Research on cost management methods used in new product development and their relationship to strategic priorities and collaborative competences:

A systematic literature review and survey of the German manufacturing industry

Zur Erlangung des akademischen Grades eines
Doktors der Wirtschaftswissenschaften

Dr. rer. pol.

bei der Fakultät für Wirtschaftswissenschaften
des Karlsruher Instituts für Technologie (KIT)

genehmigte

DISSERTATION

von

Dipl. Wi.-Ing. Susana Patricia Morales Cueva

Tag der mündlichen Prüfung:	04.02.2016
Referent:	Prof. Dr. Ir. Marc Wouters
Korreferent:	Prof. Dr. Hagen Lindstädt
Karlsruhe	14.02.2016

Abstract

Managing costs efficiently during new product development (NPD) has become a competitive weapon for organisations and a focus for research on product development. Reducing costs in the early stages of NPD creates advantages in market share, profit, and long-term competitiveness. The problem arises from the lack of empirical data on antecedents of the adoption of cost management methods (CMM) suggesting which methods can be used for NPD processes according to the organization's structure. Several scholars point out that well defined strategic priorities on the issue of NPD management as well as collaborative competencies support NPD success. Hence, firms that adopt CMM which are more suitable for their characteristics can gain a competitive advantage over firms that are unable to do so. Thus, the current research questions whether there is a relationship between the organisation's characteristics and the use of certain groups of cost management methods. This doctoral thesis presents a systematic review in both the management accounting as well as the innovation and operation management literature in 15 different methods for cost management. Subsequently, six antecedents of the adoption of CMM are identified and empirically analysed. This research shows evidence of a web-based survey of 82 German firms by testing the relationship between groups of CMM and the company's strategic priorities and collaborative competences. The studied strategic priorities are cost leadership, quality leadership, and flexibility while the collaborative competences are supplier integration, cross-functional integration, and customer integration. Spearman's correlation analyses were used for testing the research hypothesis. It was found that in a R&D context, the use of CMM is strongly related to the perception of their helpfulness, especially in medium-sized firms. The antecedents explaining the adoption of CMM during NPD are cost leadership, cross functional integrations and supplier integration. Furthermore, results provide no support in defining quality leadership, flexibility or customer integration as antecedents of the adoption. This research adds to the growing literature and further informs practitioners of cost management in NPD. An implication is that firms pursuing the characteristics detected as antecedents of the adoption of CMM can benefit from our outcomes on which methods to use to manage their NPD costs.

Acknowledgement

My deepest gratitude is due to my supervisor Prof. Marc Wouters whose encouragement, guidance and support from the initial to the final step of my research enabled me to understand and develop the subject. I also would like thank my colleagues and research assistants for their support all during these years. Last but not least, a big thank to Mr. Scheer and Mr. Grollmuss, I really enjoyed working with you on our publication.

Dedications

I owe my deepest gratitude to my parents and the rest my family as well as to my dear boyfriend for their unconditional support. I also would like to show my gratitude to all my friends who offered their support in a number of ways during the completion of my doctoral thesis, especially to Julia Kölling and Melitta Habersaat who dedicated much of their valuable time to reading my thesis and offering their excellent feedback.

Karlsruhe, December 2015

Susana Morales

List of contents

List of Figures

List of Tables

List of Abbreviations

CMM	Cost Management Methods
NPD	New Product Development
MA	Management Accounting
IOM	Innovation and Operations Management

Abbreviations of the methods

TC	Target Costing
VE	Value Engineering
QFD	Quality Function Deployment
FCA	Funtional Cost Analysis
KC	Kaizen Costing
LCC	Life-Cycle Costing
TCO	Total Cost of Ownership
SGR	Stage-Gate Reviews
DFM	Design for Manufacturing
DFA	Design for Assembly
DFX	Design for X
CC	Component Commonality
MD	Modular Design
PP	Product Platforms
TR	Technology Roadmaps

1 Introduction

1.1 Research motivation

The relevance of management accounting in high-technology firms is constantly evolving. The traditional view of management control systems as being detrimental for innovation has been challenged by the literature and empirical studies (Davila, Foster, & Oyon, 2009; Davila, 2000; Simons, 1995). A discrepancy arises from the fact that most management control mechanisms are focused on manufacturing firms (Bisbe & Otley, 2004; Kaplan & Norton, 2001), where processes are well established. The high levels of uncertainty about innovation outcomes characterise the technology intensive industry, provoking a need for a much more suitable combination of management control methods to enhance performance of new product development (NPD) processes.

This research is focused on establishing knowledge about how management accounting may be implicated in assisting NPD processes. Within uncertain environments, such as NPD projects, "accounting procedures are needed for financial control" (Greiner, 1998, p. 6). Thus, the efficient use of resources for a better innovation performance turns into a matter of paramount importance. New product development projects need to be managed to meet objectives concerning budgets, lead time, product cost, and, ultimately, success in the market. Therefore, it is highly important to identify which cost management methods are suitable according to the structure of the organisation.

1.2 Structure of the research

The concepts of new product development (NPD) and cost management methods are of major importance in this work. We conducted an extensive literature review with the objective to trace the wide variety of research on cost management methods and review findings concerning these methods not only within the literature of management accounting (MA) but also in the innovation and operations management (IOM). To create consistency throughout the thesis I decided to use "we" as the form to refer to the author(s). While writing the literature review of this thesis, I was working together with Prof. Dr. Wouters (all results presented within Chapter 3 as well as the Tables referred in Appendix A). Afterwards, Mr. Scheer and Mr. Grollmuss joined us for further research (part of the results presented within Chapter 4 and the Tables referred in Appendix B). The final papers are or will be published with co-authors. **Chapter 2** describes the criteria followed for the systematic literature review of research on 15 different costs management methods within the NPD context. The search for concepts within the MA literature covers a set of 40 journals from which 37 are suggested as being the most influential ones in academic accounting by Bonner, Hesford, Van der Stede, & Young (2006). Moreover, the review of the IOM literature focuses on 23 journals selected from relevant rankings of these academic fields (Durisin, Calabretta, & Parmeggiani, 2010; Gorman & Kanet, 2005a; Linton & Thongpapanl, 2004; Martin, Nightingale, & Yegros-Yegros, 2012; Page & Schirr, 2008; Stonebraker, Gil, Kirkwood, & Handfield, 2012). This yields 113 papers from the MA literature and 208 papers from the IOM literature which are analysed in detail (e.g., research method, industry and a summary including the research design and field work).

The results of the MA literature are presented in **Chapter 3**. It is intended to be representative within the field of accounting, but not for all research on these cost management methods, since much research is done in other management and engineering areas. The findings draw attention to a wide range of studies on the use of management accounting practices (Abdel-Kader & Luther, 2008; Abdel-Maksoud, Dugdale, & Luther, 2005; Alkaraan & Northcott, 2006; Al-Omiri & Drury, 2007; Chenhall & Langfield-Smith, 1998a; Guilding, Cravens, & Tayles, 2000; Innes & Mitchell, 1995). However, to our knowledge no prior study has investigated the antecedents of the adoption of different cost management methods during NPD. The content of this chapter was published as a book chapter in Wouters & Morales (2014).

Chapter 4 presents the research findings from the IOM literature. An outstanding characteristic is the large amount of research presenting practical approaches or decision models for the further development of a particular cost management method. Compared to the sample of studies presented in the MA literature, the findings of the IOM literature pays more attention to the development of methods to support their practical application which has an "engineering" aspect. There are also many studies looking at these methods as phenomena in organisations using surveys and case studies. But such a research focused on explanations is not as predominant as it was in the MA literature. We found a lack of research on the actual use of the various cost management methods. The findings presented in this chapter have been accepted by the journal *Advances in Management Accounting* and will be published early in 2016.

Previous research stresses that according to the companies' managerial orientation, the use of certain cost management methods can be beneficial (see, for example, Henri (2006); Bisbe & Malagueño (2009); Davila 2000; Davila & Oyon (2009)). Cost management methods, such as target costing, life-cycle costing and Kaizen, were researched extensively. However, empirical research on their adoption for NPD has remained scarce. **Chapter 5** covers the development of the research hypotheses. Firstly, the conceptualisation of the adoption of cost management methods is investigated more carefully to reinforce our knowledge about this concept. Thus, we search for survey-based research addressing our methods. The purpose of this review was to understand the potential contribution of the present study to the academic literature as well as to find relevant studies to base our research method on i.e., the conceptualisation and measurement of the adoption of cost management methods.

Secondly, the 15 different methods are clustered into particular groups based on their scope (i.e., costs, products and services considered, data source and monetisation). This serves to develop eight hypotheses on the use and helpfulness of certain groups of cost management methods as well as further hypotheses on the antecedents of the adoption of cost management methods. These hypotheses are based on the notion that cost management methods are aligned to the organisation's structure and its characteristics. On the one hand, research from the accounting literature suggests that management control systems should match the strategy of the company (Boyer, Leong, Ward, & Krajewski, 1997; Boyer & Lewis, 2002; Boyer & McDermott, 1999; M. Joshi, 2003) i.e., that control systems, methods and techniques are chosen according to the company strategy (Bisbe & Otley, 2004; Chenhall & Langfield-Smith, 1998b; Daniel & Reitsperger, 1991; Ferdows & Meyer, 1990; Govindarajan & Fisher, 1990; Van der Stede, 2000). Hence, the strategic priorities of a company may foster the adoption of certain cost management practices (Baines & Langfield-Smith, 2003; R. Cooper, 1996; Mouritsen, Hansen, & Hansen, 2001), not only individually but rather in a combination (Chenhall & Langfield-Smith, 1998b). On the other hand, organisations' performances increase when efforts are made to collaborate with customers in developing new products (Kahn, Barczak, Nicholas, Ledwith, & Perks, 2012; Kahn, 2001; Lamore, Berkowitz, & Farrington, 2013; Narver, Slater, & MacLachlan, 2004). Cost management practices provide the structure to control the costs incurred in a company which may be influenced by inter-organisational as well as intra-organisational issues (Davis & Eisenhardt, 2011; Mouritsen et al., 2001). The availability of cost data and other product related information is also of paramount importance in managing the cost structure in R&D. Therefore, the providers of this information such as suppliers, cross-sectional teams and customers might play a relevant role in the adoption of particular cost management methods. Lastly, Chapter 5 presents eight research hypotheses on the antecedents of the adoption derived from the aforementioned arguments.

Hence, the main objective of this research is to present to academics and practitioners the proof that management accounting contribute to the enhancement of NPD processes. This contribution to academic knowledge sheds light on which cost management methods are used for product development, which ones are perceived as helpful for new product development and if the use of such cost management methods is linked to the following organisation's characteristics:

- Strategic priorities:
    - Cost leadership
    - Quality leadership
    - Flexibility
- Collaborative competences:
    - Cross-functional integration
    - Supplier integration
    - Customer integration

Besides the great theoretical contribution from this broad systematic literature review, the value of this doctoral thesis lies in its empirical character. This research provides new empirical evidence not only on the adoption of 15 cost management methods but also on the antecedents for such adoption, overcoming some of the typical data limitations by using a unique survey data set of 82 German manufacturing firms. **Chapter 6** focuses on the measurement of the constructs and their methodological foundations. Hence, to strengthen the validity and reliability of the measurement used, a questionnaire was developed on the basis of previous work, primarily by Boyer & Lewis (2002) and Mishra & Shah (2009). In total, 800 R&D managers were invited to participate in a web-based survey. The questionnaire (see Appendix D and E) consisted of three sections. Section A collected demographic characteristics of the respondents. Section B addressed the use and helpfulness of cost management methods. Section C dealt with the explanatory variables. These concerned collaborative competences and strategic priorities. The questionnaire also included the definitions of all methods and a box for comments after each section.

Chapter 7 reports on the statistical analyses of the sample of 82 firms. Spearman's correlation analysis was used for testing the research hypothesis. Within this chapter we also document further analyses. The implications of our findings are addressed in **Chapter 8.** This chapter also presents the guidelines for future research.

In conclusion, this research adds to the growing literature and informs practitioners of cost management in NPD. An implication of the findings is that firms pursuing the characteristics identified as antecedents of the adoption of cost management methods benefit from our outcomes on which methods to use during NPD processes.

2 Research method for the literature review

2.1 Introduction

In this chapter we present the research method employed for the literature review. The main objective is to organise the literature around specific methods of cost management in new product development (NPD) including for example, target costing, life-cycle costing and modular design. Research findings focused on two types of literature, namely, the management accounting (MA) and the innovation and operations management (IOM) literature. This will provide an overview of approaches by reviewing both literatures and drawing conclusions for future management accounting research.

The present literature review highlights what former studies have to say about the content or the use of specific cost management methods. Many studies published in accounting do not investigate cost management methods as such, but define a more general, theoretical construct that characterises certain types of cost management methods and mention only examples of a particular type of cost management. For example, Cadez & Guilding (2008) investigate antecedents and consequences of strategic management accounting, using survey data and structural equation modelling. Here, life-cycle costing and target costing are mentioned as examples of strategic management accounting methods. Davila (2000) investigates the drivers of management control systems design in new product development. The survey results show that project uncertainty and product strategy are relevant to explain the design of these control systems. Furthermore, cost information is positively associated with project performance. Cost information is measured through the level of detail of cost information, the updating frequency of cost information and the interactive use of cost information. Baines & Langfield-Smith (2003) report on a survey of manufacturing companies and use structural equation modelling to examine management accounting change. One of the constructs in the model is advanced management accounting practices, which "can assist employees to more easily focus on achieving differentiation priorities, such as quality, delivery and customer service, compared to more traditional financially based accounting practices, as they highlight the need to satisfy customer requirements" (Baines & Langfield-Smith 2003, p. 678). Target costing is mentioned as an example of such advanced management accounting practices.

Rather than focusing on theoretical constructs, such as strategic management accounting, cost information, or advanced management accounting practices, the connecting thread in the present literature review are specific cost management methods. Describing the results from former studies in relation to one or several cost management methods is the focus of the present review, even if these are not the main results of the investigation.

Moreover, the contribution of this literature review is based on its research method, which complements other reviews on the topic of management accounting in NPD, such as Davila et al. (2009), Davila & Wouters (2007), Caglio & Ditillo (2008), and Anderson & Dekker (2009). These literature reviews are structured according to constructs or otherwise theoretically formulated topics. Sections or paragraphs address, for example, interactive control systems in NPD. Knowledge management, non-financial performance measures in research and product development, uncertainty, interdependence, trust or organisational boundaries are also addressed. Other studies investigated the wider context of management accounting in NPD through case studies, such as Jørgensen & Messner (2009) and Taipaleenmäki (2014). However, there is much more in the sense of other literature besides accounting that address cost management during NPD. In particular, a considerable amount of literature in innovation management, technology management, marketing, and operations management address this topic. For brevity, we will call this the innovation and operations management literature.

Finally, the focus on cost management methods provides a natural perspective to reflect on what is known about how firms deal with costs of NPD. This focus also helps to understand the diversity of cost management methods and how relevant these might be NPD. Finally, it enabled us to identify and incorporate studies related to cost management in NPD, including different theoretical aspects besides the “usual” management accounting constructs.

2.2 Definitions of cost management methods

Table 1 presents a list of 15 different management accounting methods that can be adopted to manage NPD costs. The initial list was composed based on prior knowledge of the topic and was expanded when new methods or more appropriate terminology was identified while reviewing the literature.

Table 1: Short description of various cost management methods applied during product development.

Cost management methods	Definition
Target costing (TC)	Before the NPD project, the allowable manufacturing costs of a product and of its components are determined, starting with the sales price of the product for end users and subtracting target profit margins and nonmanufacturing costs at various stages in the supply chain. During several stages of the NPD project, the manufacturing costs are estimated to assess if these do not exceed their allowable cost targets, which would require redesign.
Value engineering (VE)	Product cost structures are analysed to identify changes of the product design which enable it to be manufactured at its target cost.

Cost management methods	Definition
Quality function deployment (QFD)	The priorities of customer requirements are translated into the importance of the technical attributes or functions of the product, which, in turn, guides the allocation of the total allowable cost to the different parts of the product. QFD uses matrices to show the relationships between requirements, functions and parts.
Functional cost analysis (FCA)	Cost structures of products or services are evaluated to find ways for improving either the product design or the production process in order to reduce the cost of providing the required functionality and performance.
Kaizen costing (KC)	Efforts are made to ensure a continuous cost reduction process during the manufacturing phase of a product at a pre-specified amount or rate.
Life-cycle costing (LCC)	Cost estimations and measurements are extended from manufacturing costs to also include non-manufacturing costs, which may be incurred at different stages of the life cycle of a product (e.g., waste and disposal).
Total cost of ownership (TCO)	Cost accounting is used to support purchasing decisions makers to combine price and value for their sourcing decisions. This involves monetary quantification of all costs incurred by the customer as a result of acquiring and using supplier offerings.
Stage-gate reviews (SGR)	After completion of each NPD stage, the design is reviewed on a wide variety of aspects for which targets have been formulated at the start of the NPD project (such as unit manufacturing cost, other unit costs, cost and lead time of the NPD project, functionality and performance of the product). The outcomes of these reviews may lead to revisions of the product design or adjustments of the targets.
Funnels	A selection process for product development in which the number of alternatives that a firm is considering gradually decreases as the development process moves toward completion.
Design for manufacturing/ assembly (DFM/A)	NPD teams are provided with guidelines and constraints which help them to improve their product designs such that these can be manufactured at a low cost.
Design for X (DFX)	NPD teams are provided with guidelines and constraints which help them to improve their product designs such that costs can be kept low on a wide range of aspects, for example; logistics, disposal, environment and service.
Component commonality (CC)	Restricted sets of allowed materials, parts, components, packaging etc. are defined, which act as constraints during NPD, in order to share these materials, parts, components, packaging etc. across a wide range of final products.
Modular design (MD)	Products are designed in such a way that a wide variety of final products can be produced using a limited number of modules that are adjusted and/or combined with different parts and other modules.
Product platforms (PP)	A product platform concerns the basic architecture of a product by describing the physical implementation of a functional design and this becomes the basis for a series of derivative products.
Technology roadmaps (TR)	A technology roadmap describes candidate technologies and the levels of specification and required performance in a particular industry that are planned to be reached at different points in the future.

2.3 A systematic literature selection

In this section we introduce the criteria followed to conduct the systematic literature review. We looked at journals selected from the MA literature as well as from the IOM literature. Once the list of journals was set, we specify the criteria for the paper selection to be included in the sample of papers that comprise the basis for this review on cost management methods in NPD. Some aspects of the research method are presented separately for both types of literature. This arrangement aimed to keep a clear overview of the research found on each type of literature i.e., within MA and IOM (we also deal with such a distinction in Chapter 3 and 4).

2.3.1 Selected journals from the MA literature

We limited the search to a set of 40 journals from the MA literature. Bonner et al. (2006) review the most influential journals in academic accounting (37). We took this list and added three more journals that would likely also be relevant for the current study. The journals are the *European Accounting Review* (*EAR*), *Management Accounting Research* (*MAR*), and *Journal of Cost Management*. This list of journals is shown in Table 2.

Table 2: List of journals selected from theMA literature.

Nr.	Journal	Abb.
1	Abacus: A Journal of Accounting, Finance and Business studies	Abacus
2	Accounting and Business Research	ABR
3	Accounting and Finance (Accounting & Finance)	AF
4	Accounting Horizons	AH
5	Accounting, Organisations and Society	AOS
6	Administrative Science Quarterly	ASQ
7	Auditing: A Journal of Practice and Theory	AudJPT
8	Australian Accounting Review	AAR
9	Australian Tax Forum	ATF
10	Australian Tax Review	ATR
11	Behavioral Research in Accounting	BRIA
12	British Accounting Review	BAR
13	Contemporary Accounting Research	CAR
14	Decision Sciences	DS
15	European Accounting Review*	EAR
16	Harvard Business Review	HBR
17	International Journal of Accounting	IJA
18	Journal of Accountancy	JA
19	Journal of Accounting and Economics	JAE

Nr.	Journal	Abb.
20	Journal of Accounting and Public Policy	JAPP
21	Journal of Accounting Literature	JAL
22	Journal of Accounting Research	JAR
23	Journal of Accounting, Auditing and Finance	JAAF
24	Journal of Business	JB
25	Journal of Business, Finance and Accounting	JBFA
26	Journal of Cost Management*	CM
27	Journal of Finance	JF
28	Journal of Financial and Quantitative Analysis	JFQA
29	Journal of Financial Economics	JFE
30	Journal of International Financial Management and accounting	JIFMA
31	Journal of Management Accounting Research	JMAR
32	Journal of Taxation	JT
33	Journal of the American Taxation Association	JATA
34	Management Accounting Research*	MAR
35	Management Science	MS
36	National Tax Journal	NTJ
37	Review of Accounting Studies	RAST
38	Review of Quantitative Finance and Accounting	RQFA
39	Tax Law Review	TLR
40	The Accounting Review	TAR

* Journals added to the list of Bonner et al. (2006).

2.3.2 Selected journals from the IOM literature

The search of papers from the IOM literature was limited to a set of 23 journals. These were chosen by comparing six different rankings from Linton and Thongpapanl (2004), Stonebraker et al., (2012), Page and Schirr (2008), Gorman and Kanet (2005), Durisin et al., (2010) and Martin et al. (2012), see Table 3. These rankings were selected based on citations on prior relevant research, journal impact factors, and our personal judgment. Collectively, these rankings contained 94 different journals. Finally, Table 4 shows the resulting list of 23 journals. This selection process was conducted in four steps:

1. We excluded the journals already selected in the review of MA literature (i.e., *Administrative Science Quarterly* (*ASQ*), *Decision Sciences* (*DS*), *Harvard Business Review* (*HBR*), and *Management Science* (*MS*).

Table 3: Ranskings used as the basis for compiling the journal list for the review of the IOM literature.

Source	*	Selection approach	Description
(Linton & Thongpapanl, 2004)	50	Citation analysis of journals	The top 50 journals in technology and innovation management were identified, which was based on how frequently journals were cited by a set of base journals in the field (See their Table 4, p.127.)
(Stonebraker et al., 2012)	30	Journal impact factors	Collectively, 14 previous studies identified, rated and/or ranked 173 academic operations management journals. Further selection based on the availability of data on impact factors reduced the list to 30 journals. (See their Table 2, p. 30.)
(Page & Schirr, 2008)	10	Expert judgement	Ten journals in marketing, management, and R&D were identified as the leading journals publishing many papers on NPD. (See their Table 2, p. 235.)
(Gorman & Kanet, 2005b)	27	Author affiliation index	A ranking of 27 operations management journals was created with the Author Affiliation Index, which is based on the percentage of a journal's U.S. academic authors that comes from a set of 60 top U.S. business research universities. (See their Table 3, p. 10.)
(Durisin et al., 2010)	11	References in papers published in *JPIM*	The papers and books cited most in JPIM from 1984 to 2004 were identified (16 books and 28 papers). These papers were published in 11 different journals. (See their appendix, p. 450-451.)
(Martin et al., 2012)	20	Journals with the most citations to a core set of STS publications.	All 9579 non-identical references in 136 chapters in five handbooks of science and technology studies (STS) were listed. Citation analysis within these references identified a set of 155 core contributions. This analysis reflects the relative importance of these references to authors of the handbook chapters, who are experts within the field of STS. Next, all citations in Web of Science to these core contributions were listed, showing which 20 journals included the most citations to the STS core. (See Table 6, p. 1189.)

* The second column indicates the number of journals included in that particular ranking and used for journal selection in the current literature review. The total number of different journals included in all six rankings together is 94.

2. If a journal was listed in at least three of the rankings mentioned in Table 3, we considered it was more likely to be one of the most relevant journals in the context of NPD. Based on this, we selected the following eight journals: *Academy of Management Review* (*AMR*), *IEEE Transactions on Engineering Management* (*IEEE-EM*), *Industrial Marketing Management* (*IMM*), *International Journal of Operations & Production Management* (*IJOPM*), *Journal of Marketing* (*JM*), *Journal of Product Innovation Management* (*JPIM*), *Research Policy* (*ResPol*), and *Strategic Management Journal* (*SMJ*).
3. We also decided that all ten journals identified by Page and Schirr (2008) needed to be included in the current review as we considered their selection to be the most focused and applicable set of journals in NPD. This criterion added the following four journals to the selection thus far: *Academy of Management Journal* (*AMJ*), *Journal of Marketing Research* (*JMR*), *R&D Management* (*RADMA*), and *Research-Technology-Management* (*RTM*).

4. Finally, we included 11 journals from our preliminary list following our own judgment, namely, *California Management Review* (*CMR*), *International Journal of Technology Management* (*IJTM*), *Journal of Engineering and Technology Management* (*JETM*), *MIT Sloan Management Review* (*MIT SMR*), *Technovation* (*Techn*), *IIE Transactions* (*IIE*), *Interfaces* (*Interf*), *International Journal of Production Economics* (*IJPE*), *International Journal of Production Research* (*IJPR*), *Journal of Operations Management* (*JOM*), and *Manufacturing and Service Operations Management* (*MSOM*).

Table 4: List of journals selected from the IOM literature.

Nr.	Journal	Abb.
1	Academy of Management Journal	AMJ
2	Academy of Management Review	AMR
3	California Management Review	CMR
4	IEEE Transactions on Engineering Management	IEEE-EM
5	IIE Transactions	IIE
6	Industrial Marketing Management	IMM
7	Interfaces	Interf
8	International Journal of Operations & Production Management	IJOPM
9	International Journal of Production Economics	IJPE
10	International Journal of Production Research	IJPR
11	International Journal of Technology Management	IJTM
12	Journal of Engineering and Technology Management	JETM
13	Journal of Marketing	JM
14	Journal of Marketing Research	JMR
15	Journal of Operations Management	JOM
16	Journal of Product Innovation Management	JPIM
17	Manufacturing and Service Operations Management	MSOM
18	MIT Sloan Management Review	MIT SMR
19	R&D Management	RADMA
20	Research Policy	ResPol
21	Research-Technology Management	RTM
22	Strategic Management Journal	SMJ
23	Technovation	Techn

2.3.3 Papers' selection process

This section presents the procedure for determining the papers that will be analysed in this review. In this phase we performed a search of research on the 15 cost management methods using Google Scholar. The main objective was to retrieve as many papers as possible that could be relevant for our review. The search period was from 1990 to 2013 within the MA literature and from 1990 to 2014 within the IOM literature.

Some detailed issues were relevant for searching papers. We used variations of the spelling of search terms. For example, when searching for "technology roadmap" we also used the plural form "technology roadmaps" and spelled words separately or together "technology road maps". Surprisingly, this yielded some different results, which also varied when using their abbreviation as the search term, such as "quality function deployment" or "QFD." The meaning is the same but authors used different terms. Moreover, we identified additional terminology describing methods, which we then included as search terms. For example, design for manufacturing is also described as design for assembly.

From this search, we obtained thousands of papers, but not all results were substantively relevant. A first selection was obtained through a quick evaluation of each paper and excluded search results that were obviously "wrong[1]". There were several reasons for excluding papers, mainly:

- The method was not mentioned at all in the paper. For example, the search term occurred as a result of the ending of a sentence and the beginning of the following sentence or due to other language related circumstances.

- The method was mentioned only in the authors' biography, in the list of references or in the footnotes of the paper.

- The term was used as an element in formulas, but had nothing in common with the actual cost management method.

  IOM-Literature (example): Pandit and Lin (1991) was retrieved during the search for the method "**design for X (DFX)**", as the paper includes "dFx" as an element of an equation.

