auxiliary are conceptually designed. Together with the conceptual solutions to the auxiliary functions the preliminary layout are tied up into a fully-fledged layout proposal. The layout proposal is once again checked for potential weaknesses or errors. This activity apparently decides whether the layout proposal is further refined. In case the check fails the process zigzags back to one of the previous activities. If the layout passes the decision, the embodiment phase is completed initiating the detail design phase.

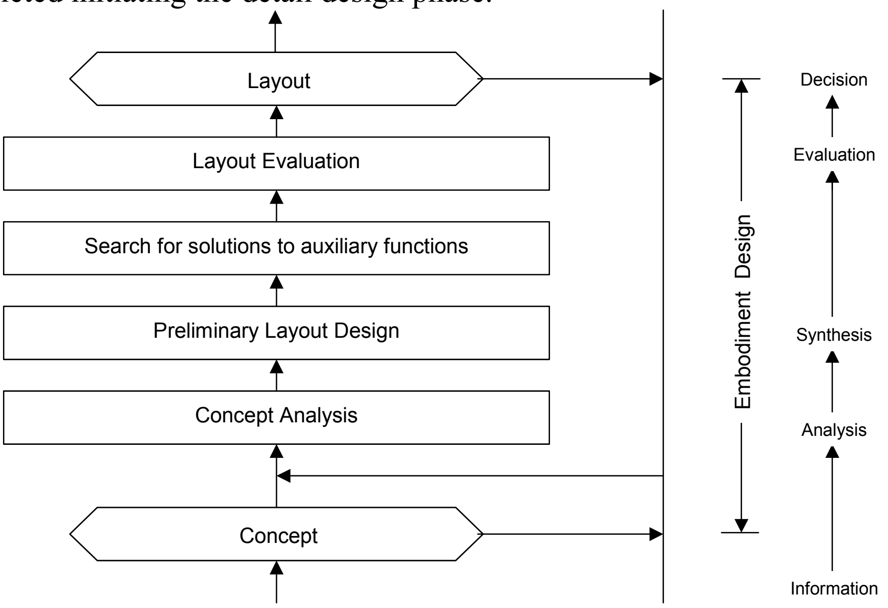

Figure 36: Activities of the Embodiment Design

5.2.1 Layout Development

Principally, the layout development – consisting of the concept analysis and the preliminary layout design (see Figure 36) – is concerned with the refinement of all solution principles (e.g. the enforcement machinery, trading rules, search engines, catalogues, etc.). For simplicity this book only addresses the layout development of the trading rules. Note that the conceptual design of trading rules renders a parametric description thereof. This description is capable of prescribing the rough structure of the future trading process. For example, the concept of trading rules define the range of messages available to the agents or the computation of messages into allocations and prices, however they do *not* exactly specify the flow of messages in detail.

While the concept provides an abstract definition of the trading process by the means of a set of rules, form is needed to shape the concept to a fully-fledged trading protocol. A protocol in general describes a *"communication pattern as an allowed sequence of messages between agents and the constraints on the content of those messages"* (Odell, Parunak et al. 2000). As any trading process requires communication, a trading protocol describes communication patterns of trading process. More precisely, this pattern covers:

- the permissible roles of participating agents (e.g. the buyers and sellers or other relevant third parties such as market maker),
- the states where agents are (e.g. accepting offer, market closed),
- the events that cause states to change (e.g. message reception, deadline time), and
- the valid (communication) actions of the agents in particular states (e.g. which messages can be sent by whom, to whom, at what stage) (Jennings, Faratin et al. 2001).

Apparently, developing the layout for the trading rules is concerned with the refinement of the institutional rules (parameters), their corresponding characteristics (attributes), and their interdependence to a (semi-) formal protocol.

In engineering design the step of embodiment design – and in particular layout development – is only scantily covered (Shahin, Andrews et al. 1999).[218] This lack can be remedied in part by consulting the service development literature and turning the attention to blueprinting.

5.2.1.1 Blueprints as Layouts

Hitherto the layout was interpreted in technical terms as a representative model or, more precisely, as trading protocol. There is, however, a straightforward economic interpretation. From a service development point of view, the layout is equivalent to the service procedure of the electronic market service. The service procedure is generally a description of all activities necessary for conducting the service. In the electronic market context the service procedure replicates the market process as service. Note that the service procedure is only replicating not reflecting the service. This slight difference accounts for the innate characteristic of services: services are produced in interaction with the customers. This implies that every service is slightly different depending on the behavior of the involved customers. For example, the electronic market service is always different, as the agents – understood as co-producers – are submitting offers spontaneously. Since agent behavior is certainly never the same, every service is unique. Now the differentiation between replication and reflection can be once more picked up. The service procedure describes the – and here is the emphasis – *hypothetical* service process in terms of the sequence of activities. Apparently, services have an ambivalent nature or *"two different states of being"* (Shostack 1982**,** 55). As the service processes are so different, only the service procedure can be planned, because it is for all services of the same type alike. The service procedure is given by means of a blueprint. "*A blueprint is a picture of a service [system] and its processes; it provides a bird's-eye view of the service system. It shows the steps of processes and interactions among processes as well as the interaction of a customer with the system"* (Haksever, Render et al. 2000, 198). Thus, the technique of blueprint printing is a holistic approach for visualizing service processes in snapshot form

[218] An exception is the approach presented by Pahl and Beitz (Pahl and Beitz 1984).

(Shostack 1984; Shostack 1987, 35-36). Developing a layout of electronic markets can apparently be interpreted as blueprinting of the electronic market service.

5.2.1.2 Objectives of Blueprints

The blueprint is a handy tool for the market firm, as it highlights all issues inherent to designing or managing the electronic market service. Those issues inherent to design comprise at least four main aspects:

- Identifying processes
  One of the primary strengths of a blueprint is that it can visualize the processes necessary for providing the service. A blueprint for the electronic market service aggregates the refined (sub-) functions identified in chapter 5.1.1 to processes. Apparently, the determination of a blueprint requires the specification of the interconnections among the (sub-) functions. Once, the processes are identified they can be analyzed upon fail points or time frames.
- Isolating fail points
  The identification of the processes helps to analyze the critical process steps. In particular the blueprint as analysis tool allows optimizing the entire process. Critical process steps for instance can be redundantly secured against failure by fail-safe processes or certain time-critical process steps can be automated (Shostack 1984). For any service the engagement of the customers is potentially critical. Generally the interface between customer and service system affects the customer satisfaction, which in turn strongly influences customer loyalty (Jones and Sasser 1995). Unsatisfied customers may defect and will subsequently not be available to act as a co-producer of the service. This may exacerbate the quality of the overall service.
- Establishing time frame
  A blueprint can also reveal information about the execution time, i.e. how long it takes to execute the single process steps. On the other hand, does the blueprint help to accelerate certain process steps. By identifying the potential bottlenecks the service system can be streamlined. Moreover, it is possible to establish reasonable time-of-service-execution standards.
- Establishing cost analysis
  As soon as the processes and the corresponding time frames are established, it is possible to develop a thorough cost analysis. The cost analysis can also render the costs per any sub-process given a certain service system.

The main difficulty in embodiment design is that commonly *"developers translate the subjective description of a need into an operational concept that may bear only the remote resemblance of the original idea"* (Shostack 1984, 133). As blueprints are, *"[...] more precise than verbal descriptions of the service processes and therefore reduce ambiguity and the likelihood of misunderstandings that may originate from them"* (Haksever, Render et al. 2000, 198). Furthermore, the technique of blueprinting almost prevents the designer from conceptual errors, because the blueprint allows *"[...] the creation, study, and testing of services conceptually on paper before costly implementation"* (Haksever, Render et al. 2000, 199).

In summary, marketing literature usually identifies three basic requirements service blueprints must meet. Firstly, the blueprint must identify all main functions (and sub-functions) of the service. Furthermore, all inputs and outputs of the function must be clarified. Secondly, the blueprint must also be capable of including the time frame of the processes. Finally, the blueprint must also define the tolerances from which any service can deviate from the blueprinted service procedure without harm to the service.

5.2.1.3 Blueprints for Electronic Market Services

There are many methods that satisfy four objectives of blueprints. The most common methods that are presented in the context of blueprinting are flow diagrams or PERT (i.e. program evaluation and review technique)[219] charts (Shostack 1982; Shostack 1984; Haksever, Render et al. 2000). Those methods incur, however, severe problems, as they do not account for the interactiveness between the service system and the customers (Shostack 1982).[220] For electronic market services this become even worse, because these services are largely provided through communication between the customers. The service system only facilitates and supervises the social process of communication, but nonetheless, the customers assume the main portion of these processes. Apparently, the previously mentioned methods appear to be inadequate to visualize electronic market services. The blueprinting literature does not address these problems yet. Due to the lack of methods, this book proposes an alternative method for the blueprinting of highly interactive service systems.

First of all, a brief excursus may more clearly elucidate the intuition of the proposed methods. Recall that electronic markets are gigantic, decentralized information processing systems (Hayek 1945; Hurwicz 1997). Private information about endowment and preferences are communicated by means of messages. The concept of message exchange among autonomously acting agents is also used in distributed systems (Reck 1998). Originally, agents in distributed systems referred to computer systems but with the advances in technology this strict restriction vanished: agents can refer to humans, computers, or even to software programs. The latter understanding of agents – so-called software agents – gave rise to the development of an agent-oriented software engineering methodologies (Shoham 1993; Jennings and Wooldridge 1996). In essence, those agent-oriented software-engineering methodologies offer procedures for developing distributed systems that resemble electronic markets. As such, blueprinting techniques can make use of those methodologies that are tailored to comparable systems.

Existing software development techniques (e.g. object-oriented analysis and design) are usually inadequate to develop complex distributed systems (Bauer, Müller et al. 2001). The shortcomings are threefold: Firstly, mainstream software engineering methods do not capture the autonomous and flexible problem solving behavior of the agents. Secondly, mainstream methods cannot represent the richness of the interaction between agents. Simple message passing by method invocation is insufficient; messages rather constitute speech-acts. Thirdly, mainstream methods are only insufficiently account for the complexity of the organizational structure of agent systems. Agent-oriented software engineering explicitly addresses those shortcomings by providing dedicated methods (Wooldridge, Jennings et al. 2000; Bauer, Müller et al. 2001).

[219] Broadly speaking, PERT charts visualize tasks, durations, and dependencies among task. Each chart starts with an initial node from which the first task(s) originates. The tasks are represented by arrows, which indicate the identifiers of the tasks, the durations, the number of people assigned to them, and sometimes even the names of the employees involved. The arrow points at another node, which identifies the start of another task, or the beginning of any slack time. Related techniques are CPM or GANTT charts.

[220] Shostack lists some more drawbacks that are more marketing oriented (Shostack 1982). For simplicity those drawbacks are omitted.

Basically only the latter two aspects (richness of the interaction and organizational structure) are also relevant for the blueprinting of electronic markets. Electronic markets are based on rich interaction structures that follow fairly complex protocols. From a macro-level, the agent society is also of concern. Electronic markets are characterized by a given society of agents that assume roles such as buyers, sellers, market makers etc. The micro-level of electronic markets is, however, less of concern for development. This stems from the fact that the participating agents are humans. Apparently, blueprinting can adopt agent-oriented methods.