- The abbreviation of a method had another meaning.

  MA-Literature (example): "**DFM**" sometimes meant "Dubai Financial Market" or "Discriminating Factorial Analysis". "DFX" were the initials of one of the authors in the paper by C. L. Comm and D. F. X. Mathaisel.
  IOM-Literature (example): "FCA" is used as an abbreviation for "Finite-Capacity Automata" in Tang and Qiu (2004).

- The method had a different meaning in the paper (e.g., in a particular research field) that did not refer to cost management.

  MA-Literature (example): "**value engineering**" meant something different in the finance journals[2], "**commonality**" sometimes referred to commonality in behaviour (Kavanagh & Drennan, 2008), and "**funnels**" often referred to buying funnels in marketing[3] (Ayanso & Mokaya, 2013).
  IOM-Literature (example): the term "**funnel**" was employed as a verb and not as a cost management method: "…they funnel the activities of the venture toward acquiring /developing

[1] At this stage, we looked at the paper to quickly assess why the paper had been included in the search result. If it became apparent within a few minutes that the paper was irrelevant, it would be excluded. Otherwise, the paper was always kept in the search results. Sometimes, it was a bit problematic to get the pdf-file of a paper and at this stage we also did not put much time in figuring out how to obtain it, but we simply kept the paper on the list.
[2] The use of "value engineering" was very extensive in finance and basically always with a different meaning than the scope for our review. Therefore, we excluded the three finance journals (JF, JFE, and JFQA, see Table 2) when searching for this particular method.
[3] The buying funnel is a well-known paradigm in marketing research for conceptually understanding customer behaviour and describing the way consumers make their buying decisions, from awareness of a need through to the final purchase of a product or service that addresses this need (Jansen & Schuster, 2011) .

certain types of resources and capabilities which then in turn affects the future horizons of the venture" (Keating & McLoughlin, 2010).

- The method was briefly mentioned but not in the scope of the research e.g., it was only mentioned once or twice in sections on limitations or suggestions for future research.

  IOM-Literature (example): de Vries (1994, p. 438) wrote in the first section of his paper: "Because all products are for mass production and therefore have to be designed in such a way that they can be produced in bulk (and since 1987 this has been formalised by using **design for assembly (DFA)** methods)". Thus, we excluded de Vries (1994).

- The method was listed among other cost management methods but was not further considered in the research.

  IOM-Literature (example): Verganti (1999, p. 370) listed several costing methods as being supportive for proactive thinking: "...(i.e., the use in the early phases of techniques such as concept screening checklists, **quality function deployment**, **target costing**, failure mode and effect analysis, **life cycle costing** and analysis...)." As the paper does not put further emphasis on these costing methods, we excluded Verganti (1999).

- The retrieved paper was a book review. We purposely excluded book reviews, as the actual contribution to research is found in the book which was being reviewed.

  IOM-Literature (example): Cole (Cole, 2000) is a review of Kolarik (1995).

This led to a preliminary list of several hundred of results. Some papers were included more than once because they included several of the search terms (i.e., methods) and were therefore retrieved in multiple queries.

2.3.4 Further selection of papers

In this step of the sample selection, we verified in more detail whether the papers addressed at least one of the selected cost management methods and if the findings reported are in this regard.

Hence, we proceeded with the further selection of papers. For example, if a paper discussed one of these methods extensively in the introduction or in the literature review section, but the focus of the research itself were different to this, then the initial screening would not yet have excluded that particular paper. Finally, the more detailed review led to excluding papers for reasons such as:

- The method was mentioned but it is not a main part of the research reported in the paper. For example:
  - The method is mentioned only when describing a source referred to within the paper.

    MA-Literature (example): Dambrin and Robson (2011, p. 430)wrote: "Miller & O'Leary (2007)indicate how the development of **technology roadmaps**..." We excluded Dambrin & Robson (2011).

  - The method was mentioned was the paper only to point out a gap in the literature and to motivate the research.

MA-Literature (example): Chan et al (2007, p. 668)wrote that "Product-development literature in marketing and operations that discusses R&D pipelines recommends a stage-and-gate system for assessing which projects to advance or terminate." We excluded Chan et al. (2007).

- The method was used to describe the setting for the research or to illustrate an example, but the focus of the research itself was different.

  MA-Literature (example): "the assumption that the restoration time is constant approximately describes the repair process of modern manufacturing equipment that is frequently based on a modular design" (Moinzadeh & Aggarwal, 1997, p. 1578).
  IOM-Literature (example): Fallah and Lechler (2008) provide "a perspective on a paradigm shift in managing global innovation" (p. 71) and contrast it to the traditional innovation paradigm, where the cost management method "funnels" is set. We excluded Fallah and Lechler (2008).

- The method is mentioned to point out or to recommend possible opportunities for applications of the research topics or to motivate further research.

  IOM-Literature (example): Germeraad (2010, p. 18) wrote: "In the R&D portfolio selection process, a background investigation of the IP landscape should be part of the first Stage-Gate review." Stage-gate was not introduced or further discussed. We excluded Germeraad (2010).

- The name of a method had a different meaning in the paper that did not refer to cost management in product development.

MA-Literature (example): **"functional cost analysis"** in financial journals often referred to the Federal Reserve Functional Cost Analysis (FCA), which is a large databank managed by the U.S. Central Bank to benchmark banks' costs and improve their performance. **"Design for X"** was used as an explanation of the design of an experiment: "these results are based on λ = 0.1 and a full factorial design for x" (Sargent & Som, 1992, p. 681). The word "**funnel**" was used as a verb as in "to direct" or as an adjective to describe results in an exhibit (e.g., "the table shows a funnel effect"). **"Modularity"** was often used in a way that was not on the scope of this review. For example, "organisational modularity" actually refers to the study of networks of firms (Karim, 2009), "supermodularity" in game theory (Chao, Iravani, & Savaskan, 2009), or modular software design in computer science (MacCormack, Rusnak, & Baldwin, 2006).

IOM-Literature (example): Karim (2006) deals with **modularity** in the organisational structure and specifically explores the reconfiguration of business units.

- Although the method was central in the research, the focus in the paper was not on cost management in product development, but on different aspects.

MA-Literature (example): Bernstein and DeCroix (2004) and Baiman, Fischer, & Rajan (2001) took product **modularity** as the starting point and investigated its impact on costs and profitability, but they actually looked at effects of outsourcing and contract relationships that were enabled by modularity. These papers did not address product development. Quite a few papers that were retained in the final sample also pay only very limitedly attention to product development and cost management, but we were very cautious and hardly excluded papers for this reason.

IOM-Literature (example): the relationship between **component commonality** and the customer service level is assessed in Yeung, Wong, Ma, and Law (1999), but neither cost management nor NPD were covered in the research.

- The paper is a predecessor of another paper that included the same or less information, being more relevant for our research its respective "successor" paper.

IOM-Literature (example): we excluded Bard and Sousk (1990), whereas Bard (1992) was part of this present literature review as the more recent, encompassing paper.

- The paper was an introduction to other papers (e.g., presenting a special issue of a particular journal) or a summary of the subsequent papers.

IOM-Literature (example): Mäkinen, Seppänen, and Ortt (2014) wrote an introduction to the *Journal of Product Innovation Management Special Issue* concerning **platforms**, contingencies and new product development.

This has shortened the list to 841 papers in total, of which 113 papers are from the management accounting literature and 728 papers from the innovation and operations management literature.

2.3.5 Identification of categories

Many of the selescted papers from the IOM literature focused on at least one of the 15 management accounting methods (that is why they have been kept) but they were still not fitting the current literature review. This is because a paper lacked emphasis on the application of the management accounting method for the purpose of cost management and/or did not consider the context of NPD.

For example, when papers broadly addressed the antecedent conditions that are associated with the adoption of a particular method, such as competition and uncertainty (Ax, Greve, & Nilsson, 2008) or rather tackled consequences and implications of the implementation of a method for the organisation, such as the impact on development time (Danese & Filippini, 2013). Several papers investigated particular aspects of the method that were barely relevant for costs management, such as measuring the level of component commonality based on technical characteristics of a product (Blecker & Abdelkafi, 2007). The mentioning of cost management method explains why the paper had been selected, but then the actual focus of the paper was on something else and did not concerned in any detail with the cost management aspect of the method. In other words, the link to one of our 15 methods meant the paper had something to do with managing costs, but only in the background.

Hence, we decided not to include these papers in the final sample of the IOM literature, but to cluster these papers in categories to provide an overview or impression of this part of the IOM literature. We formed 12 categories by following an inductive process. These categories are listed in Table 5. We first coded the papers regardless of overlaps into 68 very specific categories, such as "design for six sigma," "influence of modular design and IT on supply chain responsiveness," "measuring modular design / component commonality / product platforms," and "nuclear plant." We then looked for related categories and more abstract topics to cluster the papers into more generally formulated categories. After a few iterations, this resulted in the final list of categories. In this regard, one paper could be assigned to several categories.

Table 5: Categories defined to classify the papers not included in detail.

Category description	*	Examples
Adoption: Papers investigating which organisations or industries apply particular cost management methods, the distinctive characteristics of these organisations or industries, and their reasons for adoption. Some of these papers merely include descriptive statistics measuring the rate of adoption of the methods. Other papers investigate antecedents, preconditions and motives leading to the adoption of particular cost management methods. Most studies are based on survey data.	58	Ax, Greve, and Nilsson (2008) Ettlie and Trygg (1995) E. Lichtenthaler (2004)
Outcomes of application: Papers describing estimated or measured effects of the application of particular cost management methods (without explicitly addressing effects on costs) and the pre-conditions for these. Examples are reduction in development or manufacturing cycle times. These effects are derived from analytical models or empirical research. Moreover, it is demonstrated that the application of the methods may lead to broader organisational consequences (e.g., changing the organisational structure of a company). Benefits, identified potentials, disadvantages, and limitations of cost management methods may occur within a company and may also affect suppliers, customers or other external parties.	121	Danese and Filippini (2013) Lau, Yam, and Tang (2011) Sethi and Iqbal (2008)
Technology projecting: Papers dealing with technology roadmapping within a company. Different facets and managerial challenges around the application of technology roadmapping are examined (e.g., improvements, extensions and adaptions of the concept or the acquisition of relevant data and knowledge). Furthermore, open innovation as well as technology acquisition and exploitation are considered. In some papers, the role and impact of cross-company roadmaps (e.g., within the semiconductor industry) is discussed.	37	Cosner et al. (2007) U. Lichtenthaler (2008) Müller-Seitz (2012)
External collaboration on the supply side: "Supply chain collaboration occurs when two or more companies share the responsibility of exchanging common planning, management, execution and performance measurement information" (Anthony, 2000, p. 41). These papers investigate if and how cost management methods are applied and in which way they influence the integration of suppliers in NPD. Antecedents are identified, the degree to which suppliers are given responsibility is assessed, and it is evaluated whether the integration of suppliers in NPD has benefits for the buyer and what these may be.	44	Lau (2014) Lawson, Petersen, Cousins, and Handfield (2009)
External collaboration on the demand side: Papers focusing on the application of particular cost management methods to incorporate the needs and requirements of customers into NPD projects. This often involves the combination of several concepts, frameworks and methods. The vast majority of these papers look at QFD. Many papers deal with the prioritisation of customer requirements.	56	Armacost, Componation, Mullens, and Swart (1994), Matzler and Hinterhuber (1998)
External collaboration—strategic alliances and other partnerships: Papers dealing with how companies can work together with external parties, such as strategic alliances and other types of partnerships. Challenges and managerial issues in communicating and exchanging information as well as placing trust in partners are assessed. Furthermore, aspects of open innovation and technology acquisition are discussed.	8	Badir and O'Connor (2015)

Category description	*	Examples
Internal collaboration and coordination: Papers addressing how different functions, departments, locations, etc. within a company can work together cooperatively, and how concerns and decisions can be handled jointly. Cross-functional teams, design for manufacturing, and concurrent engineering are emblematic topics. Also, these papers discuss how information and knowledge are created, used, transferred and maintained across different interfaces and globally-distributed locations within a company.	65	Goffin and Micheli (2010) Kerr, Phaal, and Probert (2012) Zeschky, Daiber, Widenmayer, and Gassmann (2014)
Protection and management of intellectual property (IP): Papers about the application of management practices for the protection of IP, the exploitation of technologies (for example, through licensing) and patent planning.	11	Quan and Chesbrough (2010)
Product architecture and variety: Papers that deal with the efficient management of product variety by adjusting the architecture of products and by optimizing processes in R&D, manufacturing, and in the supply chain. Common components and modules, platforms, postponement and targeted individualisation enable mass customisation. Papers on measures for modularity and other quantitative assessments of product architectures also play a central role. Moreover, effects on manufacturing operations, purchasing and warehousing are considered.	77	Blecker and Abdelkafi (2007) Settanni, Newnes, Thenent, Parry, and Goh (2014) Swaminathan (2001)
Stage-gate processes: Papers that focus on the management, the implementation (set-up) and the usage of stage-gate processes in NPD. These papers primarily show insights in companies' practices and their approach in managing stage-gate systems. Also, adaptations, extensions and enhancement of Robert Cooper's initial stage-gate approach (R. G. Cooper & Kleinschmidt, 1991; R. G. Cooper, 1988, 1990) are presented.	45	Jenkins, Forbes, and Durrani (1997) R. G. Cooper (1994) R. G. Cooper (2014)
Success factors: Papers describing challenges and managerial issues in the application of particular cost management methods and proposing how these challenges can be overcome. The papers suggest success factors and guiding principles, which facilitate the implementation, use and application of these methods. Often, these factors rely on the practical experience of the authors and reflect their view on the specific method or, alternatively, the authors look in several companies and provide insight into their way of implementing the cost management methods.	82	Davidson, Clamen, and Karol (1999) O'Connor (1994) Tatikonda (1999)
Others: In this category, we consolidate remaining papers that deal with specific topics that did not fit the categories listed above.	9	Demeester, Eichler, and Loch (2004) McGrath and Young (2002)

* The second column provides the number of results included in this category, 613 in total. The number of unique papers was 389, because a paper may be included multiple times if it addresses several categories.

Of course many topics in this classification may indirectly lead to cost reduction or cost reduction potential (e.g., papers on reducing development cycle time). However, there is no direct focus on cost management in these papers. Nevertheless, a paper was included and analysed in detail if only parts of the paper dealt with cost management methods in NPD focusing on costs, even if the largest part of the paper fitted very well into one of the categories in Table 5.

We believe these categories are interesting to mention in this review for two reasons. Firstly, these categories give an impression of what research is conducted in management accounting methods in the IOM literature. This is a substantial amount of research, looking at a broad range of issues concerning management accounting topics. It may be surprising for management accounting researchers and may provide further opportunities for drawing upon relevant research and perhaps contribution to research outside accounting. Secondly, finding many papers about these methods in the IOM literature, but with a (very) different emphasis than cost management in NPD is, by itself, also an interesting difference between the IOM and MA literature. Within MA literature, we did not find such a large amount of papers that focused on a variety of issues around their selected management accounting methods. The IOM literature seems broader when it comes to research on specific management methods that are also part of management accounting.

In the process of reviewing these 728 papers in more detail, 131 papers were found to be irrelevant for this review, for similar reasons mentioned above (see sections 2.3.3 and 2.3.4) and 389 unique papers were related to the categories (as indicated in Table 5). Finally, 208 papers from the IOM literature remained and were included in this review for further detailed analysis.

2.4 Literature content analysis

In this section we define the primary concepts for the content analysis of each paper (e.g., research design and field work). We analysed some information from every paper and presented this in tables e.g., methods addressed, the journal, industry, and a summary. This summary of information focused exclusively on finding related to the cost management methods, so it was not intended to necessarily summarise all the paper. Regarding the research design, we distinguished several types of non-empirical designs, which are categorised as follows:

- Theoretical: the study motivates research topics, develops theory, proposes ideas for a cost management method or formulates hypotheses for future research.
- Analytical: the study makes inferences on the basis of mathematical analyses and proof of a formal model (for example, establishing relationships between variables or between actions and particular effects).
- Simulation study: similar to an analytical study, it is based on a formal model, but relationships in the formal model are investigated through numerical simulation.

Furthermore, various types of empirical research designs are based on particular types of data used:

- Experimental data (either generated under fully controlled circumstances or through a field-experiment).
- Data on market transactions (such as stock prices).
- Proprietary archival firm data (for example on costs, or project lead times).
- Observations (measurements and estimates initiated for the research, generating the kind of data that, by their nature, could have existed as objective, archival data, but that did not exist or were not available to the researcher).

- Survey data (based on responses to a questionnaire by research participants).
- Qualitative data (not expressed with numbers as for example: interview notes or transcripts, photos, company documents with descriptions and exhibits).
- Mixed data (in the sense that the study relied on both quantitative and qualitative data).

Insofar as empirical studies involved field work, which we understood as a substantive interaction of the researchers with actual organisations to inform the research, we differentiated between particular types of field work:

- Case study: the study generated new theoretical insights based on in-depth information (qualitative and/or quantitative data) from one or few more organisations.
- Engineering: the study presented detailed new methods and calculation models for solving or optimising particular problems ("how to"), and these were tried-out on realistic settings in actual organisations as a "proof of concept"[4].
- Management practice: the study offered pragmatic ideas for management practices based on eclectic observations of practices, "sensible" reasoning and frameworks.

[4] Some papers were essentially about developing normative methods and models for cost management in new product development, but then the authors also demonstrated the application of these ideas in a real organisation (e.g., (Burchill & Fine, 1997; Degraeve et al., 2005; Degraeve & Roodhooft, 2000; Ding & Eliashberg, 2002; Kamalini Ramdas & Sawhney, 2001; Ulrich et al., 1993). The nature of such a paper is not primarily empirical—it "looks and feels" like a theoretical or even normative paper—but there are empirical data providing some evidence for claims about the proposed benefits of the methods and models. Therefore, we coded such a paper as one of the types of empirical research (depending on the kind of data used) combined with field work of the engineering style.

3 Results - Management accounting literature review

3.1 Introduction

This chapter presents a review of research found within the MA literature addressing 15 different methods for cost management (see Table 1, Chapter 2). We analysed a total of 113 papers from this literature. The content of this chapter was published in Wouters & Morales (2014). Table 6 shows the retrieved papers per topic and per journal, whereby papers are included in each column based on their topic addressed. In other words, papers that cover multiple topics are included multiple times, which explains that the total count shown in Table 6 is 149. Furthermore, Table 7 shows the results of the research methods. For example, how cost management methods were studied, i.e., through empirical, theoretical or conceptual studies.

If we first consider the overall distribution of results, several things are apparent from Table 6 and Table 7. The number of references by topic varies greatly among journals. For example, the average number of references is 9.9[5] (when combining both columns for target costing[6]); about half of the topics have a very low number of references (between 1 and 6); target costing has received the most attention by far in the publications in our sample (38 of 149 references). Modular design, component commonality and life cycle costing are topics that have also received much attention (20, 14 and 14 references, respectively) and these topics are ranked 2nd and joint 3rd.

The number of references by journals also varies greatly. Only 17 journals of the entire list of 40 published at least one paper in the sample. Within that group of 17 journals, the average number of references per journal was 8.8, and about two thirds of the journals had a very low number of references (between 1 and 6). Most references were published in *Management Science* (40 of 149), *Management Accounting Research* (33), and *Accounting, Organisations and Society* (19).

The results above were strongly influenced by two journals, namely, *Management Science* and *Decision Science*. These two journals together published 35% of the references. Compared to this average, methods with an engineering background were published above average in these two journals: design for manufacturing (88% of the references in these two journals), component commonality (93%), modular design (65%), and product platforms (67%) (excluding topics with just a few references). Other topics were published below average in these two journals. Moreover, when

[5] Total of research counted divided by amount of cost management methods i.e. 149/15.
[6] Target costing is split into two subtopics elated to setting cost targets and early cost estimation in Appendix A, Table 1and 1b, which will be discussed in the next section.

excluding these two journals, the topics of component commonality and modular design have only one and seven references left. Thus, life cycle costing and Kaizen become the 2nd and 3rd ranked topics (with 14 and 11 references, respectively).

Table 6: Overview of the MA literature - number of references per cost management method and per journal.

		Total	Target costing	Target cositng: cost estimation	Value engineering	Quality function deployment	Functional cost analysis	Kaizen costing	Life-cycle costing	Total cost of ownership	Stage-gate reviews	Funnels	Design for manufacturing	Design for X	Component commonality	Modular design	Product platform	Technology roadmap	
	Total		*27*	*11*	*10*	*4*	*2*	*11*	*14*	*6*	*6*	*1*	*8*	*1*	*14*	*20*	*9*	*5*	*149*
1	AAR	*2*							2										
2	ABR	*4*	1		1				1	1									
3	AH	*9*	1	2	1			1			1				1	1	1		
4	AOS	*19*	7	1	1			2	1	3	1					1		2	
5	ASQ	*2*														1	1		
6	BAR	*1*																1	
7	CM	*2*		1				1											
8	DS	*12*				1			1		1		1		3	4	1		
9	EAR	*4*	2						1		1								
10	HBR	*4*									1					2	1		
11	IJA	*8*	3	1	2			1	1										
12	JB	*1*								1									
13	JBFA	*1*								1									
14	JMAR	*6*	2	1				1			1					1			
15	MAR	*33*	11	4	5		2	4	4				1			1		1	
16	MS	*40*		1		3			3			1	6	1	10	9	5	1	
17	TAR	*1*						1											
		149																	

The sample contains 113 unique papers, and if a paper addresses more than one method, it is included more than once in the counts below. This explains why the total number of references is 149. Only 17 journals of the entire list of 40 published at least 1 paper in the sample.

With regard to the research methods, these seem to be distributed in a more similar manner across topics, at least at the level of non-empirical versus empirical research (see Table 7). Overall, 98 references (66%) concern empirical research methods, and for many topics the number is at least close to this, or higher. Empirical research dominates the sample (again, excluding topics with just a few references). The main exception to this is the topic of component commonality with only two of 14 references (14%) based on empirical research.

An interesting observation is the use of qualitative data, either solely or in combination with quantitative data. Overall, 58 references (39%) were at least partially based on qualitative data. Furthermore, the use of numerical simulation as a non-empirical research method was limited and almost completely concentrated on component commonality, modular design and product platforms.

Table 7: Overview of the MA literature, number of references per cost management method and per research method.

		Total	Target costing	Target cositng: cost estimation	Value engineering	Quality function deployment	Functional cost analysis	Kaizen costing	Life-cycle costing	Total cost of ownership	Stage-gate reviews	Funnels	Design for manufacturing	Design for X	Component commonality	Modular design	Product platform	Technology roadmap	
	Total		*27*	*11*	*10*	*4*	*2*	*11*	*14*	*6*	*6*	*1*	*8*	*1*	*14*	*20*	*9*	*5*	*149*
1	Non-Empirical: theoretical	*24*	6	4	1			3	4	1	2					1	2		
2	Non-Empirical: analytical	*13*	1	1		1		1	1	1					4	2		1	
3	Non-Empirical: simulation	*14*				1									8	4	1		
4	Empirical: experimental	*3*				1				1						1			
5	Empirical: market	*0*																	
6	Empirical: archival	*9*							1	2			2			2	2		
7	Empirical: observations	*4*										1	1		1		1		
8	Empirical: survey	*24*	9	2	2			1	3	1	1		2			3			
9	Empirical: qualitative	*32*	7	2	6			5	1		2				1	5	3		
10	Empirical: mix (QQ)	*26*	4	2	1	1	2	1	4		1		3	1		2		4	
		149																	

All research methods were used, except empirical research based on market data.

3.2 15 Cost management methods - MA literature

Target costing

Target costing was researched most heavily in the reviewed sample of papers. Target costing is a detailed method to reduce costs during the product design (or re-design) stage (Ansari, Bell, & Okano, 2007; Ansari & Bell, 1997; R. Cooper & Slagmulder, 1999). It is best suited for products for which price is a key competitive dimension. In these product-markets companies often have little room to set prices and they face thin margins. Therefore, profits come from the ability to offer the functionality and performance that the price point requires at the lowest cost. Market prices and required profit margins define a target cost that product development teams use as a target to be met. From this starting point target costing provides the discipline and tools to bring the estimated cost down to the target cost through the product development process. Target costing, therefore, is a collective effort of a team with people from different departments, such as product designers, engineers, cost accountants and suppliers (Wijewardena & De Zoysa, 1999).

It is helpful to describe target costing in two phases. Firstly, target costing involves setting cost targets: the allowable manufacturing costs of a product and of its components are determined based on the sales price of the product for end users, and subtracting target profit margins and non-manufacturing costs at various stages downstream in the supply chain. The starting point is a market research to identify what combination of functionality, performance and price should be available at what point in time for customers. Think about a new car, which should be at the dealers in 2016 and which competes against a set of alternative cars. To be competitive, it should offer comparable performance and features at a comparable sales price. Establishing this package of sales price, functionality and performance is the first step in target costing.

Next, the sales price is broken down, and the required profits margins and costs at various points in which the supply chain define the allowable cost for the manufacturer. In the car example, the taxes, dealer's margin, distribution costs, import duties, the importer's cost, margin, etc have to be considered. The allowable cost for the car manufacturer is further broken down and non-manufacturing costs are subtracted (e.g., marketing and sales, development, warranty) to arrive at the allowable manufacturing cost. This is split up to determine the allowable manufacturing costs of major parts of the product i.e., the allowable cost of the engine.

The processes can also be extended towards suppliers. If a major part of the product is sourced from an outside supplier, the allowable manufacturing cost for that major part of the product constitutes the maximum purchase price that the firm will pay to the supplier (Ellram, 2006) Thus, this involves a stage in which, after the choice of supplier but before moving into the execution phase, the buyer presents a desired target price to the supplier for parts and materials and gives the supplier the responsibility for meeting this target price (Dekker, Sakaguchi, & Kawai, 2013). This often represents quite an ambitious cost target and the buyer and supplier can work together (co-development) to find ways for manufacturing the part at this allowable cost. This cooperation could go so far that the buyer and supplier not only discuss the purchase price and the design, but also the supplier's detailed cost breakdowns for manufacturing the part. This far-reaching form of target costing is an application of open book accounting (Caglio & Ditillo, 2012).

Definitions of target costing in the literature typically focus on the target-setting element of target costing: determining the target cost (or allowable cost) by subtracting the target profit from the expected sales price (Kato, 1993; J. Y. Lee & Monden, 1996; J. Z. Lin & Yu, 2002). Other authors consider target costing as "an approach to managing product design to achieve a 'target' level of cost that is defined by customers' product requirements, a price that fits with market conditions and the firm's target profit" (Anderson & Dekker, 2009, pp. 212–213).

Secondly, target costing involves (early) cost estimation: the manufacturing cost of a product or its components are estimated during product development to assess if these do not exceed their allowable cost targets, in which case the design needs to be adjusted. This should be seen in the context of a process in which the progressing design of the new product is regularly reviewed, including whether the expected performance and functionality meet their targets. These reviews can be structured around so-called stage-gate processes(Jørgensen & Messner, 2009; Wheelwright & Clark, 1992). Early in the development project cost estimation needs to be done before the design has been completed and important design details and their cost implications may still be uncertain. Target costing assumes that if the estimated cost of the new product exceeds the allowable target cost, the design should be modified.

As indicated in Appendix A, Table 1a and 1b, our sample included 38 papers that investigated target costing as a method for managing costs during new product development. Appendix A, Table 1a includes details of the papers that either explicitly focus on target setting, or investigate target costing at a more general level (for example, in a survey of practices, without going into further detail). Appendix A, Table 1b includes those studies that explicitly address the issue of early cost estimation as part of target costing. We will address the combined results.

Target costing was often addressed in combination with another cost management methods—most often with value engineering (9), Kaizen costing (9), and life cycle costing (6). This is consistent with Woods, Taylor and Fang, (2012), who argued that target costing is typically combined with other strategic management accounting methods including life cycle costing, Kaizen costing and value engineering to enhance product profitability management. Anderson and Dekker (2009) also emphasised the combination of target costing with value engineering as being important for structural cost management through joint product design with buyers and suppliers.

The studies of target costing covered various kinds of manufacturing industries, of which the automotive industry was mentioned most frequently. The studies of target costing also covered manufacturing industries in various countries, of which Japan was mentioned most frequently as an explicit geographical area for the study. For example, based on a comparison between Japanese and Australian companies, Chenhall and Langfield-Smith (1998) suggested that the majority of large Australian firms have adopted a range of management accounting methods that emphasise non-financial information, and that take a more strategic focus. Wijewardena and De Zoysa (1999) argued that Australian companies used cost control tools at the manufacturing stage while Japanese firms used control tools such as target costing (Al Chen, Romocki, & Zuckerman, 1997; R. G. Cooper & Kleinschmidt, 1996; Scarbrough, Nanni Jr., & Sakurai, 1991) for cost planning and cost reduction tools at the product design stage. Other international studies focused on the success of cost control systems (such as target costing) in Chinese business enterprises (Duh, Xiao, & Chow, 2008; J. Z. Lin & Yu, 2002; J. Wu, Boateng, & Drury, 2007)and suggested that management accounting can play a positive role in improving business management and profitability in China or other developing countries. Finally, a study in German-speaking countries investigated the relevance of management accounting methods, such as target costing, in both academic and practitioner journals (Wagenhofer, 2006); the results showed that target costing method, among others, was imported and generated the bulk of the literature that either applied these methods or tried to adapt them to the German environment.

Target costing fits several categories. This method is often investigated in an interorganisational context; 11 of the papers on target costing mention this explicitly. Target costing as an interorganisational cost management method was identified as being useful to cross organisational boundaries (R. Cooper & Slagmulder, 2004; Mouritsen et al., 2001), in reducing information asymmetry between buyers and suppliers by fostering a collaborative effort between such partners for cost management (Fayard, Lee, Leitch, & Kettinger, 2012; Seal, Berry, & Cullen, 2004) and in supporting price revisions as well as product and process design (Agndal & Nilsson, 2009, 2010). Furthermore, target costing is often mentioned as a key example of a strategic management accounting method (Roslender & Hart, 2003), an advanced management accounting practice (Baines & Langfield-Smith, 2003; Chenhall & Langfield-Smith, 1998) and Japanese management accounting (C. Carr & Ng, 1995; Dekker et al., 2013).

Several aspects of target costing seem to have (too) little attention in the MA literature. There is not much attention paid to cost estimation. Even though Appendix A, Table 1b includes 11 papers, the amount of information on estimation was extremely limited. Typically, only the need for estimation was mentioned and perhaps the use of cost tables, which we already included in Appendix A, Table 1b instead of 1a. Nevertheless, compared to target setting, the accounting literature has almost nothing to say about how to conduct (early) cost estimation for proposed product designs, as the basis for assessing during product development whether target costs will be met. Furthermore, there is not much attention for downstream steps in the supply chain. As mentioned above, there are quite a few steps involved in getting from the sales price to the allowable manufacturing costs. Much more is involved than simply subtracting a target profit margin. However, the papers in our sample have almost nothing to say about the complexity and nuances of the target setting process when considering the supply chain downstream the factory to the final customer.

Value engineering

Related to target costing is value engineering, because if the estimated cost of a product exceeds the cost target, the product design needs to be changed to achieve cost reductions. For example, different materials could be selected, or the product could be made easier to assemble. Value engineering is the analysis of a product cost structure to identify ways to change the design of the product so that it can be manufactured at its target cost (Al Chen et al., 1997). In detail, R. Cooper and Slagmulder (2004, p. 3) described the value engineering as follows: “In that process, the product’s basic functions are first identified and its target cost established. The next step is to develop prototypes, analyse their costs, and compare them to the product's target cost. If the final prototype's costs are considered acceptable, it is subjected to reliability tests and then submitted to the customer for approval. Once the product obtains customer approval, it is subjected to a second design round and its production costs are re-estimated. If these costs exceed the target cost, then a first-look value-engineering project occurs." Value engineering examines the functions which the product is designed to perform, evaluates the performance and estimates the costs of delivering all required product functions. This guides the redesign of a product at a lower cost (Al Chen et al., 1997). The basic logic of value engineering is to relate the cost of the product to what the buyer is willing to pay for a product with certain characteristics. Value engineering supports efforts to manage the trade-off between characteristics of the product and its cost. It is carried out during product development (Agndal & Nilsson 2009).

Appendix A, Table 2 provides detailed information about the papers in our sample that address value engineering. The sample includes 10 papers from the MA literature addressing this method, and nine of these also address target costing. The research is predominantly empirical (9 of the 10 papers), typically based on qualitative or mixed data gathered in a case study (7 papers). Given the close relationship with target costing, it is not surprising that there is much attention to Japanese firms.

The case studies of Agndal and Nilsson (2009, 2010) provide much information on how and when value engineering and other methods are used together. They investigated when and how suppliers and buyers jointly utilised suppliers' management accounting data in target costing, value engineering and Kaizen costing. These methods are used for price revisions and for product and process design. The deepest collaboration around cost management issues and the greatest joint use of suppliers' management accounting in the three cases typically occurred in earlier activities in the exchange process, including supplier selection, joint product design and joint manufacturing process development. Furthermore, the extent of sharing of management accounting data depended on the kind of relationship. With a transactional purchasing strategy, cost data primarily served to reduce purchase prices, so data disclosure was limited and forced by the buyer firm. With a relational purchasing strategy, cost data supported cost reduction, for example through joint development of cost efficient products and processes, using target costing, value engineering and Kaizen costing.

Quality function deployment

Similar to value engineering, quality function deployment (QFD) aims to support finding solutions to create cost-optimal products. QFD is a method used in operations management in order to understand customer requirements formulated in terms of required technical attributes; it displays the relationships between customer requirements and technical attributes through a matrix (Zengin & Ada, 2010) . QFD uses four "houses" (these are matrices showing relationships) to integrate the informational needs of marketing, engineering, R&D, manufacturing and management. Most studies focus on the first matrix: the connection between marketing and engineering, also called "house of quality" (Griffin & Hauser, 1992). Karmarkar & Pitbladdo (1997, p. 36) describe QFD as a method for relating engineering specifications of a product to the preference attributes by which the product can be described towards customers. For example, a car may be described in terms of attributes such as comfort, gas mileage and acceleration. These attributes need to be converted to engineering specifications. For example, acceleration may relate to a host of issues ranging from those necessary to produce the acceleration (engine torque, horsepower, gear ratios) to related and supporting factors (suspension, tires, seat and seatbelt design).

The sample included only four papers on QFD and details on these are provided in Appendix A, Table 3. These adopted four different research designs and are diverse in that sense that they were all published in either *Management Science* (*MS*) or *Decision Science* (*DS*).

Two non-empirical studies introduced a model (or approach) that served as decision support either for product development teams to determine the optimal configuration of attributes for customers of a new product or service (Easton & Pullman, 2001) or for quality management purposes (Karmarkar & Pitbladdo, 1997). The common denominator of these models was the use of QFD to integrate customer requirement understandings into products or services. Burchill and Fine (1997) also provided an approach for applying QFD, and this was tried out in a real organisation, which makes it an empirical study, although it also has a "normative flavour" that is comparable to the non-empirical models mentioned above.

Griffin and Hauser (1992) empirically investigated the effects of using QFD. Their starting point was the fact that new product development can be more successful if there is greater communication among marketing, engineering, and manufacturing. QFD may facilitate this. The study was conducted in the automobile industry, comparing two teams that were similar in many ways, but only one team applied QFD. The data suggested that QFD enhanced communication within the core team (marketing, engineering, and manufacturing). Furthermore, the QFD team communicated less with external information sources and with management, but more on external topics, such as customer needs and market information.

Functional cost analysis

Functional cost analysis (FCA) focuses on the evaluation of the cost structure of a product or service, with the objective of finding ways for improving either the product design or the production process to reduce the cost of providing the specified functionality and performance of that product or service. Hence, it is closely related to value engineering and quality function deployment. Yoshikawa et al. (1995) describe FCA as a cost management method derived from value analysis or value engineering. Functions are the focus of costing in FCA. These are always expressed with a verb and a noun, and they do not describe the physical product but the purpose a product or service offered to customers, for example, the function “separate paper” might be fulfilled by a staple remover but also by other technical solutions. The designs of products or services are studied in order to achieve the necessary functions at a lower cost. For example in the context of target costing, FCA helps to redesign products and services to realise the target cost. FCA is supported by extensive cost databases, known as cost tables that allow one to estimate how costs will be affected by design changes (e.g., alternative materials, alternative means of assembly).

Surprisingly, our sample contained only two papers on this topic, which are included in Appendix A, Table 4. Yoshikawa et al. (1995) conducted a case study of a manufacturing company that had been using FCA for 20 years at the time of the research. The company had realised significant financial benefits through the impact of its FCA efforts, not only on product designs, but also to make overhead processes more efficient. Furthermore, the FCA training program for their employees had increased their cost consciousness and customer awareness. Also, FCA had increased their cost understanding, for example because FCA exercises had provided data to build and amend the company’s cost tables. However, after many years of applying FCA, the emphasis tended to revert to cost reduction rather than profit improvement. Innovation and creativity was more problematic, and FCA typically did not look for opportunities regarding how products or overhead could provide more or better functionality so that although costs increased, profits did too. The study also help us to understand that the differences in management accounting between Japan and the U.K. are not in the importance or detail of accounting methods, but in how management accounting is related to other information and other departments.

Mouritsen et al. (2001) studied FCA and target costing in the context of inter-organisational controls. In two innovative high-tech firms, inter-organisational management controls (such as target costing and functional analysis) became important, because they had outsourced many product development and production processes. This created a knowledge gap that motivated the introduction of inter-organisational management controls. Yet, these did not only have an informing role. They also had effects within these organisations in terms of how they looked at their own strategy, technology and organisation. For example, the company that had outsourced much of the development processes started to see itself more as an expert on the market for its products and as an integrator of others, and less as an expert in technological development. FCA and target costing had not only inter- but also intra-organisational effects.

Kaizen costing

Kaizen costing is a system where continuing efforts are made to ensure the cost reduction process during the manufacturing phase of a product by a pre-specified amount or rate. Thus, Kaizen costing takes target costing beyond the design and development stages as it is implemented during the manufacturing phase of the product's life cycle. Kaizen costing requires continuing efforts to be made to secure further cost savings (Guilding et al., 2000). Kaizen, also known as "value analysis", can also be seen as a simple form of target costing for use after the initiation of full-speed production in order to find ongoing improvements (Agndal & Nilsson 2009).

From the descriptions above it is clear that Kaizen costing is not a method for cost management during new product development. However, we have included it because it provides a contrast that helps to highlight the distinction between cost management during and after product development. The opportunity to do much cost management during new product development may be limited due to pressure on the lead time of the product development project (time to market) or other aspects that are of overriding importance during new product development. Thus, there can be trade-offs between cost management during new product development and afterwards, during the manufacturing stage of a product. That is why we have included Kaizen costing; it reflects that sometimes cost management activities have to be postponed until the product is already being manufactured.

The sample includes 11 papers from the MA literature addressing this method and nine of these also address target costing. Detailed information about these papers is provided in Appendix A, Table 5. The research is predominantly empirical (7 of the 11 papers) and typically based on qualitative or mixed data gathered in a case study (6 papers). Furthermore, although we qualified Cooper and Slagmulder (2003) as well as Monden and Hamada (1991) as non-empirical, because they do not explicitly talk about conducting any empirical research, it is clear that these papers have been influenced by many empirical observations in companies. Surprisingly, compared to target costing, there is not much attention paid to Japanese firms (only 3 papers have been published).

Life cycle costing

Cost estimation and measurement may refer to further costs besides manufacturing ones. This is typically the scope of target costing, to be extended to non-manufacturing costs. Costs may be incurred at different stages of the use of a product, including the costs of installation, operation, support, maintenance and disposal. These costs may also be driven by decisions that are taken not at the level of individual new product development projects, but across several projects to coordinate choices on product design, materials and suppliers. Considering these costs is essential to life cycle costing (LCC) (Dunk, 2004). "Rather than costs on an annual basis, the relevant time frame in life cycle costing is dependent on the length of the stages in a product's life cycle. These stages may include design, introduction, growth, maturity and decline" (Guilding et al., 2000, p. 119). The life cycle costing philosophy emphasises that a thoroughly executed design phase is crucial for the profitability of a product over its lifetime. Hence, LCC considers the total cost incurred in product development and service support (M. Krishnan, Kriebel, Kekre, & Mukhopadhyay, 2000).

In the context of environmental accounting, Parker (2000, p. 48) described life cycle costing as an "approach that effectively attempts to internalize some of the related long-term environmental costs implied by the life cost analysis—largely those traceable to and measurable by the producing organisation." This may facilitate the development of more efficient and environmentally friendly product designs. Hence, life cycle costing is also particularly relevant for environmental management accounting (Deegan, 2008) as highlighted by Jackson, Kloeber, Ralston and Deckro (1999) who specifically focus on decisions on technology for waste site remediation.

Within our sample, the 14 papers addressing this method are listed in Appendix A, Table 6. There was a wide variety of research on this method. We note a balance between various forms of empirical and non-empirical research. The empirical results suggest that life cycle costing may have several beneficial effects for firms' cost management objectives. Studies have found that it may help organisations to anticipate future opportunities and threats associated with current purchasing alternatives (Deegan, 2008) and may increase conformance quality in software products (M. Krishnan et al., 2000). However, the survey results of Hyvönen (2003) and Guilding et al. (2000) show low adoption rates of life cycle costing. The study of Dunk (2004) may help to understand this adoption, as it investigated antecedents of the use of life cycle costing, also on the basis of survey data.

Among the non-empirical studies, Gutschelhofer and Roberts (1997, p. 42)discuss the concept of life-cycle costing in comparison to German costing methods. The German method of multiple-step fixed cost accounting is considered the closest equivalent to life-cycle costing. German cost accounting provides a new design for life-cycle cost accounting with a practical relevance in the area of marketing cost management.

Total cost of ownership

Total cost of ownership (TCO) is a cost accounting application that enables purchasing decision-makers to combine price and value in making sourcing decisions by monetary quantification of all the costs the customer incurs as a result of acquiring and using supplier offerings. Although it is typically discussed in the context of purchasing decisions, we included this for its analogy with life cycle costing. Total cost of ownership takes into account all costs that the purchase and the subsequent use of a component entail in the entire value chain of the company. Total cost of ownership goes beyond minimising purchase price and considers all costs that occur during the entire life cycle of the item in the organisation (Degraeve, Labro, & Roodhooft, 2005). It is also clearly related to life cycle costing because both cost concepts aim to quantify the total cost of acquiring, using and disposing of assets beyond the initial purchase price (Geissdörfer, Gleich, & Wald, 2009). For example, total cost of ownership may focus on quantifying transaction costs related to purchasing activities e.g., ordering, freight, quality control as well as the costs related to poor quality e.g., rejection, rework, and warranties (Wouters, Anderson, & Wynstra, 2005).

The sample of six papers on this topic is described in Appendix A, Table 7. From the MA literature there is little empirical evidence about this method being used to manage cost during product development because the focus is on its use for purchasing decisions. Caglio & Ditillo (2008) reviewed the literature and described total cost of ownership as a method for the screening and management of suppliers (i.e., for suppliers selection). Degraeve & Roodhooft (2000)and Degraeve et al. (2005) present mathematical programming models that minimize the total cost of ownership for a set of purchasing decisions. Van den Abbeele, Roodhooft and Warlop (2009) investigated how total cost of ownership information influenced negotiations between buyers and suppliers. Their experimental findings suggested that total cost of ownership information reduced the performance disadvantage of less powerful buyers. Wouters et al. (2005) investigated the adoption of total cost of ownership for purchasing decisions. Their survey findings suggest the following factors as critical for the adoption: (1) top management support and functional (non-accounting) commitment to improve cost information, (2) purchasing patterns and (3) value analysis experience.

Stage-gate reviews

Stage-gate reviews are an important management control mechanism in product development. After completion of each development phase, the proposed design is reviewed on a wide variety of aspects for which targets and other objectives were formulated at the beginning of the development project (such as functionality, performance, product cost, project lead-time and development cost). This may lead to revisions of the design and adjustment of the plans. As such, “gates are management meetings at the end of each stage in the product development process where progress is compared to the plan and the plan is adjusted in light of new information” (R. G. Cooper, 1990). Hence, it is related to target costing because the review of the estimated product cost is central in target costing, but stage-gate reviews is the overarching method for reviewing product designs as these progress during NPD projects.

Detailed information about the six papers in our sample is provided in Appendix A, Table 8. Hertenstein and Platt (2000) as well as L. Z. Song, Song and Di Benedetto (2009) provide evidence for the practicality of stage-gate reviews for cost management during product development. However, Nagji and Tuff (2012) argue that stage-gate processes may harm innovation significantly as such projects may be reviewed negatively before they are properly explored. Jørgensen and Messner (2009) showed in a case study how stage-gate processes provided a structure that helped to organise priorities and establish communication. This approach allowed for a separation in time between activities that needed more flexibility and those that were in need of more efficiency. Thus, the stage-gate process structures the relationship between tasks and provides the basis for more specific definitions of what is expected in the different stages. Engineers and managers used the same tools (such as budgets and profitability calculation tools) to achieve internal transparency within their local practice.

Funnels

The "funnel" metaphor was used in many different ways within our sample of papers, mostly, for describing search and selection processes e.g., for purchasing options by consumers or cases by researchers. The method is not so popular within the MA literature, and we finally identified one paper, which is included in Appendix A, Table 8. Ding and Eliashberg (2002, p. 346) refer to funnels as "the structure in which the number of alternatives that a firm is committed to at each stage gradually decreases as the development process moves toward completion" i.e., through the NPD stages. Hence, there is a strong similarity with stage-gate systems discussed above but in funnels there is an emphasis on the selection of projects, i.e., on limiting the number of projects that survive and actually continue to the next stage. Non-survival may be caused by technological uncertainty e.g., it may depend on the outcome of clinical trials in pharmaceutical research or it may be caused by market uncertainty e.g., survival based on the outcome of consumer research of new products.

Hence, a funnel method assists managers of R&D projects in having a better overview of when and where to "spend" R&D budgets. Ding and Eliashberg (2002) focus on R&D budgets in a setting when multiple approaches may be taken to develop a product and there is uncertainty regarding which approach will be successful. The goal is to develop one successful product and the question is how many development approaches should be invested for this purpose (also called "pipeline"). The model is based on option trees and the optimal structure of the pipeline is driven by the cost per development approach, its probability of survival and the expected profitability. Examples from the pharmaceutical industry are used to demonstrate the implementability of the model.

Several further methods for managing costs during product development have an engineering background and address the design of products directly rather than indirectly such as through cost targets. Below we discuss how encompassing these methods are:

- DFM, DFA, DFX
- Component commonality
- Modular design
- Product platforms
- Technology roadmaps.

Design for manufacturing / design for assembly

Design for manufacturing (DFM) and design for assembly (DFA) are methods that directly impact the design of products in order to reduce costs. Guidelines and constraints are provided to new product development teams that help them to improve their designs so that these can be manufactured at a low cost. DFM and DFA typically concentrate on reducing the number of parts in a design as well as reducing the time required to positioning and insert each part during assembly (Ulrich, Sartorius, Pearson, & Jakiela, 1993).

In our sample of eight papers, as shown in Appendix A, Table 9, seven were published in *Management Science* (*MS*) or *Decision Science* (*DS*). This is a very different pattern compared to the previous topics but quite similar to the topics that will follow below. All eight papers report empirical studies.

Several studies show that there is a negative relationship between design efforts and subsequent product costs during the manufacturing stage either based on archival data (Bajaj, Kekre, & Srinivasan, 2004; Datar, Jordan, & Kekre, 1997), a mix of quantitative and qualitative company data (Fuchs & Kirchain, 2010; Ulrich et al., 1993) or estimates based on publicly available information (Ulrich & Pearson, 1998).

However, measuring the implementation of design for manufacturing in a company with performance measures is problematic because there are many aspects to consider and different consequences. Hansen (2010) conducted a case study about externalities caused by non-financial performance measures in regard to the implementation of design for manufacturing. Externalities means that improved performance of one task negatively or positively affects the performance of others. Hence, the introduction of performance measures may create these. Some of the newly introduced performance measures concerned the progress of DFM initiatives, which were measured as the reduction of components on printed circuit boards and the reduction of products parts. These DFM measures involved several negative externalities in both companies.

Component commonality

Component commonality refers to the selection of limited sets of allowed materials, parts, components, packaging etc. that act as constraints during product design in order to be shared across a set of final products. This is defined by Van Mieghem (2004, p. 419) as a “strategy to assemble different products from at least one common component and one other product-specific component”. Commonality involves some intricate cost trade-offs, which need to be considered when this approach is used to manage costs during product development, and as Desai, Kekre, Radhakrishnan and Srinivasan (2001, p. 38) highlight “one component needs to be designed instead of two components”, leading to cost reduction. However, designing components that must be suitable for several different products may be more complex and costly per component. Using common components may lead to higher variable costs per unit if the component is over-specified for lower-end products; or it may lead to negative reactions from customers if the component is underspecified for higher-end products. Commonality may reduce manufacturing costs due to economies of scale in production and in purchasing, and it may reduce inventory costs due to risk-pooling.

It is remarkable how little empirical evidence was gathered within the MA literature. As seen in Appendix A, Table 10, our sample consists of 14 papers and only two papers were based on empirical data. Thus, of the 12 non-empirical papers, eight were based on numerical simulation, which is particularly surprising considering that there are only 13 unique papers (14 references) based on simulation in the entire sample. The research on component commonality in our sample is atypical in that 13 of the 14 papers were published in either *Management Science* or *Decision Science*.

In several case-studies Davila and Wouters (2004) identified commonality as a practice to manage cost for high-technology products as an alternative to target costing. Target costing primarily focusses on the costs of individual products, whereas commonality and several other methods address costs across individual product development projects. This was important when other considerations besides costs were relevant, and when many resources were shared across products. Fisher, Ramdas and Ulrich (1999) studied the automobile industry and found evidence that the degree of sharing (commonality) depended on basic parameters such as fixed and variable costs, the range of vehicle weights in the product line and sales volume.

The non-empirical studies typically modelled cost trade-offs involved in commonality. For example, Desai et al. (2001, p. 38) found that "while manufacturing costs always decline with the use of commonality, the firm's overall profits may decline because of reduced differentiation." Models of these trade-offs were mostly analysed through numerical simulation (Akçay & Xu, 2004; Benton & Krajewski, 1990; Bernstein, DeCroix, & Wang, 2011; Steele, Berry, & Chapman, 1995; Xiao, Xia, & Zhang, 2007; S. H. Xu & Li, 2007). Such models were not specific to a particular industry, which is indicated in Appendix A, Table 10, but the concept of component commonality implies some form of manufacturing. An actual illustration or application of the model is mentioned in two papers (V. Krishnan & Gupta, 2001; J. Swaminathan & Tayur, 1998). These papers focus on a real setting i.e., the computer hardware manufacturing. However, since it is "only" a brief illustration, we qualify these studies as non-empirical.

Modular design

Modular design can be defined as a cost-management method according to which products are designed in such a way, that a wide variety of final products can be produced using a limited number of modules that are adjusted and/or combined with different parts and other modules. Modules are complete subsystems which can be tested separately. Baldwin and Clark (1997) define modularity as building a complex product or process from smaller subsystems that can be designed independently yet function together as a whole. The subsystems or modules are designed independently, and the interfaces among components are standardised, so multiple products can be configured by mixing and matching from a base set of components to introduce new products (Baldwin & Clark, 1997; K. Ramdas & Randall, 2008; Terjesen, Patel, & Sanders, 2012).

Modular designs allow a company to offer a large assortment of final products in an efficient and fast way because it saves in the one hand development cost since fewer different modules need to be developed in total although each one may be more complex and costly to develop compared to when no explicit modular design strategy is used. In the other hand it saves manufacturing costs, each module is produced in a greater quantity and economies of scale can be used but for some products the modules used may be "over-specified" which increases cost. Thus, there are always trade-offs involved. Although these trade-offs are comparable to those discussed above for component commonality, a modular design is more encompassing than component commonality in how it affects product designs, and modules are larger subsystems than individual components and, therefore, these trade-offs become more significant.

The sample of 20 papers is shown in Appendix A, Table 11. The most noticeable difference with the previous topic of component commonality is that now empirical studies are in the majority (13 papers). These are based on archival, survey and qualitative data. An explanation could perhaps be that modularity is a broader topic and more strategic than component commonality, and maybe this invites researchers who prefer to conduct empirical studies, besides researchers who are more specialized in mathematical modelling of more narrowly defined phenomena. As for the previous topics of component commonality and design for … , *Management Science* (*MS*) and *Decision Science* (*DS*) published the majority of the papers about the topic of modularity in our sample (13).

Jørgensen and Messner (2009, 2010) provide a nuanced expose of the economic evaluation of modularity in a real organisation. In the company, the existing calculation models could not capture the costs and benefits of modularity. Indeed, the models such as the ones described by Krishnan and Ramachandran (2011), Lee and Tang (1997), Gamba and Fusari (2009), Ethiraj and Levinthal (2004a, 2004b) and Ethiraj, Levinthal and Roy (2008) are most likely to be difficult to implement in terms of measuring the required input data, apert from that, this models are also unlikely to adequately represent the full implications of modularity. However, in their case study the limitations of the calculation models were not very problematic because managers could intuitively combine financial and non-financial considerations as well as refine their understanding of the consequences of modularity over time and the limitations of the model left room in the discussions for managers to express their different ideas. How the models of calculations were implicated in a real organisational context with real actors was more nuanced than the "logic" of scientific analysis would assume. Other studies provide more aggregate empirical evidence regarding modularity, such as Tan (2001), Terjesen et al. (2012), and Tu, Vonderembse, Ragu-Nathan and Ragu-Nathan (2004).

Design for X

The idea of DFM / DFA is expanded under the heading of design for X (DFX). This consists of guidelines and constraints provided to new product development teams to help them improve their designs in such a way that costs can be kept low on a wide range of aspects e.g., logistics, disposal, environment and service. Hence, applying this method to manage new product development projects would clearly have a monetary impact on further manufacturing processes.

Design for X is well known in the product development literature (see chapter 4). Nonetheless, as the funnels method, DFX lacks attention in the MA literature. Our sample includes one single paper on DFX, which was published in *Management Science* (*MS*). This is included in Appendix A, Table 9. Fuchs & Kirchain (2010) address the research question on how location-specific differences in manufacturing may change the cost-optimal product design. The paper uses a combination of simulation modelling and empirical data to quantify the trade-offs for the case of optoelectronic manufacturers in deciding whether to move manufacturing off-shore. This is related to the literature on DFX and DFM in the sense that the "X" can represent a variety of matters that can be considered during product development (i.e., the manufacturing location). Results showed that off-shore manufacturing was cheaper for the prevailing technology, while for emerging technology production was cheaper in the U.S., but still more expensive than the prevailing technology.