5.2.1.3.1 Agent UML

The Unified Modeling Language (UML) has been established as a standard for object-oriented modeling. UML supports five types of models (Odell and Fowler 1999; Bauer, Müller et al. 2001):

- Use Cases
  Use cases describe the interaction with human actors with the software systems.
- Static Models
  Static models specify the static semantics of the data and the messages in both an operational and conceptual way (Bauer, Müller et al. 2001). Static models commonly include class diagrams and aggregations thereof (i.e. packages).
- Dynamic Models
  Dynamic models visualize the interaction among objects. They comprise sequence and collaboration diagrams state charts, and activity diagrams.
- Implementation Models
  Implementation models provide support for implementation of object-oriented models. As such, these models describe the component distribution on different hardware.
- Object Constraint Language (OCL)
  The object constraint language is a formal language to express more semantics in the context of a given UML model (Tchertchago 2002). By means of OCL invariants attached to classes, pre-and post-conditions of operations, and guards for state transitions can be specified.

Apparently, dynamic models would qualify for blueprints. This stems from the fact that those models are capable of capturing the dynamic interaction among the components of the object-oriented system. Owing to the abovementioned shortcomings of object-oriented modeling techniques for agent systems, UML models have experienced various extensions that eventually brought forth agent UML or AUML (Bauer 2001; Bauer, Müller et al. 2001). Hence, AUML unifies both the modeling power necessary for agent interaction protocols (AIP) and the use of an established standard for which numerous tools are available (Bauer, Müller et al. 2000). The AUML-versions for dynamic models are the so-called *protocol diagrams*.

5.2.1.3.2 Agent Interaction Protocols

The definition of an agent interaction protocol specifies *"a communication pattern, with admissible sequences of messages between agents having different roles, constraints on the content of the messages, and a semantics that is consistent with the communication acts (CAs) within a communication pattern"* (Bauer, Müller et al. 2001, 211). The protocol prescribes the way messages can be formulated in terms of communicative (speech) acts. Those communicative acts – defining the type and the content of the message – are usually following some standard (e.g. FIPA-ACL or KQML).

Protocol diagrams, as a new AUML modeling technique – combine two dynamic models being the sequence and the state diagram. This synthesis grants *protocol diagrams* the flexibility to reunite the advantages of both diagram types without incurring their disadvantages: Sequence diagrams allow defining the exact behavior of an interacting group of agents, while state diagrams enables modeling the behavior of a complete system. As such, protocol diagrams can model the behavior of an entire system consisting of defined sequences of interaction among many agents. For a better understanding of protocol diagrams a review of sequence diagrams is helpful.

Remark 5.2-1: Sequence Diagram

For all that are not familiar with sequence diagrams a brief introduction will be given (Booch, Rumbaugh et al. 1999). As aforementioned, sequence diagrams visualize the interaction among instances of classes over time. Figure 37 illustrates the basic elements of sequence diagrams. The rectangles represent instances of classes (i.e. object). For example, the rectangle could be labeled eBay/Auctioneer expressing that eBay is an instance of an auctioneer. The dashed, vertical line below the rectangles denotes the lifeline of the objects. Basically it symbolizes the life cycle of an object from the instantiation to the deinstantiation. The vertical bars that overlay the lifelines indicate which objects are active. Activity is expressed by the processing of methods that are invoked by messages sent by other objects. If an object completed a method it reports the completion to the invoking object. Graphically, the horizontal arrows defining the invoking and the invoked object illustrate the messages. The simple example below depicts a simple sequence: the object of type Class1, say *Object1*, sends the object of Class2, say *Object2*, a message of type *Message1( )*, which invokes a method at the latter. As far as *Object2* has executed the methods, it confirms completion to *Object1* by *Message2( )*.

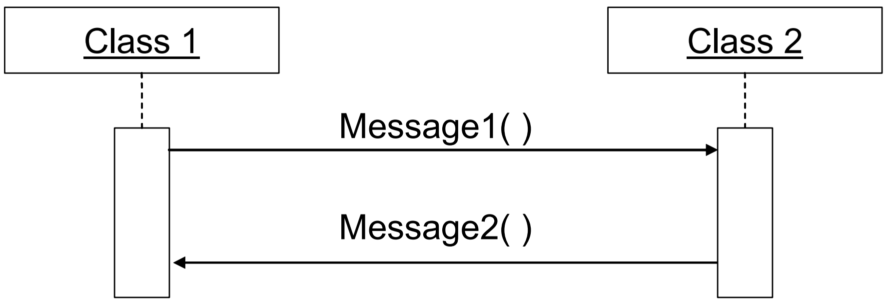

Figure 37: Sequence Diagram

The protocol diagram extends the sequence diagram by at least four aspects:

- Agent roles
- Agent lifelines and threads of interaction
- Extended semantics of messages
- Nesting (and interleaving)

While sequence diagrams depict the communications between instances of classes, protocol diagrams specify interactions among *roles* in the protocol. Basically, the term role denotes a set of agents that share common properties, interfaces, functionalities, or exhibit the same behavior. By means of roles it is not necessary to include several different identities of agents in the protocol, but just one role if agents share the same role. Agents can act in various roles within one interaction protocol. For example, in a double auction there are two possible roles interacting namely BUYER and SELLER. Clearly, agents can assume both roles simultaneously (Huget 2003).

In analogy to the sequence diagram the *lifelines* are shown as a vertical dashed line describing the time period during which the agents are participating in the protocol. When a lifeline is created a certain role becomes active for the protocol. The behavior of a role is – as in the sequence diagram – depicted by vertical bars, which are invoked by messages. The lifeline can be split into two or more concurrent lifelines to account for conditionality. Protocol diagrams distinguish between three logical connectors AND, OR and XOR for describing the conditional reaction of the agent (see Figure 38). The AND connector denotes concurrency while OR and XOR accounts for choices depending on the incoming messages. The lifelines can also merge together at some subsequent point.

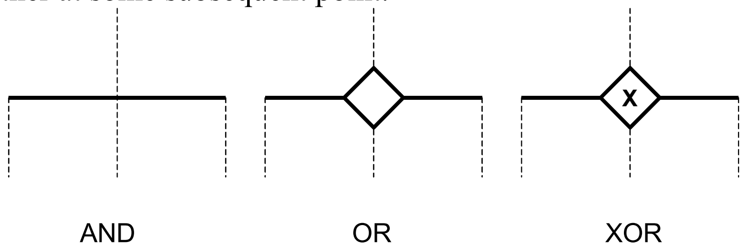

Figure 38: Connector Types

By means of the connectors the thread of interaction, i.e. the processing of incoming messages, is split up into several threads. Apparently, the protocol diagrams can directly express multiple concurrent threads. The left panel of Figure 39 depicts for example a XOR-decision situation. Depending on the incoming message either request, query or not understood different threads of interaction corresponding with separate lifelines are initiated. This notation of the XOR situation can also be abbreviated by interrupting the threads of interaction as depicted in right panel of Figure 39.

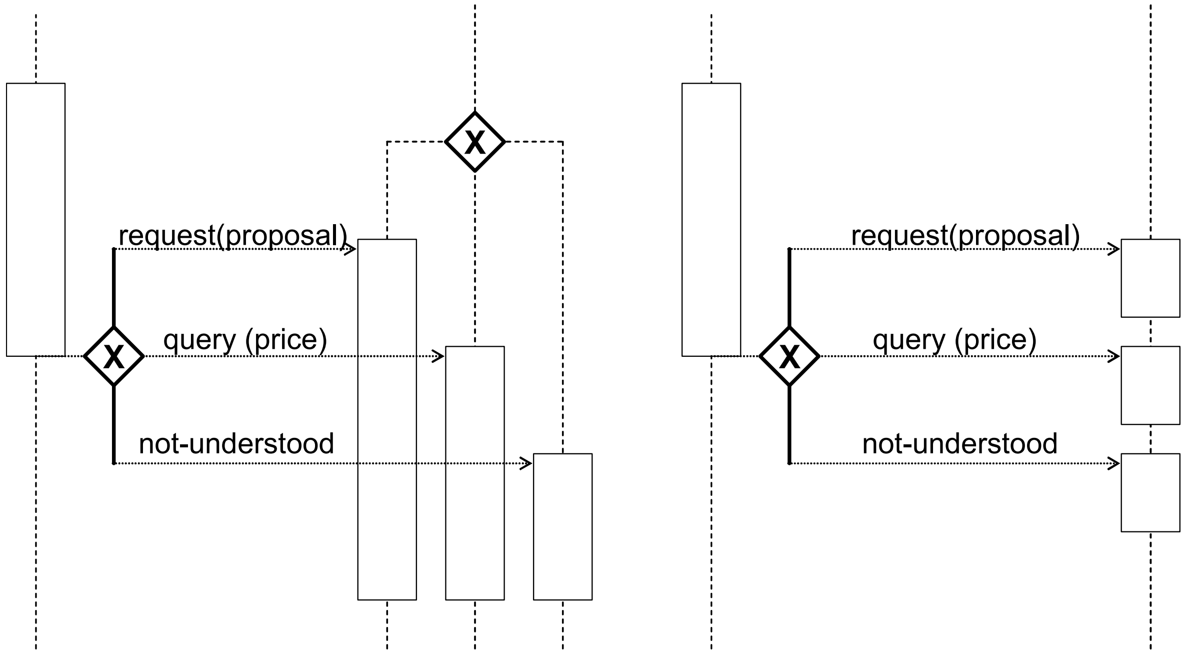

Figure 39: XOR-Connection – Full and abbreviated Notation (Bauer, Müller et al. 2000)

Protocol diagrams, furthermore, *extend the semantics of the UML messages*. Messages are no longer represented as pure messages but as communicative acts. Communicative acts not only convey the content of the message, but also contain explicit performative verbs. In other words, the utterance of a message already entails an illocutionary act, i.e. the sender's expectation about how the receiver react upon reception of the communicative act. Protocol diagrams also base communication on communication acts consisting of an illocutionary act and a propositional content (Austin 1962; Searle and Vanderveken 1985). For example in Figure 39 the sender conveys the recipient a communicative act consisting of the illocutionary act, e.g. request, and the message content, e.g. proposal. The message content can thereby contain a list of arguments with additional information. Additionally, it is possible to supplement the communicative acts with constraints, guards, or comments. As SENDER and RECIPIENT represent roles, several copies of the same message must eventually be send to several agents. The cardinality defines the number of agents, which will receive a copy of the message (Bauer, Müller et al. 2001; Huget 2003).

Sequence diagrams usually treat messages as asynchronous. The protocol diagram also introduces a symbol for the synchronized sending of messages. Graphically the arrows express the differences in the type of the messages (e.g. asynchronous, synchronous with or without delay). For example, in Figure 39 the communicative acts are sent asynchronously. In case the arrow is completely painted, the conveyance of the communicative acts is synchronized.

Remark 5.2-2: Nested Protocols

Another extension protocols diagrams concerns the property of nesting.[221] As protocols can be regarded as recognizable patterns of agent interaction, they become reusable modules of processing. As such, it can be treated as a first-class notion, i.e. any protocol combination or other entanglement is again a protocol. For example, protocols within another protocol are called nested. Broadly speaking, protocol diagrams specify the interfaces of nested protocols: The input parameters of a nested protocol are threads of interaction, which are continued in the nested protocol and all communicative acts received from other protocols. Analogously, the output parameters state those threads of interaction, which have started in the nested protocol, but need to be continued and the communicative acts addressed to agents outside the nested protocol. The notation of nested protocols can be reviewed at Bauer, Müller et al. (Bauer, Müller et al. 2001).