Product platforms

The approach of product platforms is one step further in shaping the architecture of products and thereby influencing product costs during product development. Rather than having design guidelines or common parts or even modules, product platforms imply that the product architecture is developed from the ground up to facilitate a range of different end-products and several generations of those. Product platforms can be defined as "the physical implementation of a technical design that serves as the base architecture for a series of derivative products" (M. H. Meyer, Tertzakian, & Utterback, 1997). This implies that a whole set of resources are shared across products, ranging from components to production processes (K. Ramdas & Randall, 2008).

The sample includes nine papers on modularity, of which six have been published in either *Management Science* (*MS*) or *Decision Science* (*DS*). This is atypical for the entire sample, but quite similar to the previous topics design for "X", component commonality, and modular design. Appendix A, Table 12 provides more information on the papers that address product platforms.

Technology roadmaps

As in several of the previous methods, technology roadmaps also shape choices for the design of products and thereby product costs. Through such choices, roadmaps may play a key role in the management of costs during product development. Technology roadmaps describe candidate technologies and the levels of specification and performance in a particular industry that are planned to be reached at different points in the future. These roadmaps project technological developments into the future so firms can formulate their R&D objectives and plan their R&D investments.

Roadmaps may be voluntary agreements or come from legislation. For example, in the U.S. and Europe there are emission standards that specify a future path for the levels of allowed pollution of vehicle engines[7]. Voluntary roadmaps are collectively formulated by industrial associations in order to coordinate their R&D investments more efficiently. For example, the ITRS[8] coordinates the roadmapping activities in the semiconductor industry. Technology roadmaps are a tool to share information that assist the planning and coordination of technology development. They serve as guidelines to develop a specific technology i.e., the long-term goal, where projects shall be structured into several steps or milestones i.e., short-term goals, accordingly to determined timelines and requirements previously established by the parties involved within the project e.g., developers, suppliers, etc.

As shown in Appendix A, Table 13, our sample includes five papers in accounting that looked at technology roadmaps. These have been described as a mediating instrument for a firm's own planning and investment (Alkaraan & Northcott, 2006) and for coordination with other firms on large investments decisions in high-tech product development (P. Miller, Kurunmäki, & O'Leary, 2008; P. Miller & O'Leary, 2007).

3.3 Conclusions

The purpose of this chapter was to provide an overview of the research (i.e., papers) found within the 40 journals selected from the management accounting (MA) literature on 15 specific methods for cost management in relation to new product development.

The search yielded a sample of 113 different papers. Many contained information about more than one method, and this yielded 149 references to specific methods. The number of references varied strongly per cost management method and per journal. Target costing received most attention the publications in our sample (38 of 149 references), and modular design, component commonality, and life cycle costing were ranked 2nd and joint 3rd (20, 14, and 14 references, respectively). Most references were published in *Management Science* (40), *Management Accounting Research* (33), and *Accounting, Organisations and Society* (19). The results were strongly influenced by two journals, namely, *Management Science* and *Decision Science*. In these two journals, cost management methods with an engineering background were published above average (design for manufacturing, compo-

[7] See, for example, European Commission, Transport & Environment, Road Vehicles, http://ec.europa.eu/environment/air/transport/road.htm, accessed January 29, 2014.

[8] International Technology Roadmap for Semiconductors

nent commonality, modular design, and product platforms) while other topics were published below average.

The overview of the research found indicates many opportunities for future research. Rather than listing many such topics here, which would follow quite directly from the tables presented above, we would like to highlight a few particular topics for future research.

Firstly, there is a need to understand in great detail the way different cost management methods may come together in an overall process. We propose studying such a process based on a broad notion of stage-gates as the all-encompassing process. This starts with target setting not only for product costs but also targets for its functionality and performance and the budget and lead time of the product development project. This involves information gathering, modelling of trade-offs and perhaps coordination with a technology roadmap. How do companies determine targets when there is often much uncertainty? The process has key review moments of the design, not only for its product- and project-specific targets, but also for its agreement with coordinating guidelines and rules (design for "X", component commonality, modular design and product platforms). This may involve estimation of product costs, functionality, performance, lead time, development costs and development lead time. How do companies measure performance? How do companies "know" all these things when products have only been partially designed and projects are only halfway through? Things will often be different than planned, so there are many decisions to be made. This may involve adjusting targets, redirecting development resources among projects, or shifting certain cost management activities to a later phase. How do companies deal with such complex interactions under uncertainty? This call for research is consistent with Davila et al. (2009, p. 297) who propose to examine the intersection between innovation and control by taking a process perspective. "Moving ideas into products and services requires control systems. Why do companies use stage-gate systems for their incremental innovation efforts? How do these systems fit with existing control theory? How do they manage radical innovation where plans are not going to be met? What is the role of plans in these settings? The open and relevant questions are multiple."

Secondly, future research could give more attention to describing additional examples of what companies do and document interesting practices regarding cost management in product development. Some high-tech companies spend hundreds of millions of Dollars or Euros on research and product development every year to frequently introduce new products which, to be competitive, need to offer more functionality and better performance at a lower price for the customer. Whether in the automotive industry, semiconductor industry or medical industry, it is to be expected, that companies develop and apply innovative methods for managing costs in product development. "Simply" describing inspiring examples of original management practices could also constitute valuable contributions to the literature. Such practices may not work everywhere and may not necessarily classify as “best practices”, but they can provide useful inspiration for researchers and practitioners (Roberts, 2004).

Apart from the aforementioned areas of research, we believe that it would be useful to conduct empirical research on which methods have been use for cost management during new product development, and which factors may explain their adoption. Previous studies surveyed the adoption of management accounting practices (Abdel-Kader & Luther, 2008; Abdel-Maksoud et al., 2005; Alkaraan & Northcott, 2006; Al-Omiri & Drury, 2007; Chenhall & Langfield-Smith, 1998b; Guilding et al., 2000; Innes & Mitchell, 1995), but to our knowledge no prior study has investigated a range of different methods for cost management during product development. Thus, it would be a valuable contribution to the literature to look not only at the adoption of separate methods but also to focus on how different group of methods. Such a research should explain the adoption of different methods based on antecedents, the strategic importance of costs compared to other product development outcomes (e.g., specifications and performance of the product, lead time of the product development process), the size of the product development cost relative to the product unit cost and the interdependencies among products in their effect on indirect costs.

This doctoral thesis tackles part of the last proposed research area. We develop a series of hypotheses dealing with factors that may explain the adoption of certain cost management methods for new product development. However, we refine our research motivation by also presenting the results from reviewing the IOM literature in the following Chapter 4. This review also addresses the research on 15 different cost management methods during new product development.

4 Results – Innovation and operations management literature review

4.1 Introduction

This chapter presents a review of the research found within the IOM literature in regard to the 15 different cost management methods. While writing this Chapter, I was working together with Prof. Dr. Wouters, Mr. Scheer and Mr. Grollmuss. Although their contribution is shown in the entire Tables referred in Appendix B, I wrote the description of findings for each method presented within this chapter. A paper version of these findings has been accepted by the journal *Advances in Management Accounting* and will be published with the co-authors in 2016.

We analysed a total of 208 papers from this literature. Table 8 shows an overview of the papers obtained from the IOM literature and how these are distributed among the different cost management methods and journals. Each paper may cover research on several methods, which is why the aggregate number of 275 is shown in Table 8. Furthermore, Table 9 shows the results of the research methods, i.e., empirical, theoretical or conceptual studies.

The results from the IOM literature were not equally distributed across the different cost management methods but this distribution was also not extremely uneven (see Table 8). An average of this should be 1/15th i.e., 18.3 results per method. Three cost management methods were clearly above this average: modular design, component commonality and product platforms (45, 37 and 33 references, respectively); four cost managements provided only 2-6 references per method; the remaining eight cost management methods were between 7-29 references per method.

Results for the different journals are shown vertically in Table 8. Firstly, results were provided for 20 of the 23 journals. We did not identify results in our final sample from *Academy of Management Review*, *California Management Review* and *Strategic Management Journal*. Table 8 illustrates, that the distribution of papers among the journals was very uneven. Within the set of 20 journals, uniformly distributed references would mean 1/20th = 5.0% of the results per journal (i.e., 13.8 results). Four journals had a far greater number of results than this, namely, *International Journal of Production Research* (27%), *Journal of Product Innovation Management* (14%), *International Journal of Production Economics* (12%), and *IEEE Transactions on Engineering Management* (9%). The next two journals were closer to the average number of results, namely, *IIE Transactions* (7%) and *Research-Technology Management* (5%), and the remaining 15 journals were far below-average number of references of 0.4%-3%. The results of the MA literature are also included in Table 8, and these appear to be more skewed compared to the results for the IOM literature. Only two cost management methods had 26% and 13% of the results (target costing and modular design), and the results for the other cost management methods were close to the average.

Table 8: Overview of the IOM literature, number of references per cost management method and per journal.

		Total		Target Costing	Value Engineering	Quality Function Deployment	Functional Cost Analysis	Kaizen Costing	Life-Cycle Costing	Total Cost of Ownership	Stage-Gate reviews	Funnels	Design for Manufacturing	Design for X	Component Commonality	Modular Design	Product Platforms	Technology Roadmap	*Total*
	Total			18	11	29	2	3	19	6	24	3	21	17	37	45	33	7	275
1	*AMJ*	1	0.4%								1								
2	*IEEE-EM*	26	9%	1	1	2			5	1	1		2	2	3	6	1	1	
3	*IIE*	18	7%			1			4				3	1	4	2	3		
4	*IMM*	4	1%	1						1	2								
5	*Interf*	1	0.4%															1	
6	*IJOPM*	9	3%	1		1					1		1	1	1	3			
7	*IJPE*	34	12%	7	3	2	1		2				2	2	4	8	3		
8	*IJPR*	74	27%	2	3	17	1	1	5	1	1		6	5	13	8	11		
9	*IJTM*	2	1%						1							1			
10	*JETM*	9	3%	1	1	1		1					1	1	1	1	1		
11	*JM*	5	2%												1	2	2		
12	*JMR*	1	0.4%			1													
13	*JOM*	5	2%							1			1		1	2			
14	*JPIM*	38	14%	1	2	3				1	8		4	3	2	4	8	2	
15	*MSOM*	7	3%												4	2	1		
16	*MIT SMR*	5	2%	2				1				1					1		
17	*RADMA*	9	3%			1					3				1	2		2	
18	*ResPol*	7	3%	1	1										1	3	1		
19	*RTM*	15	5%	1					1	1	6	2		1	1		1	1	
20	*Techn*	5	2%						1		1		1	1		1			
		275	100%																
Results MA literature				38	10	4	2	11	14	6	6	1	8	1	14	20	9	5	149
				26%	7%	3%	1%	7%	9%	4%	4%	1%	5%	1%	9%	13%	6%	3%	100%

The sample contains 208 unique papers, and if a paper addresses more than one method, it is included more than once in the counts below. This explains why the total number of references is 275.

Looking in more detail at the distribution of papers based on the journal of publication, Table 8 provides some interesting outstanding results. For example, *IJPE* had 34 results and target costing had 6.5% of the overall results, so the expected number of results for the cell related to *IJPE* and target costing is approximately 2.2. Thus, 7 papers on target costing was an unexpected result. This shows that *IJPE* pays relatively much attention to target costing. Similarl unexpected results includ-ed *IEEE-EM* and *IIE* concern themselves with life-cycle costing whereas *IJPR* with quality function deployment. Whilst both *IJPR* an *IJPE* pay relatively very little attention to stage-gate systems, *JPIM* and *RTM* closely analyse this topic.

Table 9: Overview of the IOM literature, number of references, per cost management method and per research method.

		Total		Target Costing	Value Engineering	Quality Function Deployment	Functional Cost Analysis	Kaizen Costing	Life-Cycle Costing	Total Cost of Ownership	Stage-Gate reviews	Funnels	Design for Manufacturing	Design for X	Component Commonality	Modular Design	Product Platforms	Technology Roadmap		**Results MA literature**	
	Total			18	11	29	2	3	19	6	24	3	21	17	37	45	33	7	275		
1	Non-Empirical: theoretical	24	9%			2			2		2		1	3	3	3	4	4		24	16%
2	Non-Empirical: analytical	21	8%	1		2			4						5	8	1			13	9%
3	Non-Empirical: simulation	67	24%	2	2	12	1		5	2			4	3	16	11	9			14	9%
4	Empirical: experimental	2	1%	1													1			3	2%
5	Empirical: market	0	0%																		0%
6	Empirical: archival	16	6%		1				4		2		2	1	3	1	2			9	6%
7	Empirical: observations	32	12%	3	2	5		1			4	2	4	2	3	1	4	1		4	3%
8	Empirical: survey	41	15%	6	4	4		1	1	1	9		8	1		5	1			24	16%
9	Empirical: qualitative	29	11%	4	1	1		1	1	2	4		1	1	4	4	4	1		32	21%
10	Empirical: mix (QQ)	43	16%	1	1	3	1		2	1	3	1	1	6	3	12	7	1		26	17%
	Total	275	100%																	149	100%

All research methods were used, except empirical research based on market data.

Table 9 presents the results for the ten different research methods, which means that a uniform distribution of the results would imply 10% for every research method. Actual results for the IOM literature were quite uneven, with three research methods having a far above-average number of results for simulation (24%), mixed research methods (16%), and surveys (15%). In total, 59% of the results (163) for IOM literature were based on empirical methods, which is comparable to the 66% (98) found for the MA literature. Target costing, value engineering, stage-gate systems and design for manufacturing were far above-averagely based on empirical research, with 83%, 82%, 92% and 76% respectively. With 35%, component commonality had the lowest percentage of results based on empirical methods. The results for the MA literature are also shown in Table 9. Four research methods had a high above-average number of results: qualitative studies (21%), mixed research methods (17%), surveys (16%) and theoretical papers (16%). It is also interesting to note that the emphasis on research methods was quite different with simulation being the most frequently used research method in the IOM literature but it is averagely used in the MA literature. However, the qualitative study was the most frequently used method in the MA literature, but it is averagely used in the IOM literature. One striking similarity between these types of literature showed a lack of studies based on market data.

When analysing the results in Table 9, it can be seen that some cost management methods have been investigated more or less than had been expected with particular research methods. For each cost management method (except for the five methods that provided only 1-3% of the results per method) we highlight when the distribution of the results was very different from the overall distribution. For example, surveys accounted for 15% of the results and target costing had 18 results in total, so we would expect around 2.7 results for the cell of surveys on target costing. The actual number of results in this cell was 6, which amounted to approximately 3.3 more than expected (i.e., a deviation of 3.3 ÷ 18 = 18%). This means that target costing was often researched based on surveys. Similarly, in terms of research based on surveys, value engineering, stage-gate systems and design for manufacturing were also researched more than had been expected. On the other hand, surveys were adopted far below expected for component commonality and product platforms. Simulations were often used for research on quality function deployment and component commonality, but less than expected for stage-gate systems. Other interesting exceptions include the analytical models and mixed research methods wich were used relatively often for the topic of modular design; analytical models and archival data for life-cycle costing and mixed research methods for design for X are both used relative often.

4.2 15 Cost management methods - IOM literature

Target costing

The IOM literature presents a broad understanding on this accounting method. Within this context, rather than asking "what will the product cost?" target costing introduces a change in thinking within product development toward the question "what may the product cost?" (Schmeisser, Mohnkopf, Hartmann, & Metze, 2008). Thus, target costing is of great value in the early phases of product development since in these phases product characteristics and subsequent costs are determined to a large extent (Dowlatshahi, 1992). In many companies, this practice has become a necessity, as for instance to improve supplier – customer relationships in the automotive industry, where competitive bidding has been replaced by target prices set by the customer (Ro, Liker, & Fixson, 2007). Instead of over-engineering products and thus generating costs which cannot be recovered through price increases, target costing aims to guide product development to fulfil customer requirements and provide the relevant functionality and performance corresponding to the target price set at the desired quality.

As indicated in Appendix B, Table 1, our sample included 18 papers. It is worth mentioning that while target costing was by far the most investigated method in the MA literature (38), in the review of the IOM literature, target costing was researched on average (18 vs. 18.3) as a method to support cost management in NPD. The majority of papers (83%) found in this review were based on empirical research, mostly addressing multiple manufacturing industries. Half of the papers on target costing covered other cost management methods such as value engineering (5) and QFD (3). A significant amount of the papers were published in *International Journal of Production Economics*.

The papers bas ed on simulations tested target pricing approaches seeking equilibrium and optimal policy under various restrictions (Li, Wang, Yin, Kull, & Choi, 2012), for example when considering the cost of capital (Kee, 2010) and integrating target costing among different functions through QFD (M. Hoque, Akter, & Monden, 2005).

Furthermore, the empirical research on target costing is very broad. On the one hand, we found research on factors influencing its adoption for NPD such as innovations characteristics (Yazdifar & Askarany, 2012) and time pressure (Everaert & Bruggeman, 2002). On the other hand, we identify research highlighting target costing settings for better results. Firms which apply target costing on a product level seem to have a significant advantage compared to its use on a component level (Afonso, Nunes, Paisana, & Braga, 2008). Regardless these findings, Filomena, Neto and Duffey (2009) propose a target costing model which divids the product design into parts, features as well as common parts and breakdown its target costs to operationalise the method during NPD. This approach enabled teams involved in NPD to have more accurate cost control. Research comparing the adoption Japanese and U.S. is quite common (Liker, Kamath, Wasti, & Nagamachi, 1996; Petersen, Handfield, & Ragatz, 2003; Rabino, 2001; Ro et al., 2007). In particular, target pricing as a method for price setting is more commonly used among Japanese suppliers compared to suppliers in USA for the supply of car components (Liker et al., 1996).

Empirical research also suggests the combination of target costing with methods such as value engineering, QFD and Technology roadmaps. For example, Albright and Kappel (2003) related target costing to technology roadmaps. They suggested “experience curves” as a base for setting price and costs targets which as well would improve on drawing pricing trends in the computer hardware industry, compared to simple time forecasts. Firms that combine target costing with QFD and value engineering benefit from cost reductions without sacrificing their products’ quality and functionality (Zengin & Ada, 2010). Plank and Ferrin (2002) surveyed the valuation of purchase offerings. They found that about every second industrial purchasing agent confirmed the use of target pricing. Furthermore, out of the 42 companies which use a TCO approach for such an offering valuation, 24 reported applying price targets. Thus, in most cases, considering various costing methods is more beneficial than using only one (R. Cooper & Slagmulder, 2004).

Within a R&D framework target costing practices are relevant for the success of NPD processes (Cooper & Slagmuide, 1999). Target costing encourage information sharing regarding costs and technology (Liker, Kamath, Wasti, & Nagamachi, 1996; Petersen, Handfield, & Ragatz, 2003; Plank & Ferrin, 2002; Ro et al., 2007). This shows to improve collaborative competences, namely, the inter-organisational collaboration i.e. between the company different functions and also the intra-organisational collaboration i.e., among NPD teams and their suppliers or customers. However, Zengin and Ada (2010) do not consider target costing suitable for the development of products entirely new to the market and discourage its application when uncertainty has a great impact on product success. Inter-organisational collaboration can be divided into three types of interaction, including, cross-functional, supplier and customer integration. Thus, we present papers addressing these relationships. Within cross-functional integration, Rabino (2001) investigated the perceived desirability of American cost accounting practices (i.e., ABC) and Japanese practices (i.e., target costing, value engineering and Kaizen costing) within NPD teams. This research suggests that the "addition of an accountant to a NPD-team can enhance the collection and interpretation of cost data. This in turn helps to identify the most appropriate product projects for the company" (Rabino, 2001, p.86). Within supplier integration, the survey conducted by Petersen et al. (2003) demonstrated that several organisations use 'target pricing' methods early in the product development cycle. These organisations involved buyer-seller teams to jointly work on alternative technical solutions to meet a target cost. However, results from Ro et al. (2007) showed that suppliers feel oppressed and constrained by their customers' target pricing or costing activities. This is exemplified through modular designs where target costs were not sufficiently adjusted regarding the extra cost faced by suppliers when they have to develop such modules. Customer integration, within this framework, target costing was identified as a helpful method to integrate the customer's needs as well as the economical aspects into product designs (Ibusuki & Kaminski, 2007). For example, Cooper and Yoshikawab (1994) claim that combining target costing with value engineering can be used to spread competitive pressure among the related functional areas by passing on all customer's requirements across the value chain.

Value engineering

Value engineering, also known as value analysis, is a cost management method which aims to improve products, processes and services by increasing the degree of value-added according to the customers' requirements with the least cost possible. Basic product functions, which are implemented with the least cost possible while assuring a defined quality level, are derived from customer requirements to ensure that the desired functionality fits the product cost, and thereby ensure that customers are willing to pay for this particular product.

Our sample includes 11 papers on value engineering. Detailed information on these papers is available in Appendix B, Table 2. Empirical research was predominant (81%) for this method. We notice that researchers paid much attention on value engineering in both literatures. However, within the IOM literature, the 11 papers on value engineering are clearly below the average (18.3), while in the MA literature, the 10 papers represent that the method is around average (9.99).

From this sample of papers only two studies used non-empirical data. Both papers address value engineering through simulations. Wang and Che (2008) focus on the problems that occur with changing parts of a product. To overcome these problems of re-designing products, a theoretical model is proposed and supported with an illustrative example. The method value engineering was one of a series of steps within this theoretical model. Moreover, Yoshikawa et al. (1994) explored the information needed to facilitate the value engineering of both products and overhead services. Through this we show how the method can be used for the evaluation of suppliers.

Apprt from the research highlighting value engineering as a complementary method to target costing (Cooper & Yoshikawab, 1994; Ibusuki & Kaminski, 2007; Rabino, 2001; Zengin & Ada, 2010), Liker et al. (1995) assessed the adoption of value engineering by comparing Japanese and U.S. car component suppliers. Findings showed that value engineering is performed in a loose manner when cross-functional teams undertake simple problem-solving activities to find and eliminate waste. This indicates that value engineering may be connected to lean management, which also aims for waste elimination and reduction.

Several benefits were identified from using value engineering. By designing less complex products, value engineering decreases the intensity of development spending. Furthermore, value engineering is positively associated with product line freshness (i.e., “how current a business unit's product line is, and how "fresh" and up-to-date the products are” Loch et al. 1996, p.12) and thereby increases output performance. Employing value engineering may not only lead to cost savings, Martínez Sánchez and Pérez (2003, p. 61) indicated that by reducing engineering changes, value analysis may also be used to achieve time savings in design and manufacturing phases. Thus, they relate it to NPD efficiency.

Further fields of application for value engineering, besides manufacturing, are presented as well. Chung et al. (2009) worked with a model for the construction industry. The model assessed different functions of the respective project development and considered the estimated actual cost to support an objective decision making process. Their case-study, developed in a hospital building project, provides detailed and practical information about a particular value engineering approach, which leads to cost savings being more than ten times higher than the expenditure needed for undertaking the value engineering activities. Hence, value engineering may also be applied to product development where the production activities are highly complex and must follow strict rules, for example, in the cruise ship industry which must adhere to the rules imposed by naval registries. Within this field, research on value engineering demonstrates the advantageous in decision making for designers with regard to alternative solutions.

Quality function deployment

Quality function deployment (QFD) is a product planning method that takes into account customer requirements in NPD in a structured manner. Thus, this method provides guidelines on how to consider such requirements for the development of products.

Our sample includes 29 papers on QFD. The research methods within the IOM literature were equally distributed among empirical and non-empirical research. The majority of the non-empirical research has a notable preference for simulations models (12 papers). These results differ from that of QFD which was studied in the MA literature (4 papers). Whereas those papers were published among two journals not entirely exclusive of accounting literature (namely, *Decision Science* and *Management Sciences)*, we can infer that the MA literature has a lack of research on this method while the literature such as innovation and operations management has the lead. Appendix B, Table 3 provides a detailed overview of the papers addressing QFD.

We found a lot of research based on simulations and oriented to test QFD within a "Fuzzy theory" framework (Bai & Kwong, 2003). In general, Fuzzy QFD can be seen as an optimisation approach to support the decision making and overcome issues of engineering uncertainty (i.e., imprecise product requirements data) within QFD in early design stages. These fuzzy based models are capable of generating a set of alternative solutions depending not only on the different design scenarios and engineering requirements (Chaudhuri & Bhattacharyya, 2009; Fung et al., 2002; Karsak, 2004), but also on taking constraints such as NPD costs e.g., design requirements (Chen & Ngai, 2008; Chen et al., 2005; Vanegas & Labib, 2001; Iranmanesh & Thomson, 2008; Ji et al., 2014; Lee et al., 2010). Within the IOM literature a lot of research based on simulations was designed to integrate QFD into another cost management method such as target costing (3), life-cycle costing (2) and DFM/DFA/DFX (4). Thus, the interactions between different functions can be enhanced by combining target costing with QFD to achieve the common goal of fulfiling customer requirements (Hoque et al. 2005). Finally, QFD based models may hedge multiple aspects of the product design when applying diverse variations of DFX (Brad, 2009).

Moreover, Hoyle and Chen (2009) consider that QFD's main objective is to fulfil customers' requirements but it lacks costs considerations and therefore they propose an analytical model to replace QFD. This design tool's main objective was to improve profits and lower unit costs by incorporating the estimates of manufacturing costs into the development process. Practical applications of QFD with a linear programming strategy (Delice & Güngör, 2011) and fuzzy numbers (Delice & Güngör, 2013) deliver the best solution for product design. Such models determine the values of design requirements for product development in uncertain environments. This enables the design team to effectively compare product design alternatives in terms of value and cost.

We found a case-study using the QFD approach to deploy flexibility related customer needs into manufacturing system features (Olhager & West, 2002) and to integrate eco-design decision making (IEDM) methodology (Romli et al., 2014). Through the application of the later concept, environmental friendlier and also more economically beneficial products can be designed. Moreover, the integration of life-cycle costing would broaden such models to encompass environmental and cost requirements throughout the entire product development process (Zhang, 1999). Through a mathematical model, Wasserman (1993) emphasises the need to consider costs when applying QFD to improve designer's decisions and the assignment of resources. He also provides a framework for product feature selection to maximise customer satisfaction subject to costs. QFD may as well be customised into a "Green-QFD" to integrate sustainability issues and external costs (such as social consequences during the product's life cycle) into the NPD (Fargnoli et al., 2013). For example, Bovea and Wang (2007) present a novel redesign approach that allows integrating environmental requirements into product development. They apply this approach in the case of office furniture products. Results showed competitive advantages when QFD is combined with LCC and some other methods; it was learned that for this particular case 50% of the customers were willing to pay 14% more on the sales price for an environmentally friendlier product.

It was proved that the adoption of QDF as a NPD practice has a positive and significant effect on project level performance which in turn may lead to market success (Heim et al., 2012). Ittner and Larcker (1997) studied the computer industry to provide empirical evidence that tools such as QDF interact with accelerated product development, leading to performance improvement in terms of return on sales (ROS) and return on assets (ROA). However, in this study, QFD is not assessed individually i.e. as a focal method. Thus, this effect cannot be entirely attributed to the application of QFD but to its combination to the methods: design of experiments (DOE) as well as failure mode and effects analysis (FMEA). Contradictory results regarding cost management advantages also arise. For instance, Griffin (1992, pp. 178–179) remarks that only about one quarter of the projects observed in her study were successful in the sense of product or process improvements, increased sales or lower product costs. Furthermore, Trygg (1993) surveyed Swedish manufacturing companies and only a little more than one half of these reported a positive impact on development cost or lead time (Trygg, 1993, p. 413). The literature review from Lager (2005) also supports the claim that QFD does not promote a reduction on manufacturing costs.