5.2.1.3.3 Internal Agent Processing Representation

Apparently, protocol diagrams are apt to represent the communication that is necessary to perform the electronic market service. Another intriguing property of protocols diagrams is "leveling". Leveling refers to the fact that any aspect of the *protocol diagram*, e.g. a communicative act or a thread of interaction, can be expressed in more detail by using a combination of diagrams. For example, in Figure 40 a protocol diagram is shown at a top-level.[222] Note that the communicative acts represent complex processing steps, which in turn may require additional interaction with other agents. It is possible to specify this in more detailed view on a deeper level, as shown in Figure 40. Apparently, *communicative act 1* requires more sophisticated processing steps than shown in the top-level, which are illustrated by an activity diagram (right box in the second level). Furthermore, agent 2's response depends on interaction, say a query, with a third agent. This interaction is not marked on the top-level but on the deeper level. Such a refinement of the problem can be arbitrarily continued until an adequate specification of the problem is reached or even code is generated.

For blueprints reflecting electronic markets, it is presumably not sufficient to visualize the protocol diagram. It will be also necessary to represent the internal processing steps that are relevant for providing the electronic market service, e.g. computation of the allocation and the corresponding prices. Those internal processing steps can be modeled by using UML's dynamic models, e.g. state charts or activity diagrams. In the following activity diagrams are

[221] Bauer, Müller et. al. also introduce the property of interleaved protocols. As this property will be not used throughout this book, it is referred to Bauer, Müller et. al. (Bauer, Müller et al. 2001).

[222] Note that the protocol diagram is not necessarily the absolute top level.

used to model the internal processing (e.g. processes of the electronic market) because their semantics provide an explicit thread of control.

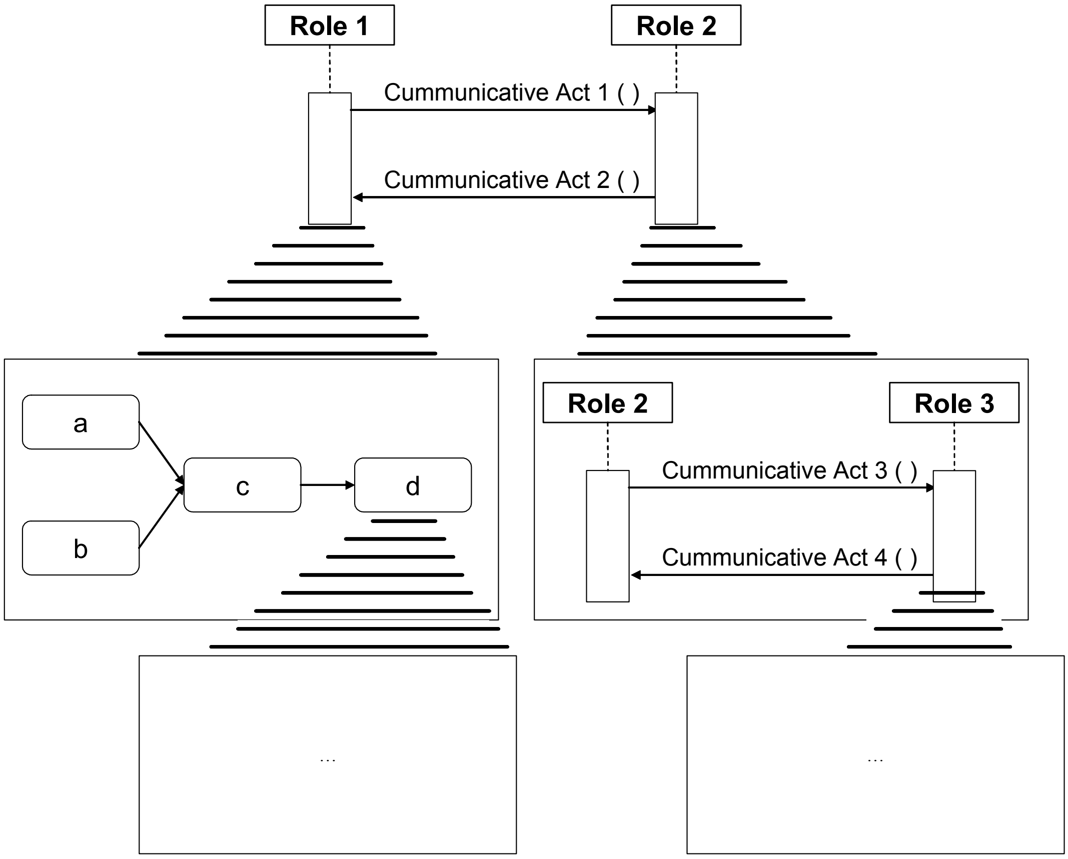

Figure 40: Leveling Protocol Diagrams (Odell, Parunak et al. 2000)

Remark 5.2-3: Activity diagrams

Basically, activity diagrams are based on the extended state-machine model defined by UML (Rumbaugh, Jacobson et al. 1999). In the activity diagram the states are activities that represent the invocation of operations. The transition from one so-called *action state* – denoting the execution of an atomic action – to another is triggered by the completion of the action. As such, the activity diagram shows the action states by showing the sequence of activities that is performed.

In UML activity diagrams, an action state is represented by rectangles with rounded edges. Having completed an activity pertaining to the action state, the subsequent activities are triggered the transition is denoted by an arrow. It is also possible that an activity has more outgoing transitions that are dependent on some conditions. Graphically, a diamond represents this decision situation, where the conditions are stated in brackets at the corresponding transition flow.[223] An example for activity diagrams is given in Figure 41. The filled circle denotes the start of the process. This start event could be initiated by for instance a message. Subsequently activity a is performed. Depending on the result either activity b or c are processes before activity d completes the process. A final state, denoted by a half-filled circle, signifies that the entire state machine is completed.

[223] For a detailed overview over activity diagrams see for example Eshuis and Wieringa (Eshuis and Wieringa 2001).

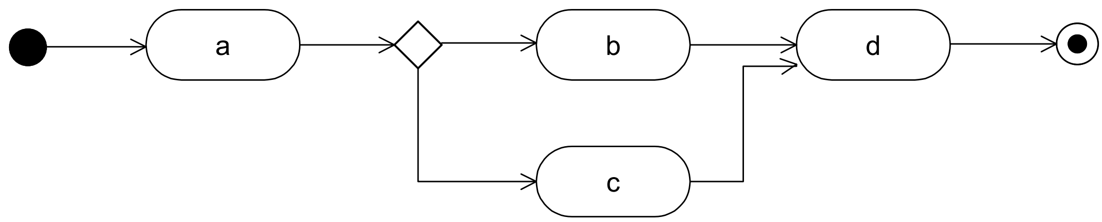

Figure 41: Activity Diagrams

5.2.1.3.4 One Example of Protocols in Agent UML

Having pointed out the most critical extensions of protocol diagrams[224], the blueprint of an electronic market service can be sketched. For illustration purposes the auction mechanism iBundle is presented.[225] Essentially iBundle is an iterative combinatorial auction mechanism that allocates heterogeneous resources with complementarities (Parkes 1999; Parkes 2001). Figure 42 demonstrates the protocol for iBundle as follows.

Two roles MARKETPLACE and BUYERS denoted by rectangles and the corresponding lifelines are involved in the auction. The MARKETPLACE thereby proxies for the (fictitious) service system of market firm that hosts the auction. The omission of a SELLER role and its correspondence with the MARKETPLACE is just for simplicity. As such, the auction starts with the marketplace agent to inform all interested agents about the initiation of a new auction. As depicted by the arrows pertaining to the communicative act *inform* in Figure 42, all interested agents are synchronously notified. Then, the marketplace agent reports for all conceivable bundles S an individual ask p_i price for any agent i. If no reservation prices exist the ask prices for any bundle starts with $p_i(S)= 0$.

BUYER agents can then bid on any bundles they would like. To do so, agents can submit either OR or XOR bids, but not combinations thereof. This is represented in the protocol diagram by the diamond symbol with the ‘x’. The semantics of an OR bid state that any agent can receive no, one or more bundles. For example, in case agent i offers 10 € for bundle {A, B} and 7 € for {C} it is possible to obtain both bundles {A, B} and {C} for 17 €. If the agent had used an XOR offer instead, the allocation would assign only one bundle either {A, B} or {C} with the corresponding prices to agent i.[226] Regardless of the used bidding language (either OR or XOR) the offered prices are supposed to exceed or at least to match the individual ask prices $p_{ask,\ i}$. It is, however, also possible that the buyer agents do not return bids but express their lack of understanding either concerning the ontology or the syntax. Apparently, the marketplace agent receives k bids comprising x OR and y XOR bids and m notifications *“not understood”*. Both bids OR and XOR bids are checked concerning their feasibility. The guard condition symbolized by the comment listed within two squared brackets that the message is sent if and only if these requirements are satisfied.

[224] For remembrance, these were agent roles, agent lifelines, extended semantics of messages and the property nesting (cf. chapter 5.2.1.3.2).

[225] iBundle is more a class of iterative combinatorial auctions consisting of three variations. As the differences in the auction formats refer to the pricing calculation only the attention of this book is restricted to the so-called iBundle(d) auction.

[226] A bidding language is a formalism for expressing valuations. Basically XOR bids can describe all valuations over heterogeneous goods. OR bids, on the other hand, cannot represent all valuations since OR bids fail to account for substitutabilities (Nisan 2000). The intuition why OR bids are provided lies in the communication complexity. Principally it is possible to express the OR bids as XOR bids (though the converse is not true). This would, however, exponentially increase the communication complexity. Reducing the communication complexity as a potential bottleneck of the electronic market system, OR bids are meaningful. Nonetheless as OR bids cannot represent substitutabilities XOR bids (or OR* bids) are also necessary (Fujishima, Leyton-Brown et al. 1999; Nisan 2000).

Remark 5.2-4: Feasibility of Bids

Generally, only those bids are feasible, which satisfies the requirement to match or exceed the individual ask-price. From this general rule, iBundle allows two exceptions: Firstly, those bids, which were provisionally allocated with a bundle in the antecedent round may repeat their bid of the previous round, even if the ask price has increased. This rule ensures that the revenue of auction monotonically increases, as agents can only rescind from the allocation when the marketplace agent receive bids that accrue higher revenue. Secondly, buyer agents can take a discount on the ask price. Once an agent takes a so-called ε-discount on the ask price, this price cannot be raised in the sequel of the auction. The underlying intuition is that agents that cannot match the ask price, because the price has surpassed their valuations may repeat their previous bids. In the subsequent auction it can happen that this agent is allocated with this bundle, although there are agents who bid higher prices on that bundle (Parkes 1999). The reason why this can happen is the following: each agent receives only one bundle. It is, however, possible to bid on more bundles. As the marketplace agent maximizes the revenue of all bundles, it can happen that the agent who cannot meet the ask price falls back into the allocation as the agent with the previous highest bid is awarded with a different bundle.

The reception of all bids triggers processing steps on the MARKETPLACE agent side, which are represented by the vertical bar. The processing steps of the MARKETPLACE agent are depicted by the activity diagram in Figure 42 and can be summarized as follows: Having received all OR and XOR bids, the marketplace agent converts all OR bids into equivalent XOR bids (Parkes 1999). Based upon those XOR bids the marketplace solves the winner determination problem by computing the allocation of bundles to buyer agents such that the revenue is maximized. Thereby it must be assured that the resources are allocated just once and that any agent receives only one bundle. Ties are resolved at first by assigning the bundles to more agents or subsequently at random. As the next step the marketplace agent checks the termination condition. Essentially, the auction ends when

1. All agents that submitted any bid are allocated with a bundle for which it placed a bid. This termination condition stems from the assumption of agents adopting a myopic-best response strategy. This strategy is not game-theoretically optimal but very simple: The agents bid only on those bundles that maximize their utility at given ask prices in a way that the probability of (provisional) winning is maximized. This implies bidding the lowest price as possible on the bundles that maximize utility. Clearly, this lowest price as possible amounts to the ask price. If the agent is unsuccessful he will get another chance to update his bids. If all agents are assigned with a bundle the auction terminates as the agents are assumed not to deviate from their bids because they cannot increase their utility.
2. All agents repeat the same bids in two successive rounds.
   Apparently, it is not advantageous for any agent to increase his utility. The auction thus terminates.

The verification if any one of these two conditions is satisfied marks the end of the marketplace agent thread of interaction or round – graphically denoted by the vertical bar. In case the termination condition is satisfied, the lower message flow (denoted by the guard condition *terminate = true*) is followed in a way that all buyer agents are informed about the end of the auction. All *l* agents that are awarded with an allocation of resources are informed about their allotment and the corresponding price they have to pay (*accept (allocation, price)*), while the m unsuccessful BUYER agents are notified about the end of the auction (*inform (end auction)*).

In case the termination condition is not satisfied the upper message flow is followed. In both cases the bidding process is once more repeated by updating the round (*inform (new round)*) as well as the ask price (*inform (ask prices)*). The ask prices are either anonymous, i.e. the same for all agents or discriminatory, i.e. possibly different for all agents.

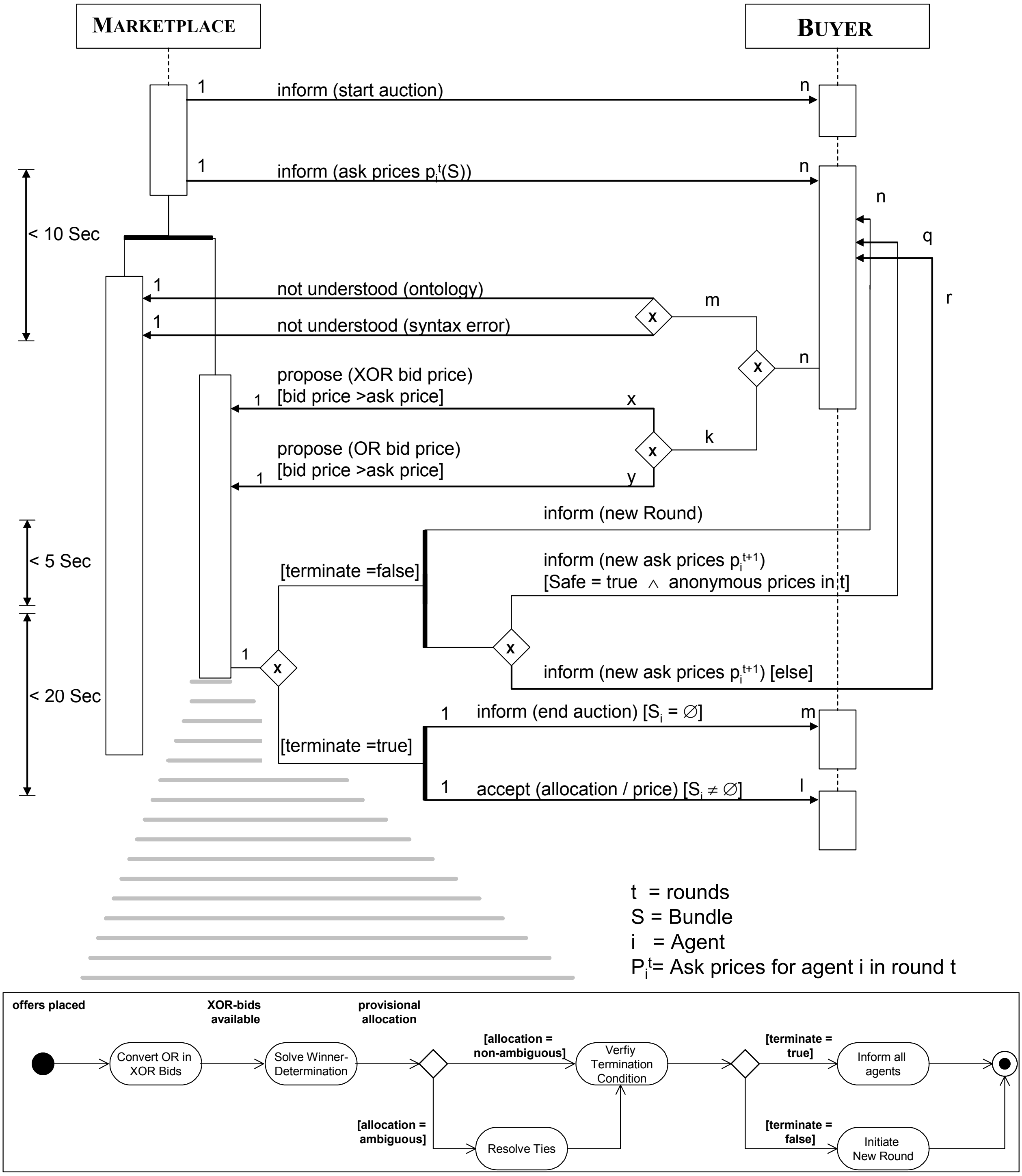

Figure 42: Blueprint for iBundle

- Agents who received anonymous prices are checked whether they satisfy the safe condition. The safe condition is met if the agent only submits a bid for just one bundle or if the desired bundles share it least one common element. Apparently, agents with anonymous prices in the previous round who satisfy the safe condition obtain anonymous ask prices

while those who violate the safe condition obtain discriminatory ask prices. At the beginning all agents receive anonymous ask prices – towards the end of an auction the agents eventually receive discriminatory ask prices. Price updates of anonymous ask prices are computed on the basis of the highest rejected bid price for a bundle. More precisely, the ask price increases if the highest rejected bid for a bundle is within an ε-increment, i.e. the minimum increment, of the current ask price (Parkes 1999).
- Agents who received discriminatory ask prices in the previous round will again receive discriminatory prices. Discriminatory prices denote that any agent receives own prices. Those prices are determined on the basis of bids received from that agent. The ask price increases only when the agent bids for a bundle but does not receive the provisional allocation and also when the bid of this agent is within an ε-increment of the standing ask price.

With the new ask prices the buyer agents can again submit either XOR or OR bids on the desired combinations of resources.

5.2.1.3.5 Protocol Diagrams as Blueprints

As the iBundle example shows are protocol diagrams (in combination with for instance activity diagrams) highly adequate for blueprints. Their use is not restricted to electronic market services but to all conceivable services. Recall that blueprints are required to identify the main processes, isolate failing points, and establish time frames and cost analysis (cf. chapter 5.2.1.2).

- Identifying the main processes
  "[...] the blueprint must identify all main functions (and sub-functions) of the service" (Shostack 1982, 57-58). It is proposed that protocol diagrams can capture the dynamic nature of services. Not only can the chronological sequence of activities be depicted but also the dynamic interaction between the market firm and the customer. While the visualization of the activities is important for defining, manipulating and supervising the service procedure, also the critical interaction with the customer must be illustrated. By defining the interaction with the customer permits control, analysis, and improvement of the activities that requires customer participation.
  Traditional blueprinting literature emphasizes the concept of line-of-visibility. Basically, the line-of-visibility classifies the activities concerning their visibility to the customer. All activities above the line-of-visibility have a direct impact on the perceived service quality. But also the activities below this line – though invisible – may also have a significant impact on the perceived quality. For example, are back-office processes necessary to perform a service in the front office. Apparently, the impact of these invisible processes is more indirect through the inputs and outputs of those activities. The customer may, however, sense changed inputs and outputs at the next visible activity following this invisible activity. As such, in particular the interfaces between visible and invisible activities are crucial for the perceived service quality (Shostack 1982; Shostack 1984; Shostack 1987). Protocol diagrams perform extraordinary well to pinpoint this interface through their reliance on roles. A communicative act from the MARKETPLACE role as a dummy for the market firm to the BUYER customer is potentially a critical process for the service. As such, the line-of-visibility separates the role BUYER (or other roles such as SELLER the customer may take on) from the role MARKETPLACE.
- Isolating fail points
  Identifying the main processes involved for the service the potential drawbacks of the service can be detected. Possible difficulties are errors – either caused by the system or the customer – and communication and computation bottlenecks.

Complexities in the communication can be very easily investigated. For example, in the iBundle example the exclusive use of XOR bids only would increase the demand for band-width as XOR statements can become extremely long. Using additionally OR bids reduces this demand concerning bandwidth as OR bids can more efficiently cover complex XOR bids. Errors or exceptions stemming from the improper use of the protocol or when the performance of the service system slows down can be explicitly modeled in the protocol diagram. For example, it is possible to define maximum time durations activities may take. Those time durations can explicitly be marked in the protocol diagram. Figure 42 for instance sets 20 seconds[227] as the maximum time duration the service system may take from the computation of the final allocation to the notification of all participating buyers about the end of the auction. All processes that violate against those time frames must undergo a fail-safe process in order to correct those errors.

- Establishing time frame
  As above-mentioned, the inclusion of time frames in principally possible but yet not standardized. Nevertheless, a recent initiative within the agent community already proposes the explicit inclusion of deadlines into the protocol diagrams (Huget 2003).
- Establishing cost analysis
  It is straightforward to see that also costs can be attached to any communicative act. Long messages to many agents are apparently more expensive than short messages to few agents. The blueprint may help to detect cost drivers and provide the service firm with the feeling about the costs the single steps of the service potentially create.

5.2.1.4 Blueprinting as Protocol Engineering

A short summary about layout development appears to be helpful to express the idea of blueprinting. Hitherto it was stated that service-blueprints are an adequate tool for designing, adjusting and monitoring services. As common techniques for service blueprints such as PERT have several shortcomings, agent UML (AUML) techniques were proposed for representing blueprints. In particular a combination of *protocol* and *activity diagrams* appears to be powerful to model electronic market services or even services in general. However, AUML denotes only the techniques not the approach of developing agent-based systems. In other words, blueprinting – the refinement of the concept into a dynamic model – is not yet supported. This need for an approach will further on be filled.