Functional cost analysis

With only 2 papers this is the smaller sample on the addressed method (see Appendix B, Table 4). Compared to the review of the MA literature, the results are not surprising as also only 2 papers were retrieved. This small sample prohibits a clustering analysis or statements toward a possible distribution.

Firstly, we have a non-empirical research based on simulations. Yoshikawa et al. (1994) provided a set of guidelines in his research with the aid of numerical examples for the application of FCA in different manufacturing areas. It is also concluded that FCA is not just limited to products but is also applicable to overhead services and business processes.

Secondly, Roy et al. (2008) used functional cost analysis (FCA) as a basis to propose a cost estimation methodology. This framework is applied at the design stage for a fast cost estimation of future products, whereas the availability of data needed was described as a relevant factor for cost estimation. Three case-studies revealed an increase of interaction between commercial and engineering cost estimators. Further results also indicate reduction on time estimation. The author claimed that FCA is only applicable for simple products or individual components of more complex products.

Kaizen costing

Kaizen costing links the concept of continuous, incremental improvement to cost management. The Japanese term "Kaizen" refers to "improvement" or "betterment" and implies improvements of any kind. In a management context, "Kaizen" corresponds to constant and gradual efforts to improve the working standard of manufacturing and business processes, for instance through the reduction of waste (e.g., defects, over-production, inventory, etc.). Hence, in contrast to major innovation or substantial investment in material assets or technology, Kaizen aims for simple improvements which are quick and easy to implement, at low cost, involving everybody within a company (Imai, 2012). In manufacturing plants Kaizen costing is geared toward the reduction of variable costs, particularly direct and labour costs, whereas in indirect departments, such as R&D, fixed cost reduction is sought (Monden & Hamada, 1991).

The research on Kaizen costing within the selected journals from the IOM literature is remarkably weak. We obtained 3 papers (seeAppendix B, Table 5). Two papers addressed empirical studies through observations and one conducted a survey. The results are highly different to the MA literature (11 papers found). However, this "difference" was expected due to the nature of this method and its common use in cost management. Within the sample, Kaizen costing was not the "direct" research focus. Rather, it is described as a component of a Japanese cost accounting approach. Although target costing, value engineering and Kaizen costing are all labelled Japanese cost management methods, one difference between these has been clearly emphasised: while value engineering aims for cost reduction for new products, Kaizen costing concerns itself with cost reduction products in the manufacturing phase. Further information on Rabino's (2001) survey is provided in seeAppendix B, Table 5. Empirical research based on observations proposes to combine Kaizen costing with target costing (Cooper & Slagmuider, 2004), value engineering and QFD (Zengin & Ada, 2010) to achieve sustainable cost reductions.

Life cycle costing

Life-cycle costing (LCC) provides a framework for cost analysis while tracking the costs attributable to a product or service throughout its entire life-cycle. It is used for "specifying the estimated total incremental cost of developing, producing, using, and retiring a particular item" (Asiedu & Gu, 1998, p. 883). Hence, life-cycle costing sets itself apart from other cost management methods used in product development due to its very encompassing scope such as upstream activities like technology evaluation and research or subsequent activities like product support, maintenance, repair, upgrades or disposal are further reflected in the cost figures (Goh, Newnes, Mileham, McMahon, & Saravi, 2010).

The 19 papers of our sample are almost equally distributed among empirical and non-empirical research (see Appendix B, Table 6). The distribution of the papers among the journals in which they were published indicates a distinction in *IEEE Transactions on Engineering Management* and *International Journal of Production Research* where half of the papers were published. Moreover, there are slight accumulations of papers which rely on archival data (21%), analytical assessments (21%) and simulations (26%). Interestingly, the research on life-cycle costing in a product development context is notable similar for both the IOM literature and in the MA literature (19 vs. 14 papers found).

While the theoretical research addresses the topics such as the role of engineering uncertainty (Goh et al., 2010), environmental issues linked to the car industry (Mildenberger & Khare, 2000) and how to deal with these when applying LCC, the analytical research focus on testing several approaches that provide the best alternatives of product design by estimating life-cycle costs (Riggs & Jones, 1990) or trying out influential factors such as external failure costs (Hegde, 1994) and fuzzy theory (Usher & Whitfield, 1993). For example, Hatch and Badinelli (1999) introduce a model-based approach to coordinate concurrent engineering and to support decision making among cross-functional design team members. In this regard, the main objective is to minimize life-cycle costs as well as total costs of ownership while seeking a solid level of product availability.

Furthermore, research based on simulations was also found. For example, Kleyner and Sandborn (2008) create different scenarios through a Monte Carlo simulation to find the ideal trade-off with regard to the relationship between the reliability of a product and its life-cycle cost. Findings indicate that the regularly requested 99% in reliability may be not the optimum amount concerning the life-cycle cost. Moreover, Quariguasi Frota Neto et al. (2010) investigated the sustainability of closed loop supply chains (CLSCs) through a fictional case-study. The paper addresses life-cycle costing as a method to manage costs and life-cycle assessment to get an overview of the environmental impacts within their model for sustainable CLSCs. The model can be used for the development of sustainable products. Appendix B, Table 6 presents more detail information of simulations combing

LCC with other cost management methods such as "Design for X" (Grote et al., 2007), and "Quality function deployment" (Zhang, 1999).

Many papers provided models which employ the life-cycle costing methodology specially to support decision making in the fields of innovation, such as the evaluation of disruptive vs. sustaining technologies (Dutta & Lawson, 2008) and research and product development such as out-sourcing of R&D (Tubig & Abetti, 1990) and targeted production volume (Folgado et al. 2010). Goffin (2000) is another example of research addressing LCC in a R&D context. He emphasised the importance of the life-cycle perspective if take-back legislation is imposed on manufacturers. The author finally proposed to incorporate aspects of product support early in the design stage for achieving cost savings.

Moreover, we found research claiming that LCC also considers environmental and ecological aspects (Elimam & Dodin, 1994; M.R. Johnson & Wang, 2008), such as customer satisfaction and environmental impact through re-use, recycling or re-manufacture of products as an alternative to their disposal (Mangun & Thurston, 2002).

Total cost of ownership

Total cost of ownership (TCO) is a cost management method closely related to life-cycle costing used to support cost estimation of an investment or purchase. TCO is frequently used in purchasing activities (Ellram, 1995) as it allows an encompassing assessment of the value and costs associated with the investment or purchase that may arise during the product's life-time. Typical costs considered include purchasing cost, running expenses and costs for repair and maintenance. Therefore, TCO provides a better opportunity to assess the "real" costs of a product instead of just the buying price/purchase offer.

The sample finally includes only 6 papers on TCO. Four papers pursue an empirical research approach and two remain on a theoretical level. Three papers address TCO in combination with other methods, which are life-cycle costing, target costing and design for X. The papers are described in detail in Appendix B, Table 7. Surprisingly, the same amount of papers was found in the MA literature (6 papers) despite the fact that the sample was less than the half (113 vs 208). This highlights a lack of research on TCO for both types of literature within a framework of new product development.

The research method is very balanced in both cases. Research based on simulations proved how TCO would improved company's performance (Heilala et al. 2006). For example, Sohn and Kim (2011) employed a cost of ownership model to determine a quantification of the expected benefits and costs of joint standardisation of correlated technologies.

Furthermore, empirical research on TCO focuses on how this method may be used to evaluate product support requirements within the design stage. For example, Goffin (1998, 2000) addressed product support during the design stage (design for supportability). He found that 45% of the companies surveyed would consider TCO in their product support planning, and about the same percentage of respondents confirmed that quantitative goals for this product support figure were consider at the design stage (Goffin, 1998). In addition, the survey is complemented by a case study at Hewlett-Packard's medical and healthcare division, which provided evidence that ensuring the easy "upgradeability" of a medical device already at its design stage would lower total costs of ownership for hospitals. Goffin (2000) confirms the necessity for "design for supportability" and the importance of considering lifetime costs instead of only development and production costs. However, Wouters et al. 2009 remark that although TCO is beneficial in principle, it is very difficult to apply during the design process due to the large amount of data needed and the fact that it is time consuming.

Stage-gate reviews

Stage-gate reviews, systems or processes provide a common engineering model according to which a product development process can be organised. As a conceptual and operational management tool it is intended to structure the process of a new product from the idea to the final product's launch with the main objective of increasing both its effectiveness and efficiency (R. G. Cooper & Kleinschmidt, 1991).

In total 24 papers were selected from the IOM literature. This abundancy of papers suggests that stage-gate systems are widely known and satisfactorily represented. This highly contrasts the poor results when looking at the MA literature (6 papers found). Moreover, from the IOM literature a vast majority of papers (92%) were based on empirical research approaches with survey data as the most used, and only two being of a theoretical nature. This was expected because formal stage-gate systems have their roots in practice, stemming from new product processes at leading companies (R. G. Cooper & Kleinschmidt, 1991; R. G. Cooper, 1988, 1990). The predominance of empirical papers is also reflected in the distribution among the different journals, as about two thirds of the incorporated sample of papers on stage-gate processes were published in the *Journal of Product Innovation Management* and *Research-Technology-Management*. Despite the vast research from the late 80´s/early 90´s (see, for example, R. G. Cooper, 1988) this method did not receive increasing consideration in research until the late 90´s, which can be seen by the quantity of publications gathered for this IOM literature review. More extensive information about the results on stage-gate systems in relation to costs is available inAppendix B, Table 8.

Within a theoretical framework stage-gates reviews was also related to the field of management accounting. For example, Boardman and Clegg (2001) propose the integration of the stage-gates approach with the balance scorecard to achieve the company's strategic objectives. Moreover, F.P. Boer (2003) draws a model on theoretical bases to evaluate projects in stage-gates management systems by adjusting for risk and applying discounted cash flow, decision trees and real option models.

A considerable number of papers within the sample assessed the impact of stage-gate systems on company performance. Relying on the results of a case study among five companies which have implemented a stage-gate process, R. G. Cooper and Kleinschmidt (1991) reported improved performance results in terms of product success rates and customer satisfaction, as well as the compliance of cost, time and quality objectives (Boardman & Clegg, 2001; Kumar & Wellbrock, 2009).

Furthermore, a positive influence on financial performance is confirmed with a significant relationship between a high-quality new product process and profitability (R. G. Cooper & Kleinschmidt, 2007; Ozer & Cebeci, 2010). Chai, Wang, Song, Halman, and Brombacher (2012) provide empirical evidence that a formal product development process makes a considerable contribution to improving the development cycle time, yet it is limited to influencing cost efficiency. However, Ettlie and Elsenbach (2007) did not find a significant relationship between the development cost and the use of stage-gate processes. Similar contradictory findings are presented by Kleinschmidt, De Brentani, and Salomo (2007), Schultz, Salomo, De Brentani, and Kleinschmidt (2013) and Harmancioglu, McNally, Calantone, and Durmusoglu (2007). However, research results in this context are often ambiguous and there is no general consent in the selected literature in terms of their performance.

Despite these previous findings, an appreciable amount of literature provides a positive impact of stage-gate systems on development performance. For example, the frequent and successful application of stage-gates in practice suggests that there are more underlying reasons for their implementation (see e.g., R. G. Cooper and Edgett, 2012). A great variety of papers focus on the criteria used to assist managers in their decision making i.e., project evaluation and selection (Baker & Bourne, 2014; Coldrick et al., 2005; R. G. Cooper, 2006, 2013; Hart et al., 2003; Jägle, 1999; Tzokas et al., 2004; Van Oorschot et al. 2013; Walwyn et al., 2002). Many of these decision criteria relied on financial data, estimates and calculations (e.g., project valuation). Some authors emphasise that financial evaluation might impair the quality of decisions or even harm innovation, for instance, through the use of "numerical estimates of expected sales, costs, investment, and profits [which] are likely to be grossly in error" (R. G. Cooper, 2006, p. 29) or through the application of sophisticated financial metrics at the early stages of the process (R. G. Cooper, 2013). Thus, decision criteria and evaluation methods mainly used at gates, especially at the early ones, are critical for choosing the right projects, ensuring a balanced mix between less risky and more venturesome projects and for achieving a high effectiveness of the entire stage-gate system.

Funnels

The notion of a converging "development funnel" or "innovation funnel" has been substantially put forward in the IOM literature through the work of Hayes, Wheelwright and Clark (1988) and Wheelwright and Clark (1992). Such a funnel "provides a graphic structure for thinking about the generation and screening of alternative development options and combining a subset of these into a product concept" (Wheelwright & Clark, 1992, p. 111). The funnel method consists of a process which narrows down the variety of development ideas in a progressive manner. Thus, the development of the funnel ensures that only a worthy selection of options turn into development projects where significant resources are allocated to create marketable products.

The search for papers on "funnels" as a cost management method delivered only 3 papers (all based on empirical research). These papers are described in detail in Appendix B, Table 9. Two of them were published in *Research-Technology-Management* and one on *MIT Sloan Management Review*. The small amount is comparable to the sample retrieved from the MA literature where only one paper was identified. Several of the papers found in early search steps also covered different kinds of funnelling processes, which all helped to gradually select items from a greater quantity e.g., M. J. Cooper and Budd (2007) employ a "sales funnel" to filter the most promising sales opportunities from a field of possible customers. This observation is similar to the results of the MA literature, finding that the 'funnel' metaphor was used in many different ways. Hence, both sets of literatures are comparable in their lack of research regarding the funnels method for cost-management purposes during NPD.

The adoption of the funnels method is in general proposed for cost and time saving (Reitzig, 2011). Within the current results both Mathews (2010) and Mathews (2011) address the funnels method and discuss an innovation portfolio evaluation process implemented at the Boeing research and development division. Rather than structuring and planning product development, the innovation portfolio focused on selecting and maturing project "candidates" for further development according to a funnel-like model. This, with the objective of improving the quality of projects found downstream into the accepted project portfolio. It is not meant to manage project tasks and deliverables or to allocate resources to projects (i.e., project execution) but seeks to deliver a coherent portfolio strategy with a set of concepts, which are selected according to concept value and business strategy criteria. For example, optional methods are employed and the quantitative attributes for concept evaluation are intentionally limited to six, in order to make savings in terms of time and costs for the analysis. Beyond that, Mathews (2010, 2011) emphasises that the innovation portfolio process at Boeing does not employ go/kill decision points as stage-gate-type systems do, but that it is rather characterised through phases where information is progressively gathered.

Design for manufacturing / design for assembly

Design for manufacturing and assembly are widely identified as methods used to integrate production requirements into their development. This method particularly relies on the notion that decisions which are made during the design phase of a product which may severely affect the product during its entire life-cycle and will determine significant portions of a product's life-cycle costs even long before its launch (Dowlatshahi, 1992). Hence, manufacturability requirements and guidelines need to be considered and be carefully evaluated in the product's design phase. Thus, the products may be designed "in such a way as to reduce the total cost of production and assembly to a minimum" (Trygg, 1993, p. 412).

Appendix B, Table 10 shows the 21 papers addressing DFM/A. This method was studied in average on both literatures (i.e., within the MA; 8 / 9.9 and in the IOM literature; 21 / 18.3). However, when looking at the MA literature, 7 out of 8 papers on DFM were published among two journals, which are not entirely exclusive of accounting literature, namely, *Decision Science* and *Management Sciences*. Hence, we can infer that while the IOM literature has the lead, the MA literature lacks research on this method. The vast majority of papers (76%) in this review (IOM) pursue an empirical research approach, of which most are based on survey data. This is consistent with the MA literature, where the retrieved papers on DFM are entirely based on empirical research. A great number of publications were published in *International Journal of Production Research*.

Few papers addressing DFM are based on non-empirical research. Three papers relied on multi-criteria model simulation to, for example, establish a methodology for facilitating the integration of these designs into early stages of product development (Curran et al., 2007) and dentify product realisation opportunities for cost reduction (Das & Kanchanapiboon, 2011; Madan et al.,2007). Taylor (1997) introduces an analytical model for global manufacturing and assembly (DFGMA) applied within a global production network during the design phase of the product. This tool supports decision-making on product sourcing, capacity management and capital procurement planning. Further empirical research claimed positive results from using this model. For example, Liker et al. (1999) worked with design-manufacturing system integration (DMSI), a methodology which combines DFM and flexible manufacturing. Results show a strong, positive effect on manufacturing time and costs. Moreover, Rusinko (1999) comprises the use and applicability of manufacturing guidelines and claim this to be positively associated with effective NPD.

Most of the papers empirically report a positive effect of DFM on cost and time, mainly in relation to manufacturing (Chan & Lewis, 2000; Lu & Wood, 2006; Sik Oh, O'Grady & Young, 1995). For example, M. Boer and Logendran (1999) address the essential notions of DFM as a methodology and provide evidence that shows that increasing the number of parts is related to cost increases and increasing the number of assembly processes is related to both time and costs. This is also supported by Heim et al. (2012), who claim that NPD practices such as DFM are positively associated with time-to-market, product performance quality, conformance quality, responsiveness, and cost control. However, Kessler (2000) indicates that DFM does not necessarily lead to a decreased development cost in a large company.

Lastly, DFM was applied jointly with methods such as total cost of ownership (Goffin, 1998; 2000), QFD (Trygg, 1993) and modular design (S. Ray & Ray, 2011) to improve NPD processes.

Design for X

The concepts design for X, design for excellence or simply DFX describe sets of guidelines which provide possible ways to consider particular requirements, goals and constraints of downstream operations during early stages of product design, with the overall objectives being to improve cost-effectiveness, decrease time-to-market and enhance quality in the respective context (Gatenby & Foo, 1990; Kaski & Heikkila, 2002; Kuo, Huang, & Zhang, 2001). The "X" in DFX can be substituted by several qualities, abilities or life-cycle phases which may impose limiting frameworks and directions onto product design. For instance, design for logistics, for serviceability, for environment and design to costs are well known DFX-methods.

In the review of MA literature, we mention that "design for X is well known in the product development literature. Indeed, we found a substantial higher result in the sample from IOM compared to the MA literature (17 papers vs. 1). The 17 papers on DFX are described in detail in Appendix B, Table 11. Moreover, It is worth mentioning that the only paper found in the MA literature was published in *Management Science* which cannot be consider purely as accounting literature but more general managerial research. Thus, we can confirm this statement at least with regard to the IOM literature. It is also important to note that the results presented here are limited to some extent as the literature search did not attempts further DFX interpretations which are mentioned above. Consequently, an unknown number of relevant papers might have been overlooked. Within the included papers, about 2/3 are of an empirical nature (11 papers), of which the majority (6 papers) employ a research approach based both on quantitative and qualitative data.

We highlight the simulation model presented by Grote et al. (2007) within the non-empirical research on DFX. This consists of DFX and life-cycle costing elements to emphasise the economic as well as ecological design requirements. A case-study based on a small household item (i.e., electric citrus press) is conducted to look for beneficial outcomes. The results indicate a reduction of CO^2 emissions and on energy costs. This type of orientation on environmental and economic considerations was also studied on an empirical basis (Bevilacqua et al., 2007).

Furthermore, the IOM literature provided methods derived from DFX such as "design for supportability" (Goffin, 1998, 2000), "design to cost" (Loch et al., 1996; S. Ray & Ray, 2011), "design for producibility" (Elgh & Cederfeldt, 2007), "for cost engineering" (Marion & Meyer, 2011), "design for warranty" (Murthy & Blischke, 2000), "design for reuse" (M.R. Johnson & Wang, 1995; Mangun & Thurston, 2002), "design for global manufacturing and assembly" (Taylor, 1997), and design management for sustainability (Fargnoli et al., 2013). Detailed information on these papers and their associated DFX methods is provided in Appendix B, Table 11. These papers all share the various DFX methods focussed on cost reduction in terms of their respective "X". Thus, relying on this set of papers, the cost orientation of this methodology can be confirmed.

Component commonality

The main objective of component commonality is that advanced engineering projects share components designs among corporate departments and organisational units or levels and even among suppliers or between globally-located institutions (Nobelius & Sundgren, 2002). Thus, in this review, we understand component commonality in an encompassing context, which includes the sharing of parts, materials, modules, tools or packaging. Zwerink, Wouters, Hissel and Kerssens-van Drongelen (2007) explicitly distinguish between re-use ("the decision to use again part of the product architecture in subsequent product generations" (p. 53)) and commonality ("the decision to use attributes across product variants in a product family" (p. 53)). Hence, since a notable number of retrieved papers blend in the boundaries between these two methods (e.g., Halman, Hofer, & Van Vuuren, 2003; Ismail, Reid, Mooney, Poolton, & Arokiam, 2007), papers about commonality through re-use are also included in this review.

The research of component commonality on a cost management context is notably higher in comparison to the other methods addressed as well in this review. With 37 papers included, component commonality is the second most investigated method after modular design. Two observations stand out when looking at the results from the MA literature. Firstly, the fact that a small amount of papers was found (14 vs. 37 papers). Secondly, from the sample, 13 out of 14 papers on component commonality were published among two journals which are not entirely exclusive of the accounting literature, namely, *Decision Science* and *Management Sciences*. Hence, we can infer that the MA literature has a lack of research on this method while the literature such as innovation and operations management has the lead. Furthermore, despite the large amount of papers retrieved for this review, most of them are of a non-empirical nature (62%) maybe this is explained by our strict search condition on its application for cost management purposes which show that the empirical research within this field is still growing. Also, it is interestin to note that 50% of the papers pursued their research on component commonality in combination with research on modular design (11) and product platforms (15). This emphasises the close relationship and integration between these three methods. Appendix B, Table 12 provides a detailed overview and provides information on the papers that address component commonality.

A considerable number of papers included in this review deal with the measurement of product structure which often relate to the degree of common components among variants and platforms (e.g., Ismail et al., 2007; Johnson & Kirchain, 2010). For example, employing a cost-modelling approach, Johnson and Kirchain (2010) assessed the correlation between such metrics and cost savings. In their case study, they found that considerable savings (between 29% and 38%) in terms of development and assembly cost are achieved through sharing parts and assembly processes. Moreover, Davila and Wouters (2007) demonstrate that increasing the percentage of generic products had a positive impact on on-time delivery as well as operational cost but not on inventory turns. Indeed, cost reduction potential during product development is the major incentive for engineers to employ common components (Halman et al., 2003). Thus, instead of developing multiple components for different products separately, the objective is to focus on "one" (i.e., fewer) common component to be (re)developed from existing products only. Meyer and Dalal (2002) show that a platform-centric product line with greater re-use lowers average product development costs more effectively than further lines with less extensive re-use. Heese and Swaminathan (2006) disprove the assumption that commonality leads to cost savings and emphasise that the loss of product differentiation leads to less attractive product lines and reduced revenues.

Moreover, the design and development of common components and platforms may be more difficult to pursue and may entail additional costs (Meyer & Mugge, 2001; Nobelius & Sundgren, 2002). This is, for example, due to the fact that common components need to fulfil the requirements and constraints of several products simultaneously and that additional efforts have to be undertaken for their integration. Hence, it may be assumed that a common component with a more general purpose is more expensive due to its complexity. Such a trade-off may, for instance, be analysed with theoretical models. In particular, Eynan and Rosenblatt (1996) apply single-period optimisation models to show that the advisability of a more expensive common component depends on the number of existing components to be replaced. Thus, even if a common component is considerably more expensive than the ones to be replaced, it may be worthwhile using it. Moreover, Zwerink et al. (2007) provide a model for product architecture evaluation to foster communication and knowledge transfer among business functions. This model also considers component commonality.

Although the majority of papers on component commonality imply cost savings in various ways, a general consensus on the cost impact seems not to be prevalent. In conclusion, it becomes evident that the cost impact of component commonality is not overlooked in academic literature.

Modular design

Modular design is a cost management method mainly concerned with internal variety and complexity reduction as well as with the costs of different types of architectures such as manufactured product architectures or software architectures, under the condition of offering external variety and customisation at the same time (Kohlhase & Birkhofer, 1996). Different definitions on modular design were found, which may focus on different aspects in multiple areas of research. In this review, modular design is understood to be a design method which enables the cost effective production of a wide variety of products with a limited set of modules that are adjusted and/or combined with different parts and other modules.

Modular design has received a substantial consideration in the IOM literature. Were found 45 papers on this method, which is far above the average (18.3). Within this set of papers, we observe a balanced research method i.e., empirical vs. non-empirical (51% / 48%) and a predilection for using mix data: quantitative and qualitative (26%), simulations (24%) and analytical models (18%). This quantity differs from the results from the MA literature, where only 20 papers were included (these are mostly empirical). However, as occurred in a few aforementioned methods (e.g., in QFD and component commonality), the majority (13 out of 20) were published among two journals (which are not entirely exclusive of accounting literature) namely, *Decision Science* and *Management Sciences*. Hence, we can infer that the MA literature lacks research on this method while the literature such as innovation and operations management has the lead. Moreover, 75% of the research on modular design analysed in this review has been published during the last 10 years, which indicates that the cost management aspect on this method is a rather young trend that has been gaining popularity in the IOM literature roughly since the turn of the millennium. Further information on the papers on modular design is available in Appendix B, Table 13.

A large amount of research based on simulation and analytical models was found. These models aimed to determine the best configuration of modules based on product structure constraints to minimise total production cost for the product family (Agard & Bassetto, 2013; Chakravarty & Balakrishnan, 2001; He & Kusiak, 1996; Kamrad, Schmidt &Ülkü, 2013; Rai & Allada, 2003). Constraints such as maximum assembly time and the number of functions of a modular unit (Agard & Penz, 2009), common components (Agrawal et al. 2013), collection of returned products (Chang & Yeh, 2013), trade-off related to return and refund policy (Mukhopadhyay & Setoputro, 2005; Chang & Yeh (2013) and volatile market (S.X. Xu, Lu, & Li, 2012).

Modular design is identified as one key factor in enhancing business performance (Huang et al. 2010). Patel and Jayaram (2014) empirically prove Hopp and Xu's (2005) analytical model which states that modularity is a suitable method for more product variety (Patel & Jayaram (2014) as it leads to higher revenues and gains market shares. However, it is also likely to increase operational efforts and hinder differentiation of products. Therefore, advantages and disadvantages must be considered when applying this methodology.

It is also argued that the adoption of modular design as a costing method is an appropriate strategy to rapidly improve markets to keep up with the pace of innovation. Magnusson and Pasche (2014) notice a tendency towards modularisation strategy when the speed of technological change and customer demands is high. The need for a modular architecture increases when customers expect a high degree of customisation. This is due to the fact that modular design involves various interfaces which reduce the costs of coordination when certain elements (i.e. modules of products) are exchanged, customised or additionally incorporated. For instance, companies that reduce the number of physical modules, while decreasing mutual dependency, may achieve reductions on inventory and operating costs (Kaski & Heikkila, 2002). Furthermore, this might explain why several papers discuss product upgrades and updates in combination with modular design (Magnusson & Pasche, 2014; P. K. Ray & Ray, 2010; S. Ray & Ray, 2011).