Currently, service literature does not provide a methodology for blueprinting. It is either assumed that the blueprint already exists or that the designer somehow develops the blueprint. As such, it is not astonishing that a discursive approach for developing blueprints does not exist. However, this does not mean that there is no approach at all. Recall that *agent interaction protocols* originate from agent-oriented systems. As developing an electronic market service can be modeled as agent-oriented system, the agent literature may provide useful insight: In literature numerous methodologies for developing agent-oriented systems have been proposed. Although many agent-oriented software engineering methodologies have been proposed, only few are both, mature and detailed enough, to be of real use (Dam and Winikoff 2003). Examples of methodologies are Prometheus, Gaia, MaSE (multi-agent systems engineering), MAS-CommonKADS, Tropos, or MESSAGE to name a few. The approach that is suggested here for blueprinting electronic markets is inspired by the Gaia methodology. Gaia – developed by Wooldridge, Jennings and Kinny – was introduced as a high-level methodology for agent-oriented analysis and design (Wooldridge, Jennings et al. 2000; Bauer, Müller et al. 2001). Basically, the methodology is intended to provide a systematic scheme that supports the designer of an agent system from the requirements to a sufficiently detailed design

[227] 20 seconds are an arbitrary number. It is highly likely that even the process of computing the final allocation, which is NP-hard, takes much longer (de Vries and Vohra 2003).

that can be directly implemented. Thereby the approach seeks to guide the designer to gradually move from the abstract to the concrete. This top-down approach implies that each successive step introduces a higher implementation bias.

5.2.1.4.1 A Discursive Approach

The Gaia methodology distinguishes all modeling activities into analysis and design. The analysis translates the requirement specification into a role and an interaction model.

- Role model
  The role model represents the computer system as organization. In other words, the computer system can be thought of a society of agents. Agents are in turn concrete instantiation of a role. For example, human organizations, say typical firms, are formed by their members. The members assume roles such as "president" or "vice president" or more abstractly every member is an instantiation of a role.
- Interaction model
  Agents usually can fulfill their objectives only in cooperation with other agents. The way through which agents can interact is defined by protocols. Any role is associated with certain protocols that are defined in the interaction model.

The design refines the role and interaction model into three models with *"a sufficiently low level of abstraction that they can be easily implemented"* (Wooldridge, Jennings et al. 2000, 295). The first model – the agent model – identifies the different agent types as set of roles that will be used in development time and the agent instances that generate these types at runtime. The second model – the functionality model[228] – documents the functions that are associated with the roles. The third model – the acquaintance model – specifies the communication links between the agent types.

Depending on the Gaia methodology the approach of blueprinting of electronic markets can be sketched (Figure 43). Recall that the Gaia methodology commences from the requirement specification. For blueprinting the concept of the electronic market service already exists. In the next step the involved roles can be deduced from the concept. Principally, any electronic market must specify the roles BUYER and SELLER. Since any mediated marketplace possesses a central entity (mediator) that offers centralized services such as control over the message flow, matching and so forth, also the role marketplace is present.[229] The role model compiles all those roles that can potentially occur. Agents can only achieve their objectives by coordinating with other agents. As a consequence, communication among the agents is necessary. By setting institutional rules communication can be defined to follow a certain format. Those rules governing the communication are codified in the protocols. In electronic markets there is at least one protocol, e.g. English auction, which defines the way agents communicate, but there can be more. For example, the agents may voluntarily choose between different trading rule sets (Weinhardt and Gomber 1998; Neumann, Holtmann et al. 2002c). In those cases there is more than just one protocol. The interactions model documents all protocols that are assigned to roles.

Blueprinting then turns to the specification of the agent types, functionalities and acquaintances. The acquaintances model becomes obsolete if the market is mediated, because in those cases all communication must go through the central entity. Having specified all the five models, the protocols must be refined. The refinement – the result of the refining the protocol dependent on the interactions and the functionality model is the service blueprint. This service

[228] Originally the Gaia model calls the "functionality model" "service model". In order to prevent misunderstandings, it is here called functionality model.

[229] Principally it is also possible that the electronic markets are unmediated. Due to space restrictions this book concentrates on mediated electronic markets only.

blueprint is intended to be the final model that is not exhibiting any implementation details. As indicated in Figure 43, the elaboration of the functions – defined in the service model – is conducted in the step of detail design.

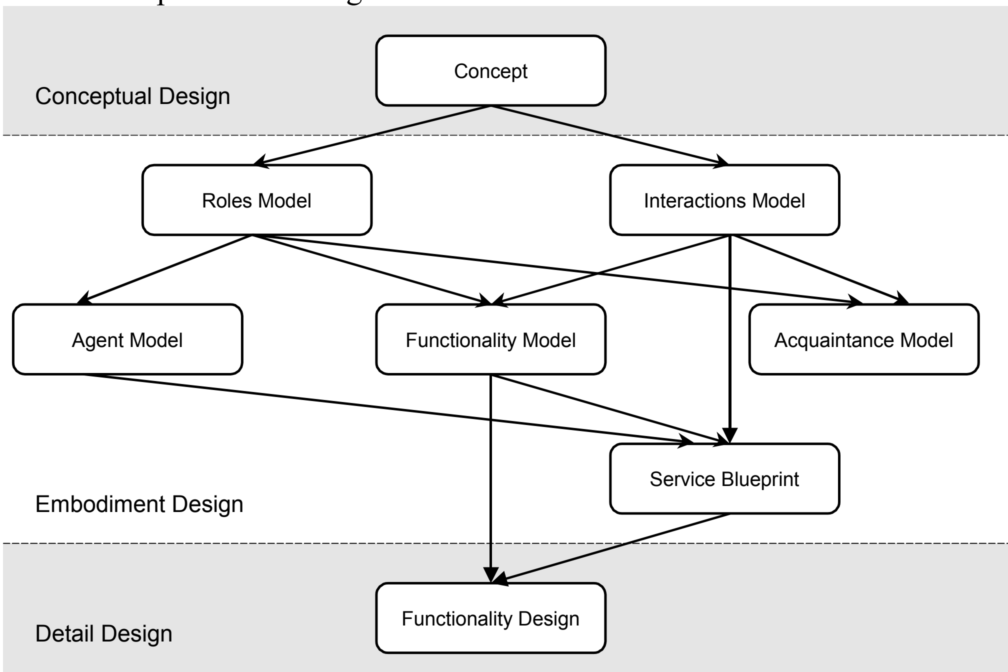

Figure 43: Roadmap for Blueprinting

5.2.1.4.2 Concept Analysis

As aforementioned, the analysis step – the concept analysis – comprises two models, (1) the roles model and (2) the interaction model. The elements of these models are briefly covered, before it is explored how the concept – derived in the conceptual design phase – can be interpreted in terms of those two models.

5.2.1.4.2.1 Roles Model

The roles model determines the key roles of the electronic market. A role essentially represents the totality of functions an entity may exercise (Wooldridge, Jennings et al. 2000; Ströbel 2001). In other words, a role can be depicted as a kind of *office* that is endowed with rights and responsibilities. For example, the role SELLER has the right to contract out resource for sale. There is, however, no responsibility for the SELLER to make use of its right – the SELLERs may act on the electronic market according to their spontaneous plans. More abstractly, a role emerges as an aggregation of rights and responsibilities (Wooldridge, Jennings et al. 2000).

- Rights
  In the electronic market context the rights a role is being granted are almost exclusively pertaining to communication (Smith 1982). The role BUYER, for example, has the right to submit offers to buy, to change those offers and to observe the other offers that are submitted to the electronic market.
  Gaia defines the rights in terms of resources. Following this approach the rights specify those resources that a role can use, in order to carry out the role. In the real world rights can for example refer to the financial budget that a role can spend, in order to fill out this role. In agent-oriented systems these resources are currently viewed exclusively as information and knowledge. This point of view matches the abovementioned interpretation of rights into communication rights: The role BUYER can generate information through the submission of a buy offer and it can access certain orderbook information.

For example, the rights adhering to the role BUYER can be exemplified as follows:[230]

reads	*sellOfferSet*	*//set of price-quantity combinations*
changes	*buyOffer*	*//price-quantity combination*
generates	*buyOffer*	*//price-quantity combination*

Apparently, the role BUYER possesses three rights. Firstly, the BUYER can access (read) the set of submitted sell offers. Secondly, the BUYER can add a new buy offer, which consists of a price-quantity combination or thirdly can modify existing own buy offers.

- Responsibilities
  The responsibilities define the functionality of a role. In the Gaia methodology responsibility are distinguished into two categories, liveness and safety (Wooldridge, Jennings et al. 2000). *Liveness responsibilities* are those functionalities a role has to perform as long as it is alive. Those responsibilities are arranged along the "life cycle" of a role. For example, a role can perform a single activity once and then terminates. Those liveness responsibilities can also comprise patterns or sequences of activities. For example, the role MARKETPLACE always performs the allocation after the matching. The patterns can be iterated once, twice or infinitely often. The role MARKETPLACE repeats, for instance, the sequence of allocation and matching, if necessary, infinitely often.
  The life cycle of the role is specified by a liveness expression, which has the following regular expression:

  ROLENAME = *expression*

  where ROLENAME is the name of the role whose liveness properties are to be defined and *expression* is a (extended) regular expression defining the liveness property of the role. In other words, the liveness expression basically defines the potential behavior pattern through various activities and micro-protocols that are associated with the roles.[231] Activities are computations or other tasks that a role can conduct without any help of other agents, while protocols involve also activities but this needs interaction with other agents. For illustration consider the following liveness responsibilities of the role MARKETPLACE

  MARKETPLACE = (Inform.((Bidding. Matching)+).Allocation.Inform)^{w}

  The expression simply states that the MARKETPLACE executes in sequence the following pattern: the micro-protocols Inform and Bidding, the activities Matching and Allocation and the micro-protocol Inform. In other words, the role MARKETPLACE first informs other agents about the start of the auction, which initiates the bidding process. The bidding process can involve a single or multiple order submission rounds, depending on the result of the Matching computation. If Matching is successful the computation Allocation is conducted in order to determine the winning bids and prices. Subsequently the bidders are informed about the outcome of the auction via the micro-protocol Inform. This pattern is infinitely often repeated, which is denoted by the appended operator. Note that the expression can be appended by an additional operator, which determines the nature of the patterns (see Table 11).

[230] The notation used here is based on the FUSION notation for operational schemata (Coleman, Arnold et al. 1994).

[231] Micro-protocols represent actions or tasks that can only performed in interaction with other agents. Micro-protocols are consisting of one or several communicative acts. Comprising, one or several micro-protocols gives rise to the design of a protocol. As such micro-protocols are the basic component of protocols (Huget and Koning 2003).

Operator	*Interpretation*
x . y	*x* followed by *y*
x | *y*	*x* or y occurs
*x**	*x* occurs 0 or more times
x+	*x* occurs 1 or more times
x^w	*x* occurs infinitely often[232]
[x]	*x* is optional
x || *y*	*x* and *y* interleaved arbitrarily

Table 11: Operators for Liveness Expressions (cf. Coleman, Arnold et al. 1994)

The second type of responsibilities are so-called *safety responsibilities*. Different to liveness responsibilities do *safety responsibilities* demand from an agent – assuming a particular role – that some condition is maintained. For example, a safety requirement can state that an agent cannot sell more resources than is in its endowment. In the electronic market context is the market maker required always to maintain a quote, i.e. a simultaneous offer to buy and to sell. Those requirements are called safety responsibilities, because they prevent undesirable conditions to occur. In the market maker example the safety requirement basically represents an obligation prescribed by the trading rules.[233]

In Gaia those safety requirements are denoted by list of predicates. The predicates in turn refer to variable that are introduced in the role's rights. To illustrate the safety requirements, the market maker example amounts to the following:

- *quote* $\neq \emptyset$

Having depicted all the elements a role principally possesses, the role model can be finalized. Both responsibilities and rights constitute a role. The compiled formal description of the responsibilities and rights form a role schema. A role schema comprises a name, description, protocols and activities, rights and responsibilities.

Role Schema: MARKET MAKER

Description:
This role involves ensuring that at any time a quote, i.e. an offer to buy and simultaneously an offer to sell, is provided.

Micro-Protocols and Activities
SetQuote, Inform, Trade

Rights:

Generate	quote
Change	buying offers
Change	selling offers
Read	submitted buying offers
Read	submitted selling offers

Responsibilities:
Liveness:

MARKET MAKER = $(\text{SetQuote. Inform. Trade})^w$

Safety:

quote $\neq \{\}$ *//Quote is always active*

Figure 44: Schema for the Role MARKET MAKER

Figure 44 exemplifies the role schema for the market maker. This market participant is devoted to supply liquidity by setting a quote. The liveness responsibility is thus determined by

[232] Newly introduced by Wooldridge, Jennings et al. (Wooldridge, Jennings et al. 2000)
[233] The market maker is for compensation reasons granted to view all offers that are being posted. Those compensations in the form of privileges can be included in the rights.

setting a quote, inform the other market participants about the quote, and subsequently to trade with other market participants. The requirement to always set a quote is compensated by the right to observe all submitted offers (in an otherwise intransparent market).

5.2.1.4.2.2 Interactions Model

In the resource allocation process the agents are interacting with each other in order to come to an agreement about the resource assignments. As these interactions are crucial to the way the electronic market functions, they must also be covered in the analysis phase. As such, the interactions model incorporates the links between roles and interactions. More precisely, the interactions model determines the *protocol definitions* that are used throughout the electronic market. The (micro-) protocols are arranged patterns of message interchange coupled with the roles that can engage in the corresponding (micro-) protocol. For example, the interaction protocol English auction specifies the participating roles, namely buyer and auctioneer, and the patterns of interaction (price announcements and valid bids) (Wooldridge, Jennings et al. 2000). The interaction model, however, abstracts from the concrete sequence of message exchange but concentrates on the purpose of the interaction. As such, the protocol definitions are also abstract descriptions of the interaction pattern specifying the participating roles and the purpose of the (micro-) protocol.

Essentially the *protocol definition* in the Gaia methodology represents the UML correspondence to a *template definition* characterizing a protocol package. In the analysis step only the demand for specific protocols must be specified. According to the Gaia methodology, the protocol definition consists of the following components:

- Purpose
  Description of the interaction
- Initiator
  The roles that may start the interaction
- Responder
  The roles that are engaging the protocol
- Information Inputs:
  Information used by the role initiator while enacting the protocol
- Information Outputs:
  Information supplied by/to the protocol responder during the course of the interaction
- Processing
  Textual description of any processing the protocol the initiator performs during the interaction

Figure 45 exemplifies the micro-protocol bidding. Basically MARKETPLACE initiates an open bidding process by announcing the standing highest bid or some reservation price. All agents assuming the role buyer can issue bids. As soon as the first bid is submitted, the micro-protocol describes that this bid is returned.

Purpose
The MARKETPLACE asks BUYER to submit bids
Initiator
MARKETPLACE
Responder
BUYER
Information Inputs
ReservationPrice || Last Bid
Information Outputs
Bid
Processing
Gather Bid

Figure 45: The Bidding Protocol Definition

This bidding protocol is one pattern how to carry out the bidding – there are several others: A different possibility would be that the marketplace announces the required price in descending order. The first buyer, who accepts the announced price, is as well as the winning price returned as information output.

5.2.1.4.2.3 Transforming Concept to Roles and Interactions

Providing general recipes of how exactly to transform the concept into (formal) roles and interactions is unfortunately impossible. This stems from the fact that the function structure, which gives rise to the parametric design of the trading rules is freely configurable. This implies that *"there does not exist any algorithm nor methodology that help designers write the formal description of a protocol given its specifications. Practice seems to be the only way to correctly handle this stage"* (Huget and Koning 2003, 182). Based on this intuition only a general advice that can be given is to iteratively deduce first roles and then protocols (Wooldridge, Jennings et al. 2000).

For the function structure that was presented in this book the transformation can slightly be simplified. The present roles are already enumerated by the parameter *"assign roles"*. Clearly, the role of the MARKETPLACE must be included for any mediated market. Nonetheless, the rights and responsibilities of the roles are not in specified in that detail. The rights can be gathered from the information revelation rules (parameter "reveal provisional winning bid"), which may comprise privileges. The responsibilities can, on the other hand, be deduced from the parameter *"dispose language"*.

The protocols can be either represented as one big protocol such as the English auction or several micro-protocols with minimal interaction. In the former case the representation of the MARKETPLACES liveness requirement are as follows:

MARKETPLACE = (EnglishAuction)+

The value of such a representation is rather limited. The latter approach would suggest representing the EnglishAuction as follows:

MARKETPLACE = (Inform.((Bidding.<u>Check</u>)+).<u>Allocate</u>)+

The latter approach reveals more structure about the protocol. The design of the micro-protocols Inform and Bidding occurs along the subsequent design process. Obviously, the latter approach is recommended, as it provides more information about the trading protocol.

Furthermore, such a representations allows implementing different protocols than the standard. Having described the concept in terms of those regular expressions, the subsequent design of the protocols can now be performed by software engineers without any idea about mechanism design theory or economics.

5.2.1.4.3 Preliminary Layout Design

Having transformed the concept into abstract models, it is the task of the design process to convert these abstract models into models that can be implemented. The Gaia methodology aims, however, at a high level modeling. In other words, as agent systems are more complex, Gaia refines the problem to that level from which classical software engineering can take on. The Gaia methodology does, nonetheless not end the design process here, as the trading protocol is refined to a service blueprint.

5.2.1.4.3.1 Agent, Functionality and Acquaintances Model

The Gaia process involves three models in the design process being the agent, functionality and acquaintances model.

The *agent model* basically accounts for two issues. Firstly, the agent model documents the potential agent types. An agent type is an aggregation of roles. For example, in a two-sided auction an agent can adopt two roles BUYER and SELLER. This, however, must not need the case. Also one-to-one correspondences between agent types and roles are conceivable. The agent model represents an *"agent type tree"*, where the leave nodes are the roles and all other nodes stand for the agent types. In other words, if the node t_1 has the antecedent nodes t_2 and t_3 agent type t1 embodies the roles t_2 and t_3 (Wooldridge, Jennings et al. 2000). Secondly, the agent model defines the instances of the agent types at run-time of the system. In the electronic market context for instance there can be n instances of the agent type Trader, which embodies the roles BUYER and SELLER. Figure 46 exhibits the agent model. The annotations at the graph of the tree – adapted from FUSION – denote the cardinality of the instances.

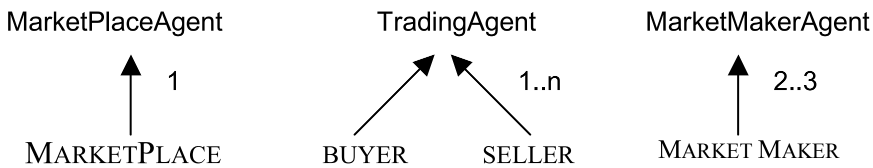

Figure 46: Agent Model

The *functionality model* identifies the functions (i.e. methods in terms of object-orientation) that are attached to each role. Also are the main properties including the inputs and outputs and the pre- and post conditions of these functions specified. The functions can be derived from the protocols, activities and responsibilities for role. Different to software agents, the functions for human agents need not be specified, as they must not be implemented. The human agents will perform those functions intuitively as fundamental part of their strategy. Hence, the function model concentrates in the electronic market context on those components that are assumed by computer systems. This sententious depiction aims at the point that the functions of the MARKETPLACE and other components such as automatic PROXYBIDDER[234] must be specified. The functionality model does not prescribe the implementation of the function. On the contrary the software engineer is free to develop the functions in whatever im-

[234] In some auctions it is possible to make use of a proxy bidder. A proxy bidder is a computer program that assumes the bidding task on behalf of the human agent. For example proxy bidders are used in the eBay auction. The participant enters the maximum willingness to pay for an item. Based on this information the proxy bidder automatically bids an increment higher than competing bids until the maximum willingness to pay is reached and then drops out.

plementation framework. It is merely detected that a function must be implemented – the concrete *functionality design* occurs at a later step in the detail design (recall Figure 43). Table 12 illustrates the functionalities of the role MARKETPLACE for an English auction with a fixed closing rule. For instance, the *informStart* function refers to the protocol inform. The information inputs are the list of all participants (participants) and the time when the auction starts (*startTime*). Apparently, the function *informStart* is associated with a protocol *inform.* Likewise the other functions can be derived in a similar format.

Functionality	Inputs	Outputs	Pre-Condition	Post-Condition
informStart	*participants, startTime*		true	participants know start time
acceptBid	*newBid,highestBid*	*highest bid*	*newBid* available	*highestBid* $\neq$ *nil*
rejectBid	*newBid,highestBid*	*highest bid*	*newBid* available	*highestBid* $\neq$ *nil*
checkTime	*timeElapsed*	*timeLeft*	true	*timeLeft* $\in$ *{yes, no}*
allocate	*highestBid*	*winner*	*timeLeft* = {No]	True
informPrice	*participants, highestBid, winner*		*winner* $\neq$ *nil*	participants know winner and price

Table 12: Functionality Model

Gaia's *acquaintances model* expounds the communication links between the agents. This model can be skipped for mediated markets, as all communication passes per definition through the central instance.

5.2.1.4.3.2 Service Blueprint

Having completed the previous models, the concept developed along the antecedent conceptual design phase is completely transformed into more formal models. In other words, the concept, which is more an economic description of the resource allocation process, is reformulated in a more formal representation. The formal description is intended to avoid misunderstandings, which could especially occur at the interface between economic design and software design. Furthermore, the more formal formulation allows an easier refinement of the electronic market service into a fully-fledged blueprint.

Starting from *the protocol definitions* it is possible to layer down from the static description of the micro-protocol to the concrete interaction between the agents. Putting all relevant micro-protocols and activities of the role MARKETPLACE in an orderly sequence together as demanded by its liveness condition, and refining them to diagrams exhibiting the dynamic interaction and the activities yields the service blueprint (cf. chapter 5.2.1.3.4). Stated differently the service blueprint represents the overall protocol, which in turn consists of nested micro-protocols.

Remark 5.2-5: Validation Process

> Having modeled the trading protocol, however, does not avoid errors in a way that some requested behavior is absent. For example, the protocol may trap the participants in a deadlock, or some desired states can never been reached. Validation of the trading protocol must thus check the protocol concerning structural properties such as deadlock freeness, termination and acceptance cycle freeness (Holzmann 1991; Huget and Koning 2003).