In a related context modularity is described as an essential element of mass customisation strategies (Ismail et al., 2007; Ro et al., 2007), as it enables cost-effective differentiation and customisation while reducing internal variety. Thus, savings on development costs are achieved through economies of scale due to re-use of internal modules and components (Ismail et al., 2007). Modular design may also give flexibility to the company due to available options for later design changes or features to be included subsequently (Gil, 2009; Jiao, 2012; Jacobs et al., 2007; Wouters et al., 2011) in the case of changing circumstances e.g., market demand for a certain novel product feature arises only after a product's launch. Additional attributes can be optimised when modularising products' architecture early in the concept of development phase such as quality, reliability, manufacturability (Nepal et al., 2005).

However, findings from Lau et al. (2007) and Lau et al. (2010) highlight a point of disagreement in the literature. The authors surveyed the manufacturing industry and although they confirm an impact of modular design on manufacturing capabilities as customer service, flexibility and delivery; a significant impact towards lower cost or better product quality could not be recognised.

Product platforms

Product platforms provide a common technical foundation for a family of products on the basis of constant parameters, features and/or components (Simpson, Maier, & Mistree, 2001). To create distinct products within a product family one or more parameters are defined as variables and may be set individually. Muffatto and Roveda (2000, p. 619) define product platforms as "a set of subsystems and interfaces intentionally planned and developed to form a common structure from which a stream of derivative products can be efficiently developed and produced". Furthermore, principles and methods of modular design are utilised supportively to facilitate the development of product platforms. Commonality is also of great importance in defining a shared base architecture within a product platform. This method can be employed to manage and balance cost savings through shared components, parts and processes against the degree of distinctiveness of products (which may have implications for marketing and sales) (Robertson & Ulrich, 1998). Hence, component commonality, modular design and product platforms are closely related to each other.

As shown in Appendix B, Table 14, 33 papers from our sample focus on product platforms. This amount highly contrasts with the results from the MA literature where only 9 papers were found. Here we discovered that, as in other methods which were also of a more engineering character, the majority of these results were published in *Management Science*. Thus, this reduces even more the retrieved papers from the MA literature. Moreover, we can say that research methods on product platforms within the IOM literature are balanced. Our sample reported about 50% of the research conducted empirically where the preferred research method is based on qualitative and quantitative data. In regard to the non-empirical research, simulations are distinguished. Almost every third paper on product platforms was published in the *International Journal of Production Research*. Moreover, the technical and content-related proximity to modular design and component commonality is substantiated by the fact that 21 out of 33 papers about product platforms also address the aforementioned cost management methods.

We found several papers based on simulations with focus on the designs of cost-efficient platforms (Agrawal et al. 2013; Farrell & Simpson 2010; Zhang et al. 2008; Zhang & Huang 2010) and the optimal number of platforms within a product family (Ben-Arieh et al., 2009; Bhandare & Allada, 2009).

Within the empirical research, we analysed the study from Luo et al. (2011) and Cao et al. (2014) who cover the issue of supplier selection. Luo et al. (2011) focus on the selection of components and suppliers in order to maximise profits, whereas Cao et al. (2014) address outsourcing cost and supply chain risk management. In relation to the reduction of outsourcing cost, Marion et al. (2007) argue that product platforms are not always the best approach to accomplish such goals.

Similarly, the method component commonality depends on the targeted product group. Some fundamental guidelines for the implementation of a platform strategy are given by Muffatto (1999) and Robertson and Ulrich (1998). Furthermore, while Krishnan et al. (1999) present a model which balances the efforts of developing a platform against subsequent benefits, Rai and Allada (2003) suggest a simulation model for the selection of modules for cost efficient platforms. Product platforms are well suited for market environments with a low speed of change including customers needs for cost effective and functional products with a relatively low degree of customisation (Magnusson & Pasche, 2014).

Furthermore, cost reductions through product platforms were confirmed empirically (Sanderson & Uzumeri, 1995; Sundgren, 1999). For example, Moore, Louviere and Verma (1999) conducted a case-study at an electronic company and report economies of scope as benefits of product platforms: “Engineering costs [...] were high enough to be unprofitable when applied to a single product line, but were profitable when shared across multiple products” (p. 36). The extensibility of product platforms, that is the introduction of follow-up products and versions at minor additional cost, is found to be positively related to the platform cost efficiency (Chai et al., 2012; Meyer & Dalal, 2002; Meyer & Mugge, 2001). Hence, higher initial costs for product platform development may be compensated by inexpensive derivative products, resulting in lower average development cost compared to products which are not based on a platform.

The theoretical model proposed by John et al. (1999) aligns a platform according to the high-end of the market, thus including as many features as necessary. Derivative products for lower-end segments could then be introduced simply and inexpensively through the omission of features. However, this model was challenged by Nobelius and Sundgren (2002). They conducted three case-studies where parts could not be carried over from the most expensive model to lower variants, since they were too expensive to be in accordance with the cost strategy of these variants. Jiao (2012) also contends that such a flexible product platform may not always be the optimal solution. Results suggest that the financial performance of flexible platforms improves with an increasing uncertainty in the market, even though a flexible configuration may entail significant costs. In case of “less” uncertain market demand and low variety requirements, flexible platforms are outperformed by inexpensive, less flexible ones. This is in line with findings of the MA literature, suggesting that an extensive reuse of platform components and a reduced differentiation of platforms might have a negative impact on the profits of firms and may hinder innovation. Presumably this is due to a lack of focus on customer satisfaction (Hauser, 2001).

In a similar context, Kang, Hong, and Huh (2012) concern themselves with platform replacement planning and provide numerical analyses to determine the optimal lifetime of platforms based on annual platform profit maximisation. The results of this analysis indicated that companies employing cost management methods like product platforms, whose application in some way becomes apparent to customers, must not address costs in an isolated manner, but should consider possible implications on marketing, sales and profits as well.

Technology roadmaps

Technology roadmaps find an increasing recognition in research and management fields. These roadmaps denote a set of different paths or routes to reach future objectives. Technology roadmaps are frequently used to provide a time-oriented plan for the future development of products. These illustrate how product requirements and specifications related to future technology. Hence, instead of only setting the objective, technology roadmaps rather serve to break an objective down into more viable parts, providing a way to ensure that technologies are available at certain points in the future when needed for product development. In this review, we can distinguish two kinds of technology roadmaps: the corporate technology roadmaps, which are developed and used within a company and the industry technology roadmaps, which are developed and used by associations and companies affiliated to a distinct industry.

7 papers on technology roadmaps were included in detail (see Appendix B, Table 15). Four papers followed a theoretical approach and three an empirical one. Thus, we find this sample surprisingly small, considering the source of literature and the considerably large search conducted. The MA literature provided us with 5 papers on this method, which is also a small sample. This suggests that technology roadmapping may not be directly related to cost management.

Moreover, within the selected journals, research on technology roadmaps has only been available since the early 2000s, this applies for both the set of paper analysed in detail and the ones classified into categories. Papers published before the year 2000 were not retrieved. Simonse, Hultink, and Buijs (2014, p. 3) addressed this issue by listing the key contributions to the literature on roadmapping with a notable accumulation of papers published between 2001 and 2010. Hence, technology roadmaps are rather recent management tools which have found notable consideration in recent research.

Research based on a theoretical model had a common characteristic of focusing on implementational issues, such as cost of data management (Choi et al. 2013; Kostoff & Schaller, 2001) and its benefits in the form of cost savings (Lee et al. 2008; Simonse et al. 2014).

Within the empirical research Albright and Kappel (2003) focus on the deployment of product-technology roadmaps in practice and share practitioner-oriented experiences. They recommend including a temporal breakdown of costs of goods in contrast to the forecasted costs with target costs. Hence, this indicates that the use of target costing may change the product configuration and performance. Moreover, this method allows NPD teams to compare their roadmaps with the competitors' roadmaps and finally to assess a product's performance costs (Sarangee, Woolley, Schmidt, & Long, 2014). Further advantages promoted by technology roadmaps are the improvement of communication (i.e., decision-making) among NPD related parties (Pardue et al., 1999).

4.3 Conclusions

This chapter provides a review of the IOM literature in which the main focus was 15 different methods for cost management (see Table 1, Chapter 2) within a NPD context. We reviewed 23 different journals of the aforementioned corresponding literature.

The search process identified 208 unique papers with 275 results, whereby one paper could be included multiple times if it referred to several of the cost management methods. We found results in 20 of the 23 journals selected. Four journals have the largest number of results, namely, *IJPR*, *JPIM*, *IJPE*, and *IEEE-EM*. This top-4 accounts for 63 % of all results. The purpose of this review was to compare results for the IOM literature with the results obtained from the MA literature (see previous Chapter 3). Within IOM, three cost management methods clearly receive most results: modular design, component commonality and product platforms, together 42% of all results while the same group of methods only represents a 29% of the results in the MA literature. Of which, target costing was by far the mostly researched cost management method (26%). It is also interesting to observe that the emphasis on research methods is quite different: simulation is the most frequently used method in the IOM literature, but it was averagely used in the MA literature; qualitative study was the most frequently used method in the MA literature, but it is averagely used in the IOM literature.

Furthermore, we found many papers that actually focused on at least one of the 15 management accounting methods, but did not correspond to the current literature review. This was because a paper lacked emphasis on the application of the management accounting method for the purpose of cost management and/or it did not consider the context of NPD. We clustered these papers into 12 categories (listed in Table 5, Chapter 2) to provide an impression of the research conducted around cost management methods in the IOM literature. This was a substantial amount of research, looking at a broad range of issues concerning management accounting topics which may provide researchers of this field with further opportunities for drawing upon relevant research and perhaps a contribution to research outside accounting. Additionally, the large amount of papers found on these methods within the IOM literature albeit with a different emphasis than cost management in NPD. This shows a significant difference between the IOM and MA literature. It suggests the IOM literature has looked at a wide range of issues around these cost management methods, which we would also regard as management accounting.

We found a large amount of papers characteristics of the IOM literature which presented practical approaches on decision making models for the further development of a particular cost management method. This is a marked difference from the MA literature. For example, different stages for target costing are described, target costing is combined with QFD, fuzzy logic is used to extend QFD approaches, cost estimation methods for life-cycle costing and TCO are developed, managerial and pragmatic studies suggest how to implement stage-gate systems, DFA/M guidelines for reducing costs are extended and models for trade-offs around component commonality and modular are presented. Some of these studies provide empirical support by implementing their proposed approach or decision model in a case study without making it a real field experiment. Many studies rely on numerical simulation, analysis of mathematical models or only conceptual argumentation as support for these approaches or decision models. Compared to the sample of studies presented in the MA literature, this sample of the IOM literature pays more attention to the development of methods with the aim of supporting their practical application—with an “engineering” flavor. There are also many studies looking at these methods as phenomena in organisations using surveys and case studies, but such research focused at "explaining" is not as predominant as it was in the MA literature.

Future research could also provide in-depth descriptions of innovative cost management practices. Many companies in the car industry, consumer electronics, semiconductors, medical devices, drug development, or the aerospace industry spend vast amount of Dollars or Euros every year on new product development. Therefore, "simply" documenting and analysing inspiring examples of innovative management practices could also constitute valuable contributions to the literature. Although these practices may not work everywhere and may not necessarily classify as "best practices," they can provide useful inspiration for both researchers and practitioners.

Moreover, we found a lack on research on the actual use of the various cost management methods. Although the review of the IOM and MA literature identified various survey-based studies on the adoption of specific cost management methods during NPD, we are not aware of studies that investigated a whole range of different methods in supporting the management of costs in the development stage. The present literature review shows that such methods are often studied in combination and it seems likely that these would also be adopted in combination but we lack empirical evidence.

Therefore, the strength of the current study lies in the empirical evidence of the combination of cost management methods used during NPD. The next parts of this doctoral thesis refer to the conducted empirical research which also investigates the adoption of certain cost management methods in relation to the organisation's strategic orientation and its managerial approach with regard to collaborative competences.

5 An empirical study of the adoption of cost management methods for NPD

5.1 Introduction

In the literature review (previous chapters 3 and 4), we focused on 15 different methods for cost management during new product development. Prior research in this field has addressed several areas of interest in management accounting. These include the settings needed to successfully adopt cost management practices (Al Chen et al., 1997; Eatock, Dixon, & Young, 2009; Guilding et al., 2000; P. Joshi, 2001; Wijewardena & De Zoysa, 1999; Yalcin, 2012; Yazdifar & Askarany, 2012), for example, the users' characteristics and input data in applying certain methods (Binder, Gust, & Clegg, 2008; Lawson et al., 2009; Mishra & Shah, 2009; Narasimhan & Kim, 2002; Petersen et al., 2003; Schiele, 2010; Terjesen et al., 2012), the company profile (Ax et al., 2008; Dunk, 2004; P. Joshi, Bremser, Deshmukh, & Kumar, 2011; Tu et al., 2004; Yazdifar & Askarany, 2012) and strategic objectives (Boyer & Lewis, 2002; Boyer & Pagell, 2000; Duh, Xiao, & Chow, 2009; Swink, Narasimhan, & Wang, 2007). However, most of these studies do not explain in detail the company's reasons for the adoption of certain methods.

This chapter presents the arguments that lead to the development of our hypotheses on the use of cost management methods in the German manufacturing industry. We searched for survey-based research addressing the listed 15 cost management methods to reinforce our knowledge on the adoption of cost management methods (see Table 1, Chapter 2) and to support the development of our research method. The purpose of this literature review was two-fold. We needed to identify the existing survey-based research on the adoption of these various methods to understand the potential contribution of the present study as well as the relevant research that serve to build on our measurement instrument.

Later on this chapter introduces eight hypotheses on the adoption of cost management methods in a new product development context. Hence, the present study contributes to the literature by examining the use and helpfulness of these methods and explaining their use on the basis of six factors, the first three of which relate to the company's *strategic priorities* including cost leadership, quality leadership and flexibility. This is followed by three factors concerning collaborative competences consisting of cross-functional, supplier and customer integration.

5.2 Review of survey-based studies on the adoption cost management methods

There is no doubt that cost management methods such as target costing and Kaizen costing have been practiced by the industry over the last couple of decades. However, we learned from our literature review (Chapters 3 and 4) that there is little empirical knowledge about the adoption of these cost management methods for new product development. Hence, to support our research method, we were interested in finding further survey-based research around cost management practices. For this complementary search[9] we used Google Scholar, and regardless of the journal source, we applied as search criteria the key words: "survey" and "questionnaire" within the year of publication from 1990 to 2013. This search was conducted repetitively for each one of the 15 cost management methods (see Table 1, Chapter 2). As a result, we selected[10] 35 papers that serve to better position our investigation within a management accounting perspective.

Figure 1 shows the distribution of the survey-based research in relation to our set of cost management methods. We can observe that such type of research is unbalanced among these methods. Thus, while methods such as funnels and component commonality have not been studied through a survey-based research at all, three of our 15 methods represent together 53% of the collected research (target costing - 33%, quality function deployment - 10% and modular design - 10%). Moreover, the ten remaining methods were addressed in very few survey-based studies. Hence, in regard to empirical evidence based on large samples, there is still much to be done to understand how the companies operate to foster their performance.

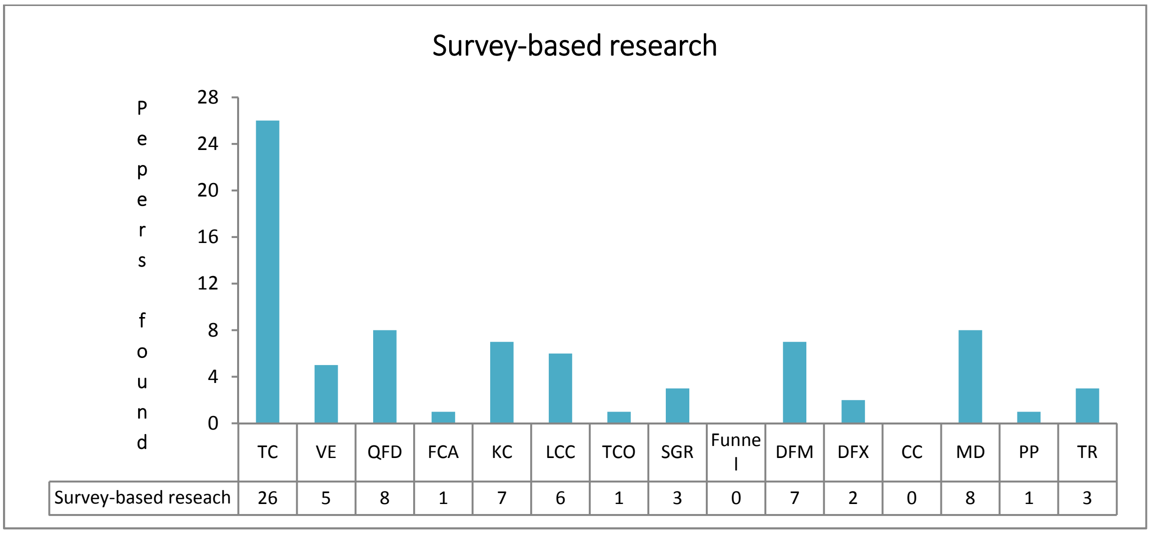


Figure 1: Survey-based research addressing 15 cost management methods (period of publication from 1990 to 2013). Please refer to the list of abbreviations.

[9] This search was not limited neither to particular set of journals nor to the context of NPD.
[10] This selection was not as systematic as the research method used for the literature review presented in Chapter 2. Rather, the selection of paper was based on our own judgment. Thus, after reading about a hundred papers, we finalize the search with a sample of 35 papers.

5.2.1 Review of survey-based studies: research context

We could highlight three meaningful research contexts based on the review of the survey-based studies (see Appendix C) and observed that research is centred on either cost management (CM) context, new product development (NPD) context, or on a combination of both (CM-NPD). We classified the papers that examined methods that manage costs incurred at the organisation under the research context "cost management (CM)". This could be used during manufacturing and further functional areas. Al Chen et al. (1997) for example, did not address a specific application of such practices for new product development. They rather approach a strategic cost management through the investigation of the use of cost management practices by U.S. based Japanese subsidiaries. Therefore, the research context of this paper is classified as purely "cost management".

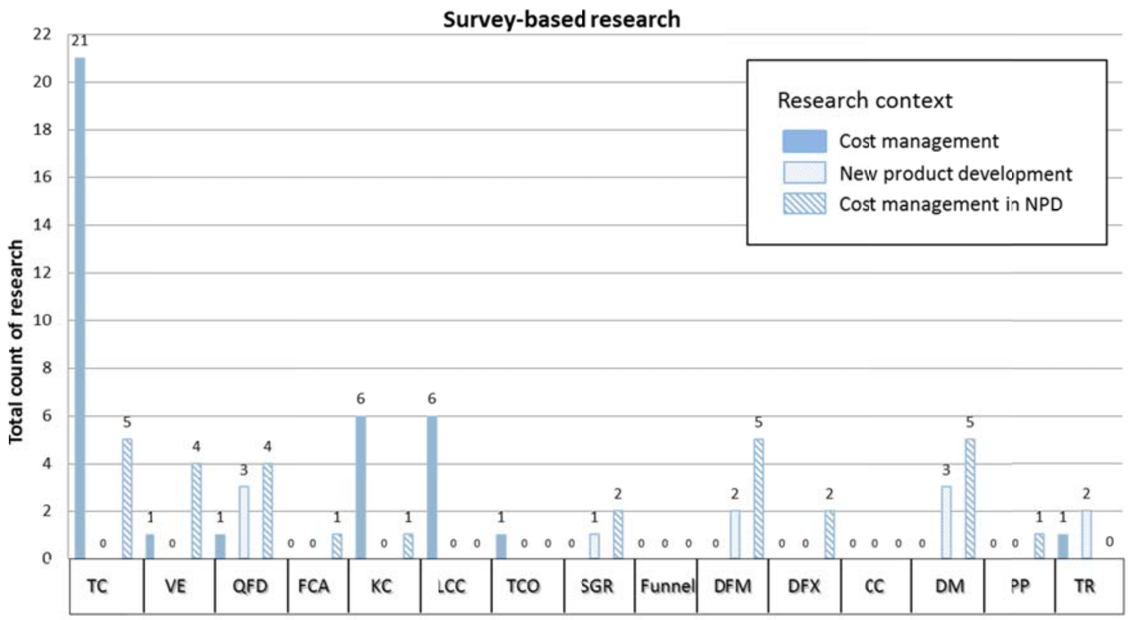


Figure 2: Overview of studies on the adoption of cost management methods and their research context. Please refer to the list of abbreviations.

We also found papers which examine cost management methods explicitly for its use in new product development processes. However, these methods are not used for cost management purposes per se. For example, the research on methods such as quality function deployment (Miranda González & Banegil Palacios, 2002; Swink, 2003) and technology roadmaps (S. N. C. Chai, Sun, & Lau, 2010; Holmes & Ferrill, 2005) show their adoption primarily being to provide guidelines to launch new products successfully. Hence, the new product development (NPD) context can be highlighted.

Finally, few papers combined the previously mentioned research contexts (CM-NPD), i.e. research where the methods were used to manage costs especially within product development stages. Examples of this type of research on target costing include Afonso et al (Afonso et al., 2008), Ax et al. (2008) and Baines and Langfield-Smith (2003).

Figure 2 illustrates the distribution of papers[11] in regard to their research context. The most counted research related to a purely cost management context (47%) where the most addressed methods are target costing followed by Kaizen costing and life cycle costing. Research centred on new product development context (14%) has also its most popular methods, such as quality function development and modular design. Research on cost management in product development (38%), has most often looked at target costing, design for manufacturing, and modular design. Hence, interesting is that although target costing one of many methods, has certainly been the most studied method by far. Thus, in relation to the other 14 methods, there is a clear imbalance. Perhaps the broad application of target costing explains its popularity for cost management.

The previous review of survey-based studies provided us with a comprehensive overview of the existing literature addressing cost management practices in such manner. In general, academic literature has focused on these methods within different contexts over the last few decades. Research on cost management methods is still a relevant and an attractive topic for academics and practitioners. However, research is scattered among the aforementioned contexts and there is still much to prove empirically about its adoption in practice. Therefore, a relevant research question would be about the ability to offer an explanation for adopting these methods to support new product development processes.

5.2.1.1 Review of survey-based studies: conceptualisation of the adoption

Within the research on cost management methods, the concept of "adoption" can be interpreted differently. Thus, after analysing previous survey-based studies we identified six different conceptualisations of adoption. There are "implementation", "use of", "relevance", "experience", "effectiveness" and "perceived benefits" (see Table 10 for the description of concepts). This research provides a broad and interesting conceptualisation of "adoption" (summaries of these papers can be found in Appendix C). For example, while Dunk et al. (2004) dedicated his research to prove how different factors influence the use of product life cycle cost analysis, Ax et al. (2008) studied the adoption of several cost management practices under a competitive and uncertain environment. Hence, we classify both papers under the concept "use of" (see Appendix C).

Furthermore, each research paper may investigate different aspects of one or more cost management practices. For example, the research of Chenhall and Langfield-Smith (1998a) had three different purposes. These were (a) to examine if companies were using target costing, (b) if there were perceived benefits and finally (c) the degree of relevance of such practices for the business unit. Therefore, this investigation is classified under three concepts, namely, "use of", "perceived benefits" and "relevance".

[11] This chart contains 35 papers; however, if the paper addresses more than one method, it is included more the once in the count of the table. This explains why the total number of references is 78.

Table 10: Conceptualisation of adoption among survey-based research.

Conceptualisation of adoption	Description of the concept
1. Implementation	The research addresses the process efficiency of introducing certain cost management methods which are new to the organisation.
2. Use of	The research measures the extent to which the organisation adopt cost management methods. Since the methods may be called differently, studies may focus on different characteristics to examine such adoption.
3. Relevance	The research focus on the level of engagement from top managers in using cost management methods and to which extent they foster its execution.
4. Experience	The research measures the skills and abilities of employees in relation to the used method i.e., how well prepared are employees to apply particular method.
5. Effectiveness	The research focuses on the method's performance i.e. how reliable and useful certain methods are for achieving the company goals. Most research of this type relies only on the employee's perception.
6. Perceived benefits	The research directly measure specific benefits gathered from practising certain methods (i.e., consequences). These could be financial or non-financial.

Figure 3 illustrates distributions of the six concepts of adoption. This chart shows a high percentage on research on the concept "use of" (56%). Thus, we look in detail at each papers and most of these are simply explorative with no explanation of such adoption in practice (Afonso et al., 2008; Ahmad, Schroeder, & Mallick, 2010; Guilding et al., 2000; J.-Y. Kim, Wong, & Eng, 2005; Miranda González & Banegil Palacios, 2002; Salvador & Villena, 2013; Swink, 2003; Terjesen et al., 2012; Yeh, Pai, & Yang, 2010). This lack of explanatory variables reflects a gap in the literature.

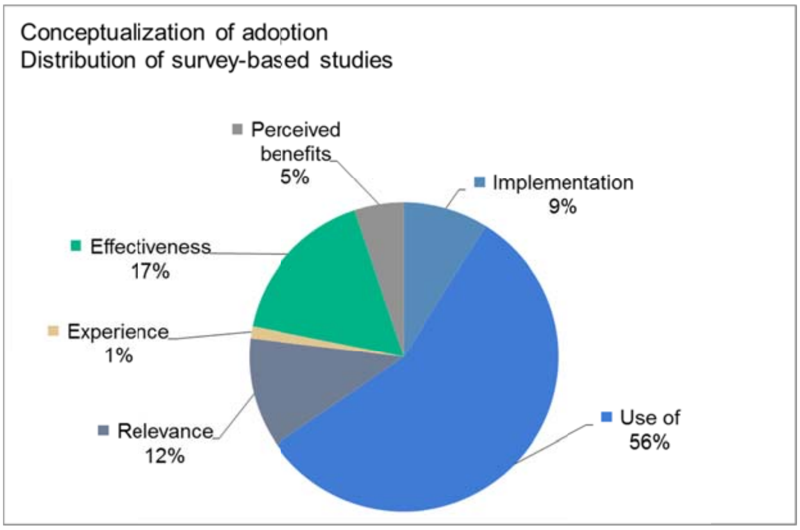


Figure 3: Distribution of research based on their research focus.

Furthermore, we find substantial research on cost management practices limited to identify which methods are used accordingly to the company demographics (Al Chen et al., 1997; Chenhall & Langfield-Smith, 1998a; Duh et al., 2009; Eatock et al., 2009; P. Joshi, 2001; J. Wu et al., 2007; Yalcin, 2012; Yazdifar & Askarany, 2012). Such research describes circumstances in which these cost management practices are used (e.g. firm's size, location, revenues). However, it does not consider further reasons for applying such methods, which may be more insightful and meaningful for practitioners.

Previous studies also suggest further research on the factors that may drive companies to adopt certain cost management methods. For example, within a more global view, Chenhall and Langfield-Smith (1998a) suggested the need for research on the factors that influence the adoption of management accounting practices. Follow up studies such as Dekker and Smidt (2003), Ax et al. (2008), and Yalcin (2012) suggest there is a lack of research on the reasons for adopting cost management practices (e.g. target costing). Joshi et al. (2011) claim as well the need for further studies on management accounting practices in Europe.

Moreover, Yeh et al. (2010) underline in their research the idea that certain techniques are relatively unexploited despite the proven benefits of these techniques on new product development. Their research proposes reasons to explain this phenomenon, including the engineer's lack of proficiency and knowledge of which technique to use at each stage of the NPD process. In the present study we suggest further factors to explain the adoption of cost management methods. Duh et al. (2009, p. 25) state that "some management accounting and control systems may act as substitutes for each other, while others may be mutually supporting each other". Their research suggests that firms using a combination of cost management practices may shed further light on the motivation and effects of adopting these practices. This doctoral thesis follows this idea and examines the combination of cost management methods for new product development.

Despite the research explaining the use of CMP based on factors such as competitive environment (Ax et al., 2008; Baines & Langfield-Smith, 2003; Dekker & Smidt, 2003; Dunk, 2004), NPD strategies and structures (Ettlie & Elsenbach, 2007a) and supply chain integrations (Terjesen et al., 2012; Tu et al., 2004), we believe the literature is lacking of research on the relationship between the use of cost management methods and further relevant factors explaining its use. Hence, this current investigation contributes to the literature by addressing this gap because to our knowledge no previous studies have examined the reasons for adopting cost management methods in a new product development context.

5.3 Development of initial hypotheses

Research within MA literature focuses on the adoption of management practices (Afonso et al., 2008; Al Chen et al., 1997; Baines & Langfield-Smith, 2003; Duh et al., 2009; Eatock et al., 2009; Miranda González & Banegil Palacios, 2002; Narasimhan, Swink, & Kim, 2006; Swink, 2003; Tipping, Zeffren, & Fusfeld, 1995; Yazdifar & Askarany, 2012; Yeh et al., 2010). However, the current study investigates not only the adoption of cost management methods employed to support NPD processes but also the antecedents of the adoption. Thus, we framed the use and helpfulness of these methods in a NPD context (see Figure 4). For the testing of the first set of hypotheses (H1 – H5) we grouped these methods based on their scope. The following section explains in detail this clustering.

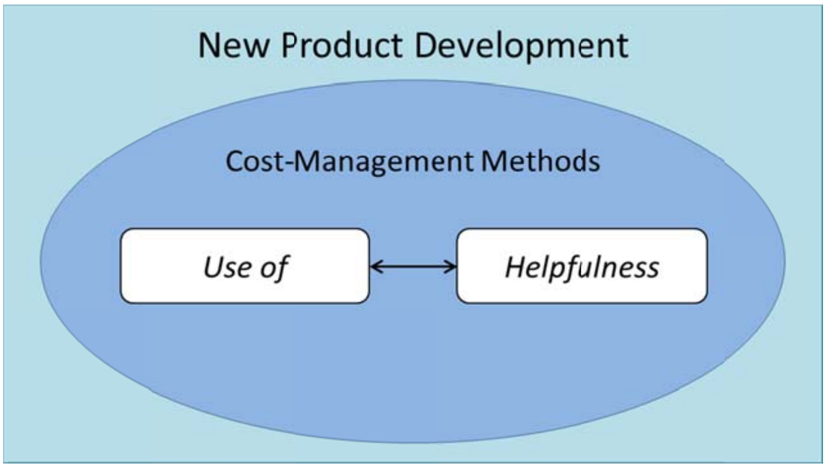


Figure 4: Illustration of two constructs "Use" and "Helpfulness" for the context of the current research.

5.3.1 Clustering of cost management methods based on their scope

The selected methods can be employed to manage cost during new product development (Afonso et al., 2008; Eatock et al., 2009; Ettlie & Elsenbach, 2007b; Salvador & Villena, 2013; Swink, 2003; Yeh et al., 2010). We observed that certain groups of methods share particular characteristics (e.g., objectives, fields of application, types of data used, etc.). For example, while the method "technology roadmaps" have been recognised for promoting inter-functional communication during the development of single or several products (Holmes & Ferrill, 2005), "product platforms" would promote successful product families (J.-Y. Kim et al., 2005). Certain cost management methods can be applied distinctively to individual products or to a portfolio of products. Therefore, we find it appropriate to develop the hypotheses based on the distinction of particular groups of cost management methods. Moreover, we study the adoption of particular groups of methods that share a scope. The antecedents of such an adoption are investigated on the same basis.

Cost management methods in NPD include the formalised procedures and systems for the planning of and reporting on organisational activities for new product development. It is helpful to distinguish between these product development activities themselves and their objects which include new products and services (Davila & Wouters, 2007). Figure 5 presents a classification of methods based on their scope.

Scope-group based on costs considered			
	Unit manufacturing cost of new product / service	I Target Costing Value Engineering Quality Function Deployment Functional Cost Analysis Kaizen Costing	II
	Entire cost of product / service, so including cost of development activities	III Life Cycle Costing Total Cost of Ownership Stage-gate Reviews Funnels DFM, DFX[12]	IV Component Commonality Modular Design Product Platforms Technology Roadmaps DFM, DFX
		Individual product / service	Portfolio of products / services
		Scope-group based on products / services considered	

Figure 5: Classification of cost management methods based on costs and products /services considered.

Scope-groups based on costs considered: within this group we find methods which its similarities are distinguished based on the type of activities that are considered for the cost management. We divided this scope into two groups which are explained as follows:

- <u>Unit manufacturing cost of new products and services.</u> The cost management for new products and services concerns the cost, functionality, performance, and other relevant attributes of the products and services that are being developed to define their "unit manufacturing cost". For example, a car company will develop a business case for the new car, plan the sales price, estimate many different elements of the product cost, decide on the features of the new car, etc. It will review the progressing design of the new car toward its manufacturing: does it meet those planned targets regarding costs, features, performance, etc.? Target costing is a key example of a method that addresses such concerns for managing the costs of new products and services.

- <u>Entired cost of products including the cost of product development activities.</u> The most concrete level of NPD activities are the separate projects for the development of a new product. Such a project incurs costs for personal, research facilities, externally acquired technology, etc. and is characterised by lead time, uncertainty, and other relevant aspects of development projects. For example, when a car company develops a new car, it will budget the cost of this development project (butgets are broken down into items such as internal engineering hours, hired consulting engineers, crash tests, quality tests), plan the lead time (e.g., 4 years, but also broken down into several milestones), and identify risks. The car company will then measure the actual costs and progress during the execution. If there are differences between the plans and the actuals (thus far into the project) or estimates (also for the rest of the project), decisions must be made on corrective actions or adjusting the plans. Stage-gates reviews are commonly used for this purpose.

[12] With exception of the methods design for manufacturing and design for X, which are allocated into two quadrants due its wide application.

Scope-group based on products / services considered: within this group we find methods which its similarities are distinguished based on the production range considered for the application of cost management. We also divided this scope into two groups which are explained as follows:

- Managing the cost of an individual product under development. The starting point is the sharp understanding of cost targets, strict monitoring of actual costs, and strong emphasis on cost reductions to meet those cost targets. This is typically underlying the first set of methods included in this study: target costing, value engineering, quality function deployment, functional cost analysis, and Kaizen costing. However, the scope of these methods is limited. Product design choices made in separate development projects have an impact on their shared costs, such as for logistics, customer support, or quality. The various product design choices, made within different development projects, shape the organisation's costs. These externalities are typically not incorporated in the cost models supporting target costing. Although life-cycle costing and total cost of ownership look at costs in a more broadly way.

- Managing costs across a portfolio of products being developed. The cost management encompass the coordination of the choices that are made within separate development projects projects providing an overview of multiple projects. Component commonality, modular design, and product platforms are key examples of this. The cost of an individual product may even increase through the application of such methods, but the intention is to manage overall costs of the organisation. Anderson and Dekker (2009) talk about structural cost management when describing key decisions such as on supplier selection, joint product development with suppliers, and collaboration regarding inventory management and logistics.

5.3.2 Hypotheses on the use and helpfulness (H1-H2)

This study investigates cost management methods with regard to their use and how helpful they are within the NPD context. For this research we define the concept "*use of*" as the extent to which the organisation applies a particular method for the purpose of cost management in new product development. Furthermore, we will examine of how helpful such methods are and thereby we define our construct "*helpfulness*" as the perception of advantages in applying a particular method within an organisation to achieve its goals in new product development. Table 11 contains the definitions of all constructs relevant for this study.

Table 11: Definitions of constructs.

Construct	Definition
Use	The extent to which the organisation applies a particular method for the purpose of cost management in new product development.
Helpfulness	The perception of advantages in applying a particular method within an organisation to achieve its goals in new product development.
Cost leadership	This strategic priority refers to the firm's intentions to strive for the most cost efficient producer status in the industry (Parthasarthy & Sethi, 1993, p. 530)
Quality leadership	This strategic priority refers to the firm's intentions to strive for industry recognition based on product design and performance (Parthasarthy & Sethi, 1993, p. 531).
Flexibility	This strategic priority refers to the firm's intentions to compete in one or more markets based on prod-uct/volume mix and product innovation in a cost effective manner (Parthasarthy & Sethi, 1993, p. 531).
Supplier integration	The process of acquiring and sharing operational, technical and financial information and related knowledge with the supplier and vice versa (Swink et al., 2007, p. 151) within new product development.
Cross-functional integration	The degree of interaction, communication, information sharing or coordination across functions (Troy, Hirunyawipada, & Paswan, 2008, p. 132) such as R&D, manufacturing, logistics and marketing.
Customer integration	The process of acquiring and assimilating customer requirements, information and related knowledge (Swink et al., 2007, p. 151) within new product development.

Previous research suggest that although it can not be easily studied that adopting cost management practices may increase the organisation's performance (Baines & Langfield-Smith, 2003; Cadez & Guilding, 2008; Duh et al., 2009), the perception from obtaining any kind of benefits from practising certain methods plays a significant role in its adoption (Chenhall & Langfield-Smith, 1998a; Duh et al., 2009; Guilding et al., 2000; J. Wu et al., 2007). For example, the research from Joshi (2001) and Joshi et al. (2011) suggest that the adoption rate of traditional cost management practices is strongly related to the perception of its benefits. Hence, we expect organisations to employ cost management methods which correlate to their perceived helpfulness for new product development (Dekker & Smidt, 2003). Thus, the first hypothesis (H1), examines whether the use of cost management methods is, in general, been considered to be helpful for managing cost during product development. We pose our first hypothesis as follows:

H1: The greater the *use of* all methods,
the greater their perceived *helpfulness*

The previous section (5.3.1) introduced a framework for clustering cost management methods according to their scope. To our knowledge the methods within a scope-group may be used to complement procedures as well as exchangeable methods to manage costs (see Figure 5). Thus, we do not examine the helpfulness of cost management methods on an individual level but rather of a particular scope-group. Consequently the hypotheses 2a, 2b and 2c (H2a - H2c) deal with the use and helpfulness of methods from certain groups.

H2a: The greater the *use of* methods from group I, the greater their perceived *helpfulness*

H2b: The greater the *use of* methods from group III, the greater their perceived *helpfulness*

H2c: The greater the *use of* methods from group IV, the greater their perceived *helpfulness*

5.4 Development of hypotheses on the antecedents of the adoption

This current research contributes to the literature by explaining the adoption of 15 different cost management methods on the basis of six factors. The first three relate to the company strategic priority, namely, (1) cost leadership, (2) quality leadership and (3) flexibility. Followed by three factors concerning the organisation collaborative competences, namely, (4) cross-functional integration, (5) supplier integration and (6) customer integration. Figure 6 shows the conceptual model tested in the current research. The model depicts the influences of the company strategic orientation and managerial approaches on the use and helpfulness of cost management methods.

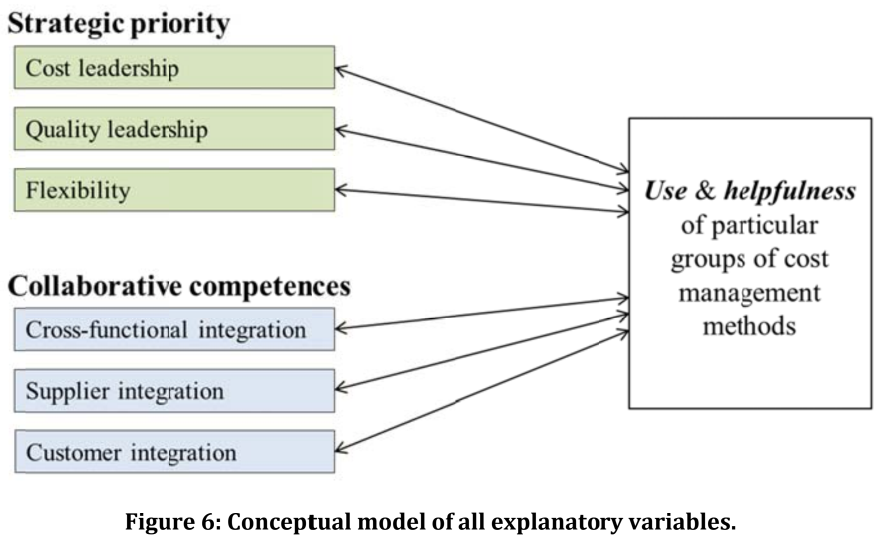


Figure 6: Conceptual model of all explanatory variables.

5.4.1 Hypothesis on strategic priorities as antecedents (H3-H5)

We find a vast amount of research from the accounting literature suggesting that management control systems should match the strategy of the company (Boyer et al., 1997; Boyer & Lewis, 2002; Boyer & McDermott, 1999; M. Joshi, 2003) i.e., that control systems, methods and techniques are chosen according to the company strategy (Bisbe & Otley, 2004; Chenhall & Langfield-Smith, 1998b; Daniel & Reitsperger, 1991; Ferdows & Meyer, 1990; Govindarajan & Fisher, 1990; Van der Stede, 2000). This findings leads us to believe that for a company to carry out its strategic priority successfully, specific cost management methods are required. For example, the method target costing is adequate in fulfilling the strategic priority of cost leadership (Chenhall & Langfield-Smith, 1998b). Hence, we expect a strong relationship between cost management methods and the strategic priority of the organisation which is congruent with previous studies and the nature of our set of methods (see Figure 7).

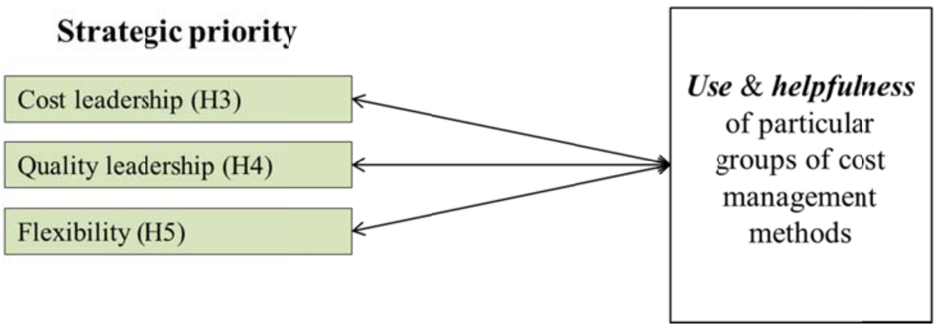


Figure 7: Conceptual model of strategic priorities as explanatory variables.

Strategy is by definition a “construct that provides a map of where the organisation is going” (Boyer & Pagell, 2000, p. 365) whilst the available resources are considered (Porter, 1985, 1996). From a managerial perspective, business strategies (S. Carr, Mak, & Needham, 1997; Parthasarthy & Sethi, 1993) may also be seen as strategic priorities (Chenhall & Langfield-Smith, 1998b). Furthermore, within the engineering literature strategic priorities are viewed as “competitive priorities” (Boyer & Lewis, 2002; Boyer & Pagell, 2000; A. De Meyer & Nakane, 1989), “competitive capabilities” (Swink et al., 2007) or/and “management priorities” (M. Joshi, 2003). Finally, we borrow the definition Strategic priority provided by Boyer and Lewis (2002) who accurately describes it as “the emphasis on developing certain manufacturing capabilities that may enhance a company’s position in the market place” (Boyer & Lewis, 2002, p. 9). This can be explained as the most valuable capability of a company, which provides a focus for allocating the resources of a company to achieve a competitive advantage.

Strategic priorities are of paramount importance in manufacturing companies as they guide them in achieving higher performance by shaping their competitive advantages (Boyer & Lewis, 2002; M. Joshi, 2003; Kahn et al., 2012; J.-Y. Kim et al., 2005; Parthasarthy & Sethi, 1993). Hence, after reviewing the literature, we choose primary strategic priorities within organisations, which are cost leadership, quality, flexibility and delivery (Adam, 1989; Boyer, 1998; J. Miller & Roth, 1994). However, the last one will not be considered in our investigation due to its lack of relevance to our research context. These priorities were defined by Parthasarthy and Sethi (1993, pp. 530–531) as follows:

- "Cost leadership refers to the firm's intentions to strive for the most cost efficient producer status in the industry"
- "Quality leadership refers to the firm's intentions to strive for industry recognition based on product design and performance"
- "Flexibility refers to the firm's intentions to compete in one or more markets based on product/volume mix and product innovation in a cost effective manner"

The strategic prioritiy of a company may foster the adoption of certain cost management practices (Baines & Langfield-Smith, 2003; R. Cooper, 1996; Mouritsen et al., 2001), not only individually but rather a combination of them (Chenhall & Langfield-Smith, 1998b). Hence, we believe that methods pertaining to a specific scope-group (see Figure 5) may be used to support the particular strategic priority of the organisation. Consequently, the following subsections introduce in detail the hypotheses addressing these relationships (H3a-H5b).

5.4.1.1 Strategic priority of cost leadership (H3)

Previous research suggest that the strategic priority of cost leadership is related to the successful use of cost management practices, suggesting that production cost reduction can also be achieved during early stages of product development (Anderson & Dekker, 2009; R. Cooper & Slagmulder, 1999; Davila, Foster, & Li, 2008; Davila & Wouters, 2004). Two groups of methods presented in Figure 5 would be suitable for achieving this priority. While Group–I stands out for their use for managing unit manufacturing cost of a new product, Group–III is distinguished for managing the entire cost of developing products, considering in a wider range of stages such as development activities and cost of purchasing decisions. Both groups focus on managing costs of individual products or services. Hence, the methods that were classified in these two groups may support the strategic priority of cost leadership.

For example, methods whose primarily objective is to manage the costs on an individual product level are more suitable in achieving lower cost production as required by the strategic priority cost leadership. Thus, with the adoption of **target costing** desirable prices will be set to further break down the cost structure to maintain the permitted production costs (Ansari et al., 2007; Chenhall, 2008). Along with the adoption of other methods such as **value engineering**, procedures and product designs can be redefined and cost reduction opportunities can be identified to finally achieve predetermined costs (Agndal & Nilsson, 2010; Al Chen et al., 1997; Kato, 1993). Moreover, once the product reaches the manufacturing stage, **Kaizen costing** assesses companies to re-evaluate cost reduction initiatives in continuous process (Agndal & Nilsson, 2009; Guilding et al., 2000). Furthermore, using methods such as **life cycle costing** and **total cost of ownership** an efficient resources allocation away from the manufacturing stage can be expanded (Degraeve et al., 2005; Parker, 2000). This extends into the product supply chain (Arping & Lóránth, 2006) and therefore supports the company strategic priority of cost leadership as a competitive advantage.

Furthermore, it is important to note the belief that two priorities do not fit together within a single company (Boyer & Lewis, 2002). For example, cost leadership and flexibility contradict each other principles. Thus, it is not likely that firms whose main goal is to reduce costs, would be willing to pay as well the "price" for being flexible i.e., to compete in one or more markets based on product/volume mix and product innovation. Hence, methods classified in the Group–IV that could increase costs in R&D such as component commonality, modular design and product platforms may hinder the priority of cost leadership. Finally, we propose that only methods located in Group–I and Group–III (see Figure 5), such as target costing, Kaizen costing, life cycle costing, and total cost of ownership, will be aligned with the strategic priority of cost leadership. Likewise, organisations with this strategic priority will promote the use of such methods and recognize its helpfulness for new product development. We have the hypothesis as follows:

H3a: The greater the strategic priority of *cost leadership* in a company, the greater the *use of* methods classified in group I

H3b: The greater the strategic priority of *cost leadership* in a company, the greater *the use of* methods classified in group III

H3c: The greater the strategic priority of *cost leadership* in a company, the greater the perceived *helpfulness* of methods classified in group I

H3d: The greater the strategic priority of *cost leadership* in a company, the greater the perceived *helpfulness* of methods classified in group III

5.4.1.2 Strategic priority of quality leadership (H4)

Whereas it is in the best interests of the whole company to profit from market recognition of their high quality products, organisations may focus on specific cost management methods that seem to be more suitable than others in achieving such quality leadership. Nevertheless, quality is an ambiguous concept[13] and it may be difficult to achieve unless its interpretation is clearly defined. Organisations which strive for a high quality product may use methods classified in Group–I and Group– III (see Figure 5), where the main objective is to manage NPD costs based on costs of certain functionalities, performance and other attributes which determine the quality of products. Thus, these groups of methods may support the strategic priority of quality leadership. In conclusion it can be argued that the literature review suggests a relationship between the adoption of certain cost management methods and the strategic priority of a company.

For example, to ensure that customers perceive the quality of the products, methods such as **quality function deployment** become more meaningful to foster communication between customers, marketing, engineering, and manufacturing (J. Cristiano, Liker, & White, 2000; Govers, 1996; Griffin & Hauser, 1992; Khoo & Ho, 1996; Swink, 2003). Moreover, quality may be interpreted as the pursuit of a viable project to develop a new product. Hence, techniques such as **funnels**, **designs for manufacturing / assembling** support the design of such projects (Ding & Eliashberg, 2002; Fuchs & Kirchain, 2010). Furthermore, once the project has been specified, the "quality" may be interpreted as an efficient process to develop products. Thus, the **stage-gates review** provides the necessary structure to evaluate project performance at each stage (Davila et al., 2009; Ettlie & Elsenbach, 2007a; Hertenstein & Platt, 2000). Finally, quality control may be reinforced using **total cost of ownership** to assess purchasing activities avoiding costs related to poor quality (Wouters et al., 2005).

Furthermore, it is important to note the belief that two priorities do not fit together within a single company (Boyer & Lewis, 2002). For example, if been the first in launching a product into the market is of highest importance for the company, it more likely that such companies would focus on methods such as modular design or component commonality and further methods from Group-IV. However, based on the findings from previous resarch, we believe that methods located in Group–I and Group– III (see Figure 5), such as quality function deployment, design for manufacturing, stage-gates, funnels, and total cost of ownership are more suitable in achieving the strategic priority of quality leadership as a competitive advantage for the company. Hence, organisations with quality leadership as strategic priority promote the use of such methods and recognize its helpfulness. We hypothesize as follows:

H4a: The greater the strategic priority of *quality leadership* in a company, the greater the *use of* methods classified in group I

H4b: The greater the strategic priority of *quality leadership* in a company, the greater the *use of* methods classified in group III

[13] See Karmarkar and Pitbladdo (1997) for an overview that brings together quality concepts from marketing and manufacturing.

H4c: The greater the strategic priority of *quality leadership* in a company, the greater the perceived *helpfulness* of methods classified in group I

H4d: The greater the strategic priority of *quality leadership* in a company, the greater the perceived *helpfulness* of methods classified in group III

5.4.1.3 Strategic priority of flexibility (H5)

As previously defined, organisations with the strategic priority of flexibility can be distinguish for its efforts in rapidly adapting to market needs, i.e., to beat markets based on product/volume mix and product innovations. Likewise, in order to support this strategic priority, certain cost management practices may be more helpful than others (Davila & Wouters, 2004; Fisher et al., 1999). In order to compete within dynamic markets, Group–IV provides the methods to manage a diversity of products in an effective manner by analysing cost structure of a portfolio of products.

For example, **product platforms** provide the flexibility for companies with a portfolio of products to focus on directing production processes to react quickly to the changing market needs (W. C. Kim & Mauborgne, 1997; V. Krishnan & Ulrich, 2001). Similarly, once the priority for flexibility has been set and the organisation decides to pursue this strategic goal, methods such as **component commonality** improve the product design in such a way that allowed materials, parts and/or components can be shared among the series of products now and in the future (Desai et al., 2001). Furthermore, during early development stages where products are developed, **modular design** plays a central role in managing how resources can be combined and shared among a portfolio of products efficiently and rapidly (K. Ramdas & Randall, 2008) even under market uncertainty (Terjesen et al., 2012; Tu et al., 2004). The strategic priority of flexibility may also foster the use of **technology roadmaps.** Firms which adopt this method can project their R&D objectives and continuously adapt their plans to achieve these (P. Miller et al., 2008; P. Miller & O'Leary, 2007), i.e., shape the choices for product designs (Alkaraan & Northcott, 2006).

Thus, component commonality, modular design, product platforms and technology roadmaps address costs management across product development projects and a portfolio of products, which refers rapidly adapt to the market needs in an economically efficient business model. Hence, we expect that organisations whose strategic priority is flexibility promote the use of such methods from Group–IV (see Figure 5) and recognize its helpfulness. Hence, we hypothesize:

H5a: The greater the strategic priority of *flexibility* in a company, the greater the *use of* methods classified in group IV

H5b: The greater the strategic priority of *flexibility* in a company, the greater the perceived *helpfulness* of methods classified in group IV

5.4.2 Further hypotheses on collaborative competences as antecedents (H6-H8)

The last set of hypotheses concerns to the relationships between the adoption of cost management methods and the collaborative competences of the organisation (see Figure 8). The literature highlights three competences as relevant for organisation's performance. These are cross-functional teams, supplier integration and customer integration (Binder et al., 2008; Mishra & Shah, 2009; Narasimhan & Kim, 2002; Swink et al., 2007; Terjesen et al., 2012; Wong, Boon-itt, & Wong, 2011). The current examination links these concepts and posits three hypotheses (H6-H8) in regard to the use and helpfulness of cost management methods based on company collaborative competences.

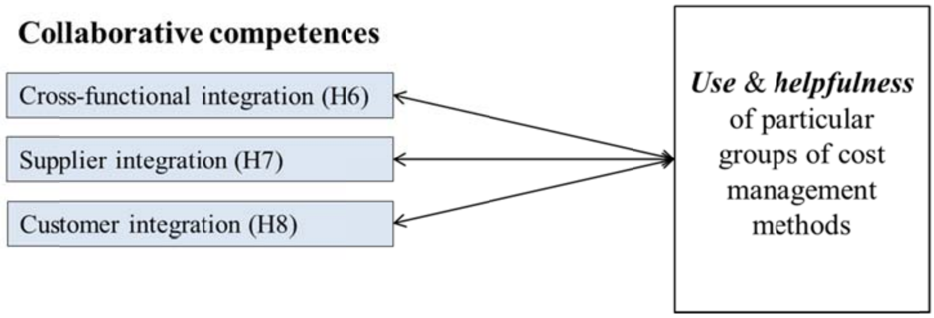


Figure 8: Conceptual model of collaborative competences as explanatory variables.

A Collaborative competence has been defined as "the ability to simultaneously involve key stakeholders in the new product development process" (Mishra & Shah, 2009, p. 325). In this R&D context, supply chain integration (SCI) is a critical factor within and beyond organisational boundaries but highly beneficial for the development of new products (Binder et al., 2008; Mishra & Shah, 2009; Narasimhan & Kim, 2002; Swink et al., 2007; Terjesen et al., 2012; Wong et al., 2011).