5.2.2 Design of the Auxiliary Functions

All functions that were considered auxiliary while establishing the function structure (see 5.1.1) must now be conceptually designed. Principally, the basic functions such as general inquiries, registration or tutorials qualify for auxiliary functions. As previously mentioned, the classification depends on their importance in the service concept. Auxiliary functions are not in the primary focus of design, as they are not crucial for the (electronic market) service. This is why they have not received any closer attention in the market engineering process. Within the scope of the embodiment design it is important to design and if necessary layout these auxiliary functions. Consistent with the concept and (partially) on the layout of the main functions, it is searched for solution principles that may realize the desired functions of these auxiliaries.[235] The concepts consisting of combinations of solutions principles necessary to perform one or more auxiliary functions can be modeled into layouts (e.g. class, activity and sequence diagrams), but it is also possible to postpone the layout development activity into the subsequent detail design phase.

5.2.3 Layout Evaluation

Having compiled the layouts for all main sub-functions as well as the conceptual design for the auxiliary functions, an overall layout can be obtained. The overall layout apparently comprises the definition of the entire electronic market service. By means of the overall layout, the electronic market service is described in detail without clarifying implementation details. Before the overall layout can be released for detail design and subsequent programming, it is essential to verify its feasibility. Furthermore, a weak spot analysis is needed to identify possible errors or other disturbances. Once the overall layout is approved, the realization of the layout is initiated. In other words, market engineering turns to software engineering. As all critical points are specified in a (semi-) formal way by the layout, the software engineering process can use the layout as requirement specification.

5.3 Chapter Summary

The market engineering process delineates the systematic approach to the design of an electronic market service. In this chapter the core phases of the market engineering process, namely the conceptual and the embodiment design phase, are discussed. As there does not exist any traditional method that supports one of the phases, this chapter suggests a coherent design process beginning from the crude specification of the environment analysis up to the beginning of the software engineering process.

The conceptual design phase is basically divided into four parts. In the first part the electronic market services is abstracted to its overall function. This overall function is subsequently further decomposed into sub-function. The decomposition is finally stopped, when a solution proposal or principle can be found. In the electronic market context the sub-functions corresponds to algorithms or institutional rules. Algorithms are the abstract solution for sub-functions that do not require interaction with the market participants to attain their goal, while institutional rules solve those sub-functions, which requires interaction. A good example for institutional rules as an abstract solutions are the trading rules. As the overall function aims at an objective, which can only be fulfilled by the interaction with the market participants, it is necessary to set incentives in form of the trading rules such that the market participants will act in a desired way. This setting of institutional rules, however, requires the correct prediction of the market participants' behavior. This is exactly the problem of designing the trading rules. Predictions are extremely difficult to obtain, as the behavior depends on the individual circumstances. Nonetheless, it is possible to generalize agent behavior such that social effects can be identified. Those social effects are less reliable and more ambiguous than physical effects, since social effects are based on typical patterns of behavior rather than on natural laws. These ambiguous social effects play a central role in the design of trading rules, as they are used to design the institutional rules. By means of a parametric design the trading rules are gradually configured according to their potential effect on the objectives. As contradictions

[235] As those functions are auxiliary the application of abstraction is not that important, as me-too solutions may also work.

can frequently occur, which cannot be resolved with reference to the approach presented here, conceptual design is tightly connecting with experiments. After the abstract design of the trading rules, a business analyses are conducted in order to perceive the economic potential of the intended electronic market service.

As the conceptual design phase only produces concepts for the electronic market service on an abstract level, it is necessary to refine the concepts into a concrete layout. In other words, there are many ways to satisfy the concept but not all of them are desirable. As such, the embodiment design phases proposes a two-stepped method to obtain a blueprint of the electronic market service. A blueprint conceptually reflects the concrete working of the electronic market without implementation details. For representation the UML-derivative AUML is suggested. Basically electronic markets are gigantic, decentralized information processing systems, thus resembling agent systems. In particular the trading rules can be adequately modeled. The resulting overall layout is now detailed enough to initiate the software engineering process, which subsequently will realize the layout.

6 Summary and Future Work

"Our models and theories of human behavior are still in their infancy" (Kambil and van Heck 2002**,** 199)

The big meltdown of dot.com online markets at the beginning of 2000 and 2001 shook the believe in electronic markets considerably. Apparently, working markets are not *"arising like weeds in the garden or fish in the sea"* (Lerner 1972**,** 259). Instead, markets – and in particular electronic markets –*"don't always grow like weeds—some of them are hothouse orchids"* (Roth 2002**,** 1373). For markets various issues need to be designed: *"Time and place have to be established, related goods need to be assembled, or related markets linked so that complementarities can be handled, incentive problems have to be overcome, etc"* (Roth 2002**,** 1373). Typically, theory is in many cases silent about these issues. As such, designing markets calls for *"an engineering-oriented design literature, and the theory that supports it"* (Roth and Peranson 1999**,** 773).
For electronic markets the problems are even more severe, as the issues that need intensive care are more numerous taking the infrastructure or the fee structure design into consideration. Designing electronic markets apparently also requires an engineering-oriented approach. This obvious need of engineering-oriented design literature gave rise to the introduction of market engineering.

6.1 Summary

In this book market engineering is introduced as the engineering design of electronic markets. As such, it is more general than economic engineering, which strives for designing the trading rules of the market. Recall that designing the trading rules is particularly difficult because of their inherent context-sensitivity. Designing electronic markets is, however, even more cumbersome, as the design of the trading rules is only one part of an electronic market. But what exactly are the design issues of electronic markets?
This book explores this question by extending the microeconomic system framework to electronic markets. The so-called electronic market system framework can be understood as a foundation of electronic markets in a New Institutional Economics sense. As such, the herein presented electronic market system framework is meant to serve as a roadmap for market engineering.
In effect, market engineering is concerned with the design of all elements of the electronic market. This design is, however, challenging, for the following two reasons. Firstly, the problem definition, i.e. how the electronic market should look like, is a priori not given. Secondly, there is no possibility to ultimately measure the goodness of the design along the design process, as any measure is associated with uncertainty. Thus, market engineering can be characterized as an inherent ill-structured problem. To make this ill-structured problem tractable, a systematic design process is proposed, which decomposes the complex overall design task into several smaller less complex tasks. What is then needed, are design methods that can actually solve those smaller design tasks.
This book introduces both, a market engineering process, which is founded on the discipline of engineering design and appropriate design methods. The market engineering process integrates models and methods of various disciplines such as economics, management sciences, decision sciences, or artificial intelligence into a single prescriptive process. Owing to its inter-disciplinarily nature the market engineering process can holistically design all elements of the electronic market in an appropriate way. As the process is not too tight, the creativity of the market engineer can further flourish.

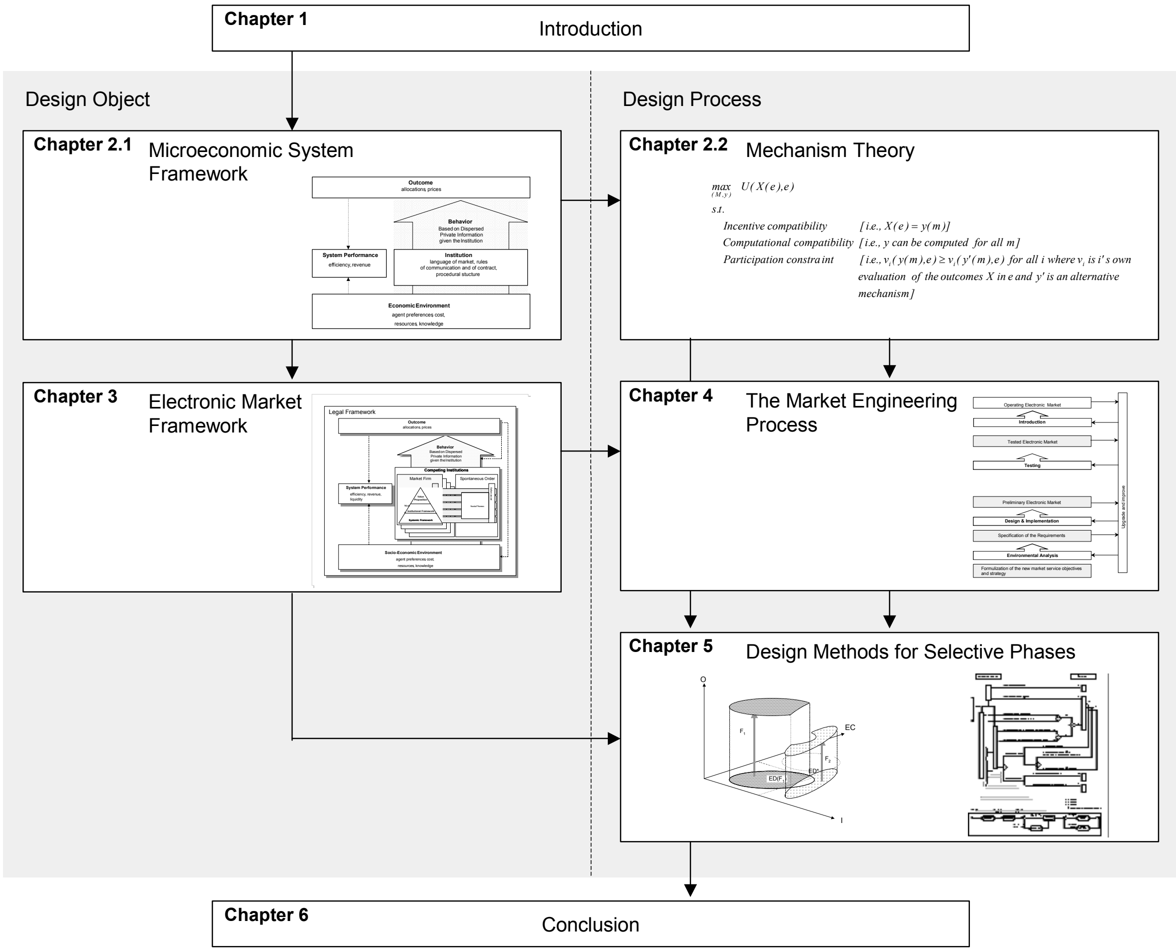

Figure 47: Summary of the Book

Figure 47 summarizes the central steps and results of the chapters. In essence, chapter 1 starts the elaboration with the observation that electronic markets work better in theory than in practice. Two possible interpretations are suggestively presented. Firstly, theory is too optimistic and, secondly, there are severe implementation problems. As a matter of fact, this book is primarily devoted to the second interpretation, as it attempts to derive a market engineering process. This derivation requires deep knowledge about electronic markets as foundation. Since theories only capture parts of the electronic market, this book provides a comprehensive framework for electronic markets.

Chapter 2 introduces the market from a new institutional economics point of view. The microeconomic system framework, illustrated in chapter 2.1 describes the components of a market. Accordingly, the market consists of two parts: the economic environment, describing the demand and supply situation, and an institution, i.e. the way, how prices are being determined. Different than the original microeconomic system framework introduced by Reiter and Smith (Reiter 1977; Smith 1982), this book refines the adjustment process rules following the computational mechanism design literature (Wurman, Wellman et al. 1998; Wurman 1999; Wurman, Wellman et al. 2002). Thus, a coherent, integrative framework for markets can be provided.

Chapter 2.2 gives an overview over theories that either explains the impact of different institution, environment combinations on the outcome (i.e. allocation and prices) or prescribe the design of an institution in a given environment such that some desiderata is attained. Basically these theories are highly sensitive to the context – underlining the claim that markets are hothouse orchids.

Chapter 3 extends the microeconomic system framework to electronic markets. Essentially, the extension comprises the relaxation of many restricting assumptions. In this context, the assumption of no transaction costs of carrying out market processes is no longer maintained. This relaxation has major ramifications: the medium through which the market process is conducted plays a role. Additionally it also requires the presence of an entrepreneur who is willing to assume the risk of running an electronic market. Altogether the institutional view on electronic markets extends the microeconomic system framework by several aspects. Furthermore, another view – the organizational view – becomes relevant, as electronic markets are giving rise to a service firm. This introduces entrepreneurial and strategic aspects into the analysis of electronic markets. Furthermore, those service firms are also exposed to competition. Electronic markets, thus, also constitute an industry view. Comprising, chapter 3 motivates and introduces the electronic market system framework, which consists of three different views (institutional, organizational and industry view). As such, the framework identifies the most relevant concepts of an electronic market, stressing not only the institutional but also the organizational and competitive facet of electronic markets.

Chapter 4 contains the design process of electronic markets. Different to chapter 2.2, the impact of electronic markets on the outcome cannot be computed anymore. Owing to the extensions many assumptions that made the problem mathematically tractable were relaxed. As such, designing electronic markets is no longer a well-structured mathematical optimization problem but an ill-structured problem. Based upon engineering design methodology, a systematic design process is derived that decomposes the entire design tasks into smaller tasks. Those smaller tasks address all elements that were previously identified in chapter 3. Basically the market engineering process can be distinguished into four stages. The first stage could also be headlined as *"marketing engineering"*. In this stage the relevant field is determined in which the electronic market is intended to work. Subsequently the electronic market is designed and implemented. As this step is the crucial step in market engineering, it is detached from chapter 4 and moved into the separated chapter 5. Stage 4 prescribes a testing procedure, which considers both functionality and economic performance. Having past the testing stage, the electronic market is launched completing the market engineering process. This market engineering process is the first attempt in literature to provide not only knowledge about the design object, i.e. the specific electronic market, but also about the design process, i.e. how the electronic market *should* be designed.

Chapter 5 hallmarks the early steps of the design stage. Basically the conceptual design phase transfers the systematic design process from engineering design to market engineering. Starting from an abstract definition, the electronic market is analyzed according to its functions that it performs (functional analysis). Those functions are subsequently decomposed into subfunctions until abstract solutions can be found. Abstract solutions thereby either refer to algorithms or institutional rules. The design of institutional rules is particularly difficult, as they affect agent behavior. As such, the design of rules must anticipate the reaction of the agents. This is quite an ambitious task that has not yet systematically been attempted.

This book suggests the first discursive procedure how to use social regularities in order to design the institution of trading rules. In essence, the results of economic design theory (chapter 2.2) are coded in economic effects that are subsequently used to parametrically design the trading rules. The degree of abstraction of these trading rules is, however, very high. Embodiment design suggests – based on agent-based methodology – a two-stepped approach how the results of the parametric design can be refined into a into a model with sufficiently low level of abstraction that traditional software engineering techniques may be applied in order to implement it.

In summary, this book motivates market engineering when moving from the microeconomic system framework to the electronic market system framework. Electronic markets are much more complex than “pure” mechanisms, such that the design problem becomes inherently ill-structured. By providing a market engineering process which bases

6.2 Future Work

Although many researchers have called for engineering approaches in the design of markets, no such attempt has yet been undertaken. This book applies methodologies and techniques from mechanical engineering and transfers it to the design of electronic markets. Once the electronic market has been fully designed, ordinary software engineering can take on and further develop the layout into a running software system. As the suggested market engineering process is a primer, there are several directions for future work.

6.2.1 Extensions and Limitations of this Approach

The suggested approach only sketches the market engineering process and refines only selective design steps. For a comprehensive design process it is necessary to specify any design task. For any stage of the market engineering process extensions are conceivable.

- Environmental Analysis
  The definition of the trading object definition is currently more of a trial and error. Discursive methods are not existent. Taking the impact of the trading object definition into consideration, it suggests becoming a burning research topic. Furthermore, marketing techniques must also be better integrated into the process – in particular the assessment of market segments.[236] At present, the market engineering process does not give any strategic advice how the market engineers ought to define and select their market. Lastly, the requirement analysis of the environmental analysis is currently a black hole.
- Design and Implementation
  The suggested parametric design procedure incurs several problems. Firstly, the approach is build upon uncertainties. More research would be needed to better deal with those uncertainties. For example, the application of fuzzy logic might be promising. Secondly, there is a tremendous need for interpreted economic effects. At the moment the database is way too small. Clearly, the accumulation of further knowledge about the effects of institution environment combinations on the performance is also subject for further research.
  The conceptual design of all institutional rules except the trading rules, e.g. the design of the enforcement machinery, is completely missing. At the moment neither structural analyses nor discursive design approaches exist.
  The proposed procedure for embodiment design results in a semi-formal description of the process using the AUML toolset. A further refinement into a formal language may be desirable, as for instance the validity of the protocol can be proven.
- Testing
  Economic testing has recently experienced a surge in popularity. Laboratory experiments and simulations have established themselves as accepted testing methods. However, both methods incur disadvantages, which diminish their applicability in the field. New testing methods such as field experiments, Internet tournaments or automatic black-box test-beds are necessary to overcome the disadvantages of the traditional testing methods.

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[236] This is, however, not a specific market-engineering problem.

- Introduction
  The stage of the electronic market introduction is momentarily unexplored. Case studies may help to understand the difficulties and crucial factors involved in the rollout process.

Currently the market engineering is purely conceptual. Although, the insights that finally led to the market engineering process were gained along the development of several electronic market prototypes (see for example AMTRAS, VTR, e-FITS[237]), an empirical stress test is missing.

6.2.2 Extension to Electronic Negotiations

The market engineering process presupposes that auctions can solve the resource allocation problem. Auctions are traditionally price-dependent, which implies that electronic markets employing auctions are often devoted to lowering procurement prices or to increasing selling prices. However, there are many situations, where the price is not the only relevant criteria. For example, in procurement settings buyers and sellers are also interested in quality, dependability and more importantly established relationships. To support the exchange of complex products and services, auctions have been extended to multi-attribute auctions (Che 1993; Bichler 2001; Veit, Müller et al. 2002; Strecker and Seifert 2004).
From a conceptual point of view, multi-attribute auctions could principally be integrated into the suggested parametric design procedure. However, theoretical and empirical work is currently rather limited.

Alternatively, when participants are more interested in inter-business relationships than in the price, they may want to engage in bilateral negotiations. Different than auction protocols bilateral negotiation protocols support collaboration among companies, in which value is created rather than distributed (Kersten, Noronha et al. 2000). Despite their differences, both types of protocols – either bilateral negotiation or auction protocols – affect the outcomes of the negotiation. As such, the design of bilateral negotiation protocols should ideally also anticipate the negotiators' reactions. Principally, it is possible to use the parametric design procedure also for the design of negotiation protocols. However, the focus should emphasize more social effects associated with fairness, reciprocity, attitude and culture, which have not yet been recognized.[238]

In summary, the proposed market engineering process can presumably be extended to all kinds of electronic negotiations (i.e. auctions as well as other negotiation protocols). This goes in line with the initiative of the electronic negotiation group, which demands for a systematic engineering of electronic negotiations (Bichler, Kersten et al. 2003; Kersten 2003; Ströbel 2003; Ströbel and Weinhardt 2003). Apparently, those two research paths can be reconciled in the future.

6.2.3 Computer-Aided Market Engineering

Finally, another direction for future work can be headlined as Computer-Aided Market-Engineering (CAME). In essence computer-aided market engineering seeks to automate phases of the market engineering process.
In the discipline of software engineering the requirements are similar to those in market engineering: high functionality software applications must be developed in a short period of time. This can be achieved by the means of so-called CASE technologies (Computer-aided software

[237] These electronic market prototypes are described at (Weinhardt and Gomber 1998; Budimir and Holtmann 2001; Budimir, Holtmann et al. 2001; Neumann, Holtmann et al. 2002a; Neumann, Holtmann et al. 2002c).

[238] This omission is almost self-evident, as auction protocols are typically anonymous.

engineering). CASE tools allow automating significant parts of this time-consuming software development life cycle. In analogy to CASE tools, specific development tools for market engineering are also deemed promising to speed up the design process. Furthermore, the quality of the design process can be enhanced by a standardized, tested toolset[239].
Market Engineering is facing similar problems. In the most cases the market engineer do not have the time (and money) to develop the market software in detail. Time-to-market is important particularly for innovative electronic market solutions, as the first-mover advantage is essential. However, if this early appearance is achieved by incurring severe design failures, the chances of the electronic market are tremendously diminished.[240] Apparently, market engineering requires a quick and thorough conception and implementation, which gives rise to computer-aided market engineering. First attempts for an integrated CAME toolset have been undertaken along the e-FITS project (Czernohous, Kolitz et al. 2003; Maekioe and Weber 2004; Weinhardt 2004).

The market engineering process provides a structured approach to the deliberate design of electronic markets. Nonetheless is market engineering no panacea to success: *"To build an effective online marketplace, one needs to identify unfulfilled trading opportunities, design a suitable negotiation mechanism, and provide (directly or through ancillary parties) well-integrated discovery and transaction services. This is of course quite a tall order, and the specifics are dauntingly open ended. Nevertheless, assembling all these functions still is not sufficient to ensure marketplace success"* (Wellman 2004**,** par. 1.4).

[239] Note that the engineering process is an open process. Knowledge acquired during the engineering process is added to the knowledge base and will be accessible for other projects.

[240] Recall that the market quality (in this respect liquidity) is a chicken-and-egg problem: Once a market started with low participation, the chance of catching up is low since negative network effects work against this market.

Appendix

List of Abbreviations

ACL	Agent Communication Language
AGV	d'Aspremont and Gerard-Varet,
AMTRAS	Agent Mediated Trading System
API	Application Programming Interface
AUML	Agent UML
B2B	Business-to-Business
CA	Communicative Act
CAME	Computer-Aided Market Engineering
CAP	Combinatorial Allocation Problem
CASE	Computer-Aided Software Engineering
CBOT	Chicago Board of Trade
CPM	Critical Path Method
CV	Common Value
DTB	Deutsche Terminbörse
ECN	Electronic Communication Network
EDI	Electronic Data Interchange
e-FITS	Electronic Financial Trading System
EMH	Electronic Market Hypothesis
EMS	Electronic market system
ERP	Enterprise Resource Planning
FCC	Federal Communications Commission
FIPA	Foundations for Intelligent Physical Agents
FPSB	First-Price-Sealed-Bid
GL	Groves-Ledyard
GUI	Graphical User Interface
GVA	Generalized Vickrey Auction
IPV	Independent Private Value Model
IT	Information Technology
JAD	Joint Application Development
KQML	Knowledge Query Management Language
MAS	Multi Agenten System
MaSE	Multi-agent System Engineering
OCL	Object Constraint Language
OEE	Observable socio-economic-environment-based effect
PERT	Program Evaluation and Review Technique
ROCE	Return on capital employed
ROI	Return on investment
SIPV	Symmetric, independent private value
SW	Social Welfare
TAM	Technology Acceptance Model
UEE	Unobservable socio-economic-environment-based effect
UML	Unified Modeling Language
VCG	Vickrey-Clarke-Groves
VTR	Virtual Trading Room
ZI	Zero Intelligence

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