Research conducted addressing different phases of the supply chain including the product design stage or later in the manufacturing process, suggests that particular departments may benefit from such integration differently (Ettlie & Elsenbach, 2007a; Fullerton, Kennedy, & Widener, 2013; Z. Hoque & James, 2000; Ulrich et al., 1993). Companies looking into full supply chain integration (SCI) are more likely to achieve a profitable trade-off when efforts are made to consider the involvement of suppliers and customers into their development processes. For example, by sharing technological information early on to be able to capture external expertise early in the process, will generates benefits such as higher technical and financial performance. (Lawson et al., 2009; Petersen et al., 2003; Salvador & Villena, 2013; Schiele, 2010; Tan, 2001). Moreover, organisations gain operational advantages after combining efforts from several cross-functional teams (Ahmad, Mallick, & Schroeder, 2013; Ahmad et al., 2010; X. M. Song, Montoya-Weiss, & Schmidt, 1997) and increase their performance when efforts are made to collaborate with customers in developing new products (Kahn et al., 2012; Kahn, 2001; Lamore et al., 2013; Narver et al., 2004).

Cost management practices provide the structure to control the costs incurred in a company which may be influenced by inter-organisational as well as intra-organisational issues (Davis & Eisenhardt, 2011; Mouritsen et al., 2001). The availability of cost data and other product-related information is of paramount importance in managing the cost structure of R&D. Therefore, the providers of this information such as, cross-sectional teams, suppliers and customers play a relevant role for the adoption of particular cost management method.

5.4.2.1 Classifications of methods to explain the collaborative competences as antecedents

The 15 cost management methods are classified into six groups based on two new scopes. These classifications are more suitable when studying the collaborative competences of an organisation as antedents of the adoption of such methods. Hence, we develop hypotheses H6 to H8 based on this new grouping of cost management methods.

Figure 9 presents these classifications based on two new scopes. The definitions of method provided in Table 1(see Chapter 2) support our reasons for classifying the methods in such a manner. The first scope is divided as well into three sub-groups. Moreover, the second scope is divided into two sub-groups.

Scope of data source	External	Customers	**V** Quality Function Deployment	**VI** Technology Roadmaps
		Suppliers	**VII** Target Costing Value Engineering Life Cycle Costing Total Cost of Ownership	**VIII** Stage-Gates Reviews Modula Design Technology Roadmaps
	Internal		**IX** Value Engineering Functional Cost Analysis Kaizen Costing Life Cycle Costing	**X** Stage-Gates Reviews Funnels DFM, DFX Component Commonality Modular Design Product Platforms
			Financial calculations	Non-financial guidelines
			Scope of monetarisation	

Figure 9: Classification of cost management methods based on: data source and monetisation.

Scope-group based on data source: this scope refers to the information needed to apply different cost management methods. Such information is presented either in the form of cost data or as product requirements, but more importantly it reflects the source of such information. Cost data may arise from functional areas such as R&D, manufacturing or marketing, etc.

- Internal sources may be enough to provide data to apply certain cost management methods. Furthermore, relevant cost data can be generated using information arising from internal sources and in combination with suppliers' guidance.
- External sources complement the information flow towards the organisational interest, including cooperation with customers and provides of valuable data (e.g., detailed product requirements). Consequently, we distinguish three data sources needed to use the methods, namely, internal sources (i.e., functional areas), external sources; suppliers and external sources; customers.

Scope-group based on monetarisation: this scope refers to the cost related data that companies obtain as a result from practising certain cost management methods. The method's approach may be used either for financial calculations or as non-financial analyisis and guidelines.

- The scope-group of financial calculations primarily refers to a cost evaluation performed by the organisation for its economic growth. We understand financial data as the amount of money that has been spent or that could be saved.
- The methods considered in this examination as non-financial analysis and guidelines primarily focus on providing instructions to proceed in a cost management framework. This means that through the adoption of such methods, the organisation does not only obtain financial data but most it acquires a systematic manner in how to perform towards a cost efficient product development.

Contrary to the previous classification (section 5.3.1), methods within this clustering could belong to various scope-groups. This hinders the description of scope-groups including representative methods. Therefore, we present in the next paragraph few examples of the methods' classification to illustrate our reasons for proceden in this way.

Organisations collect a large amount of information related to their product and production processes whilst looking for opportunities to reduce costs within the whole production process. This data is continually interpreted and used to apply methods such as **target costing** to reach allowable product costs, or **Kaizen costing** to reduce cost during the manufacturing phase. Therefore, on the one hand, we classified target costing in Group–VII because this method involves cost data from suppliers for financial calculations. On the other hand, the method Kaizen costing was allocated in Group–IX for its internal use and its purpose of financial calculation. **Design for manufacturing** was classified in Group–X because the main objective of this method is to provide guidelines to develop a product efficiently. Therefore, when this method is employed, the interaction between functional teams within the organisation increases, in such a way that meaningful information is shared at the design phase to avoid future manufacturing costs. In contrast **value engineering** can be found in the Group–VII and IX. One objective of this method is to analyse the cost of a product's function i.e., financial calculation. Thus, to achieve this goal, the method can be applied as an inter-organisational management control system, which involves several departments related to the development of a product, i.e., marketing, manufacturing and R&D, among others (Group–IX). However, to foster better conditions in which the method **value engineering** may be practiced, entities external to the organisation may be involved to improve the performance of such methods, e.g., involving suppliers (Group–VII) when applying value engineering provide valuable information regarding cost structure and, hence, more accurate results. **Stage-gates reviews** provide the structure for development projects, where several stages have to be fulfilled before the project moves to the next one. Moreover, stage-gates reviews may be used not just internally but may also involve suppliers as data source for better project planning. Hence, we can place this method in Group–VIII and X, i.e., the combination of methodology that involves not only information from internal functional teams (Group–X) but also suppliers' cost data (Group–VIII). Lastly, **Technology roadmaps** is a particular case, this method pursues the commercialisation of new technologies. Thus, a partnership between particular industries, in this case, potential customers and suppliers become of paramount importance in providing clear guidelines for developing candidate technologies. Hence, this is the only method classified in Group–VI.

Finally, the expected relationship between the adoption of cost management methods and collaborative competences is explained as follows. On the one hand, our framework suggests three data sources that may be needed to apply certain methods (internal sources, external-suppliers and external-customers). On the other hand, the literature suggests three collaborative competences relevant for the organisations, which are cross-functional, supplier and customer integration. Thus, this current examination links these concepts and posits three hypotheses in regard to the adoption of cost management methods based on the company collaborative competences. Therefore, we propose in hypothesis 6 a relationship between internal data sources and cross-functional integration. In hypothesis 7 a relationship between the external data sources suppliers and supplier integration. We also propose a relationship between the external data sources customers and customer integration in hypothesis 8.

5.4.2.2 Collaborative competence: cross-functional integration (H6)

As pointed out by the operation management literature, intra-organisational involvement is one of the most popular collaborative competences for the success of product development processes

(Mishra & Shah, 2009; Narasimhan & Kim, 2002; Wong et al., 2011). Thus, the integration of functional areas (such as R&D, manufacturing, and marketing) is identified as a competitive advantage for manufacturing companies. While reviewing this vast literature, we find that some authors refer to “internal integration” (Narasimhan & Kim, 2002), “cross-functional teams” (Mishra & Shah, 2009) or “inter-departmental interdependencies” (Bouwens & Abernethy, 2000) although they all investigate the same concept. For the purpose of this research, the collaborative competence “*cross-functional integration”* is understood as “the degree of interaction, communication, information sharing or coordination across functions” (Troy et al., 2008, p. 132) such as R&D, manufacturing, logistics and marketing. Hence, we interpret these concepts as the collaboration across functions pursuing interdependencies and knowledge sharing between the departments which are closely related to product development. This may occur in the form of individuals or functional groups working together. Song et al. (1997) investigates the antecedents of cross-functional cooperation within a product development context. The results suggest that internal mechanisms, i.e. internal control systems in the form of policies and procedures, foster cooperation between R&D, manufacturing and marketing areas. Thus, the author highlights how cost management practices are meaningful when organisations strive for the particular collaborative competence “*cross-functional integration”*.

This current research examines whether organisations pursuing cross-functional integration are inclined to apply certain groups of cost management methods for product development and, if so, which groups are recognised as helpful for product development. Therefore, we propose that there is a relationship between “cross-functional integration” and adoption of methods classified within the scope-group data sources’ “internal” in both types of monetisation i.e. finanacial calculations Group–IX and non-financial analysis and guidelines Group–X (see Figure 9).

Empirical research supports the idea that the adoption of methods in Group–IX enhances the involvement of cross-functional teams. For example, the findings from large surveys indicate that relevant characteristics of **target costing** and **value engineering** promote the integration of functions to achieve target costs (Dekker & Smidt, 2003; Tani, Okano, & Shimizu, 1994). This occurs when internal data sources are crucial for product development i.e., gathering information from different departments such as marketing, manufacturing and R&D (Bouwens & Abernethy, 2000; Sherman, Berkowitz, & Souder, 2005; X. Song, Thieme, & Xie, 1998). Likewise, empirical research in the form of case-studies suggest that firms striving for cross-functional integration turn to target costing to ensure that different functional areas have a common understanding of cost structures within product development (Ellram, 2000, 2002).

Furthermore, we also propose a set of cost management methods most commonly used as non-financial analysis and guidelines. These provide structure on how to proceed within a cost management context (see Figure 9). They also rely on internal data sources to coordinate and join internal efforts for new product development. For example, **design for manufacturing** constantly requires the participation of several departments i.e., cross-functional teams to improve product design. The empirical study of Ettlie (1995) on integrated product-process development approaches focussed on the relationship between such integrated product-process and the organisational success. DFM training was one of the three practices to measure the use of the integrated approaches (Ettlie, 1995). Furthermore, Jayaram and Malhotra (2010) investigated concurrency on new product development projects. The results from their survey propose DFM as a proactive method to foster cross-functional coordination, which influences time-to market performance.

Moreover, Sosa, Eppinger and Rowless (2004) conduct a field study on product development. This consists of eight modular systems. The research concludes that **modular designs** increase the need for cross-functional teams to interact in achieving a successful incorporation of such modules. Moreover, Ahmad et al. (2010, p. 48) claim that "Product design is inherently an interdisciplinary endeavour". Their study, in the form of a survey, develops from the idea that modularity increases the interdependency between R&D, manufacturing and marketing functions to coordinate projects in a more holistic way thereby improving production processes. In conclusion, the empirical evidence from this research supports the relationship between cross-functional teams and modular design to enhance firms' competiveness.

Empirical evidence shows that **stage-gates reviews** support cross-functional integration. The work by Hertenstein and Platt (2000) in the form of a case-study, illustrates that stage-gates reviews and multi-functional teams are closely connected. From this, guidelines are set to support new product development process. Furthermore, Ettlie and Elsenbach's (2007a, p. 30) findings claim that stage-gates reviews are "significantly related to formalisation of NPD strategies and structures, use of virtual teams, and adoption of collaborative engineering systems". Thus, all in all, stage-gates reviews are a suitable practice to adopt when organisations engage in cross-functional integration.

Finally, we acknowledge that certain cost management methods may be improved by including cost data from suppliers and product requirements determined by customers (see next hypotheses – H7 and H8). Currently we only focus on the use of cost management methods that belong to the Group–IX and X (see Figure 9). Based on the previous evidence, we propose that involving different functional areas within product development processes relate to the *use* of certain methods and the *helpfulness* of such methods is recognised when companies strive for the collaborative competence: "cross-functional integration". Hence, we hypothesize:

> **H6a: The greater the *integration of cross-functional teams* during NPD, the greater the *use of* methods classified in group IX**

> **H6b: The greater the *integration of cross-functional teams* during NPD, the greater the *use of* methods classified in group X**

H6c: The greater the *integration of cross-functional teams* during NPD, the greater the perceived *helpfulness* of methods classified in group IX

H6d: The greater the *integration of cross-functional teams* during NPD, the greater the perceived *helpfulness* of methods classified in group X

5.4.2.3 Collaborative competence: supplier integration (H7)

The integration of supply chain actors such as business partners and suppliers serve as a powerful tool in improving product development endeavours (Cousins, Lawson, Petersen, & Handfield, 2011; Lawson et al., 2009; H. Lee & Tang, 1997; Petersen et al., 2003; Salvador & Villena, 2013; Schiele, 2010; Tan, 2001). The concept "supplier involvement" is essentially attributed to the commitment between an organisation and its suppliers to join forces for successful product development. For this current research, supplier integration refers to "the process of acquiring and sharing operational, technical and financial information and related knowledge with the supplier and vice versa (Swink et al., 2007, p. 151) within product development".

The main objective of involving suppliers for knowledge sharing is to find improvements within product designs, manufacturing, storage and sales. Hence, the adoption of a suitable cost management practice that fosters this integration becomes of paramount importance for manufacturing firms. Previous research theorizes about the adoption of cost management practice to involve suppliers particularly for product development (Caglio & Ditillo, 2008; R. Cooper & Slagmulder, 2003; Tan, 2001). The nature of cost management practices provides an overview of which methods may benefit from input data created within the organisation and which may use data sources beyond the organisational boundaries (see definitions in Table 1, Chapter 2).

Therefore, the methods grouped in the Group–VII are associated with financial calculations while those in Group–VIII primarily serve as non-financial analysis and guidelines (see Figure 9). In both cases, these methods consider the organisation's external data sources. Moreover, the adoption of these methods is strongly related to the involvement of suppliers for manufacturing processes (Agndal & Nilsson, 2009, 2010; C. Carr & Ng, 1995; R. G. Cooper, 2004; Dekker et al., 2013; Seal et al., 2004; Wijewardena & De Zoysa, 1999). Hence, our argument in considering *supplier integration* as an explanation of this adoption lies in the perception that certain groups of cost management methods assist companies in gathering relevant information from suppliers. The use of these methods also stimulates companies in involving suppliers during the product development process which may reduce costs and improve performance.

Manufacturing companies striving for supplier integration embrace methods for cost reduction and planning (i.e., for monetary assessment) that will fit into an inter-organisational structure. Hence, numerous case studies can be found, mostly from accounting literature that investigates how cost management methods such as target costing, value engineering and Kaizen may be promoted by supplier integration. Likewise, cost management methods stimulate different aspects that should be considered in successfully involving suppliers within product development. For example, the early field studies from C. Carr and Ng (1995) show how **target costing** principles are used to support a company's efforts in integrating their suppliers. This is achieved by providing the structure to "open-book suppliers" for delivering a complete breakdown of the price of their products, i.e., material, packaging and shipping costs. Similarly, Seal et al. (2004) present comparable observations without the factor "time-to-market pressure".

Furthermore, target costing could be reinforced, combining methods such as **value engineering** and **Kaizen costing** to manage high levels of cooperation and information sharing**.** This helps to overcome the information asymmetry that may arise between buyers and suppliers (R. G. Cooper, 2004) when processes are shared. Information sharing also provides support for suppliers' selection, joint product designs and manufacturing process development (Agndal & Nilsson, 2009, 2010). The results from the Dekker et al. (2013) large-scale survey expose target costing as a control practice used to manage risks associated with collaboration between manufacturing firms and their supply chain partners.

Moreover, the literature provides empirical evidence of a relationship between supplier integration and the methods which are used as a methodology to provide guidelines. Two examples of this are modular design and technology roadmaps. The integration of suppliers by using the **modular design** method is often investigated through large surveys. Research concludes that modular design is used to prevent diseconomies arising from supplier interdependence i.e., buyer-supplier integration (Salvador & Villena, 2013) through the cost data management (Terjesen et al., 2012). Finally, Hoetker et al. (2007) worked with archival data from a period of more than two decades and claim that modular design guides suppliers, helping them to emphasise their ability to respond to changes whilst still delivering on time (i.e., supplier assessment strategy).

Furthermore, field work in the form of case-studies suggests the use of **technology roadmaps** for supplier integration. These are identified as a tool to share technology and cost related information between suppliers and the focal firm (Lawson et al., 2009; Petersen et al., 2003). This enhances purchasing activities which in turn improves sourcing decisions (Schiele, 2010). These roadmaps are used as a "mediating instrument", supporting large R&D investment decisions when many different parties are involved e.g., joint ventures and suppliers (P. Miller et al., 2008; P. Miller & O'Leary, 2007).

The literature also suggests a relationship between supplier integration and methods commonly used to internally manage cost structures (see Figure 9). For example, Degraeve and Roodhooft (2000) and Degraeve (2005) worked with archival data and find that **total cost of ownership** was used to improve sourcing decisions by assessing the absolute cost of purchasing from one or more suppliers' offerings. Moreover, the results of a large experiment conducted by Van den Abbeele et al. (2009) conclude that TCO information reduces the weaker buyers' performance disadvantage when negotiating with suppliers. The empirical results from Binder et al. (2008), explain how **life cycle costing** provide companies with the ability to extend their cost structure whilst taking into consideration costs beyond organisational boundaries. However, most of these studies are based on qualitative research, indicating that most of this is still within an exploratory phase. Hence, there is a lack of generalisation of findings within this topic.

We believe that the methods grouped within the scope: "external data sources" support the process of retrieving and sharing knowledge with suppliers (i.e., *supplier integration*). Hence, this provides companies with beneficial cost information for product development. Consequently, we propose that involving suppliers during the product development process is related to the *use* of certain methods and that the *helpfulness* of such methods is recognised when companies strive for the collaborative competence: "supplier integration". Hence, we hypothesize:

H7a: The greater the *integration of suppliers* during NPD, the greater the *use of* methods classified in group VII

H7b: The greater the *integration of suppliers* during NPD, the greater the *use of* methods classified in group VIII

H7c: The greater the *integration of suppliers* during NPD, the greater the perceived *helpfulness* of methods classified in group VII

H7d: The greater the *integration of suppliers* during NPD, the greater the perceived *helpfulness* of methods classified in group VIII

5.4.2.4 Collaborative competence: customer integration (H8)

While some authors suggest that market orientation promotes collaboration between functional departments such as marketing and R&D for product development (Lamore et al., 2013), it may not create any new value-added opportunities (Narver et al., 2004). In contrast, other authors argue that market orientation has a weak relationship or no direct relationship at all to R&D performance (Greenley, 1995; Kahn, 2001). Hence, when operational departments such as manufacturing and R&D strive for market orientation, this leads to confusion.

Marketing literature has a vast amount of research on market orientation (see literature review by (Liao, Chang, Wu, & Katrichis, 2011). Ruekert (1992) presents an accurate definition of market orientation based on the research conducted by Kohli and Jaworski (1990) and Narver and Slater

(1990). This definition reads as follows: "The level of market orientation in a business unit is the degree to which the business unit: (1) obtains and uses information from customers; (2) develops a strategy which will meet customer needs; and (3) implements that strategy by being responsive to customer needs and wants (Ruekert, 1992, p. 228)". Whereas market orientation can be broken down into different concepts, the concept of customer orientation can be one key element to be exploited. Thus, we are faced with the question of how to satisfy customers. This is particularly relevant for departments such as R&D and manufacturing. Hence, a fundamental question is no longer to ask what the market wants but how to manufacture a product that satisfies customers' wants and needs. Beyond the concept of customer orientation, the integration of customers for product development opens a wide research field where management accounting can also make a contribution. Therefore, one of our research questions is regarding which cost management methods to use when organisations work together with customer to develop its products.

Customer integration is commonly related to the collaboration between a company and its customers for the development of new products. This includes the involvement of customers' ideas, needs and wants during early stages of product design. Thus, this current study is based on the definition given by Swink et al. (2007). We refer to *customer integration* as "the process of acquiring and assimilating customer requirements, information and related knowledge" (Swink et al., 2007, p. 151) within product development.

The MA literature also lends itself to research development within collaboration between organisations and their customers (Bajaj et al., 2004; Bhimani, 2003; Dunk, 2004; Nixon, 1998). Previous research recognizes benefits for the organisation when external data sources such as customers are considered for product development (Arping & Lóránth, 2006; Kahn, 2001; Lamore et al., 2013). We believe there is a link between the collaborative competence "*customer integration"* and the use of certain cost management methods. We use the same logic that was employed by the aforementioned hypotheses to group cost management methods suitable for involving customers in product development.

Firstly, Group–V (in Figure 9) refers to methods used for financial calculations. These methods require external data sources: "customers". Thus, we found empirical evidence relating the methods from this scope-group to the concept of customer integration. For example, through an experiment Griffin and Hauser (1992) compare two product-development teams using different approaches, namely, the phase-review development process and **quality function deployment (QFD)**. Their study involves two functional teams, where just one team applies QDF. Primarily, QFD facilitates the communication between functional areas i.e., marketing, engineering, and manufacturing. As a result, QFD stimulates the team consciousness about customers' needs and instance market information. Further empirical research such as Burchill and Fine (1997) and Swink (2003) support Griffin and Hauser´s (1992) findings. Hence, **quality function deployment** can be used to understand the customer´s environment, converting this understanding into technical requirements and most importantly operationalizing customers' input (Burchill & Fine, 1997).

Secondly, Group–VII (in Figure 9) refers to methods used as a guideline which also requires the external data sources (e.g., customers) to be practiced. For example, when **technology roadmaps** are used, organisations extend their development efforts to cover the entire supply chain e.g. in exploiting a partnership with both suppliers and customers (Jordan, Jørgensen, & Mitterhofer, 2013; P. Miller et al., 2008; P. Miller & O'Leary, 2007). Whereas manufacturing companies adapt such methods to their needs, customers´ input remain as key requirements when applying certain cost management methods. Hence, current and potential customers can provide detailed data needed to use certain techniques to manage their cost structures for product development.

We present further empirical evidence for the adoption of certain cost management practices if an organisation is willing to involve customers in their development process. Nixon (1998) argues that when costs are a critical design parameter, **target costing** may be useful to integrate customers' requirements in the product development process. Hence, this method deals with high levels of cooperation and information sharing beyond the firms' boundaries i.e., between the organisation and its customers. The research also suggests that target costing may be reinforced by adopting methods such as **value engineering** to meet the many technical and financial goals. Furthermore, Bhimani's (2003) empirical research shows that companies learn about the perceived customer value of specific product functions and can compare such value with the cost of functions through processes based on **target costing** (PBTC). Dunk (2004) claims that **life cycle costing** is a meaningful method for the organisation responsiveness to customer orientation, i.e., for responding to specific customer requirements by improving information-system quality. Moreover, through **design for manufacturing (DFM)** companies shift the resource consumption to the design phase. Hence, a regulated interaction with customers is of paramount importance when applying this method (Bajaj et al., 2004). Finally, **modular design** enables companies to offer mass-customised products, whereas customers´ integration is essential to achieve an optimal designs that reduce cost and improve product value (Feitzinger & Lee, 1997; Tu et al., 2004).

Despite the empirical evidence contrary to our reasons for classifying target and life cycle costing, DFM, and modular design methods in the scope data sources: "customers", we find greater support for framing our hypothesis based on the nature of the methods QFD and Technology roadmaps. These methods which include an external data source i.e., quality function deployment and technology roadmaps, involve customers in product development by definition (see Table 1, Chapter 2,).

Finally, companies may be able to gather valuable information needed to improve product development through methods whose focus is to include external data sources such as customers within their development processes. Hence, we expect that customers´ involvement explains the adoption of certain methods to manage their cost at the early design stages and that the *helpfulness* of such methods is recognised when companies strive for the collaborative competence: "customer integration". Hence, we hypothesize:

H8a: The greater the *integration of customers* during NPD, the greater the *use of* methods classified in group V

H8b: The greater the *integration of customers* during NPD, the greater the *use of* methods classified in group VI

H8c: The greater the *integration of customers* during NPD, the greater the perceived *helpfulness* of methods classified in group V

H8d: The greater the *integration of customers* during NPD, the greater the perceived *helpfulness* of methods classified in group VI

6 Research method

6.1 Introduction

German manufacturing industry was selected to test the hypotheses proposed in the Chapter 5. Thus, through a web-based survey this research investigates which cost management methods are being used for product development and if the used methods are perceived as helpful for new product development. It also investigates if the use of such cost management methods is linked to the organisation's strategic priority (i.e., cost leadership, quality leadership and flexibility) and to particular collaborative competences of the organisation (i.e., supplier integration, cross-functional integration and customer integration).

Prior to launching the survey, we developed a questionnaire, conduct a pilot study, created the electronic version of the questionnaire and defined the sample selection criteria. This Chapter follows the same structure.

6.2 Survey method

In preparing the questionnaire we looked at research conducted not only within MA literature but also outside this field (see Chapters 3 and 4). The review of survey-based studies served also for the conceptualisation of the adoption and development of the measurement instrument (a detailed summary of these papers can be found in Appendix C). A diversity of measurement instruments among these studies was identified. For example, studies such as Guilding et al. (2000) used single items to measure the proposed constructs i.e., one item per variable measured. Occasionally a compilation of definitions of the investigated methods was added to the questionnaire to promote a clear understanding of the meaning of the concepts. Moreover, authors such as Dunk (2004) and Salvador and Villena (2013) used multi-items to measure the construct. For example, the construct “modularity-based manufacturing practices” was defined and surveyed through a three-dimension construct i.e., through a set of items (Terjesen et al., 2012; Tu et al., 2004). The Likert-type scale was often employed (either on a five-point or seven-point scale) with a variation of anchors. Nevertheless, in a few research papers a binominal scale was used to assess a set of items i.e., a list of specific techniques and methods were given to the respondents who had to evaluate them through a “yes”/”no” answer (Miranda González & Banegil Palacios, 2002). Table 12[14] highlights previous survey-based research that served as role models for developing the questionnaire of the current research.

[14] Notice that neither the work from Boyer and Lewis (2002) nor Mishra and Shah, 2009 address on their research any of our fifteen cost management practice. Hence, they were not included in Appendix C: The conceptualisation and measurement of the adoption of cost management practices (survey-based research from 1990 to 2013).

Table 12: Role model papers and its contribution to our measurement items.

Research (Author/date)	Use of	Help-fulness	Strategic Priorties			Collaborative Competences		
			CL	QL	F	CFI	SI	CI
Bhimani (2003)		X*						
Boyer & Lewis (2002)			X	X	X			
Duh et al. (2009)	X*							
Ettlie & Elsenbach (2007)	X*							
Guilding et al. (2000)	X*	X*						
Joshi et al. (2011)		X*						
Mishra & Shah (2009)						X	X	X
Swink (2003)	X*							
Yeh et al. (2010)	X*	X*						

CL= cost leadership, QL = quality leadership, F= flexibility, CFI= cross functional integration, SI= supplier integration, CI= customer integration, X*= the research address at least one of our cost management methods.

6.2.1 The unit of analysis

Theoretical foundations used to postulate the hypotheses of this thesis refer to the adoption of cost management methods at the organisation level. Thus, the "organisation" was chosen as the unit of analysis for the current study. This was explicitly stated in the questionnaire as following: "Please indicate to what extent your organisation uses each of the following cost management methods for product development". Hence, if the organisation was part of a larger group, respondents should interpret the word "organisation" as their business domain. Respondents needed to consider the part of the business domain they believe is coherent in terms of products, customers, or technology, and the interdisciplinary projects they are familiar with. In this way the business domain was considered as the unit of analysis in this empirical investigation

6.2.2 Structure of the questionnaire

The web-based survey[15] was structured in three sections (A, B and C) containing in total 62 questions. The paper-based version of the questionnaire can be found in the Appendix D (see Appendix E for the English translation). Further details regarding each section are presented in the following:

- **Section A** collects demographic characteristics within regard to the organisation[16] and the respondent. In this section respondents were requested to indicate: the industry type and size of their organisation as well as their main functional area (i.e., R&D, Production, controlling or other) and main role on new product development projects.

[15] We used the software for online survey Unipark, and the survey tool Questback EFS 10.5.

[16] We offer the option to answer the questionnaire anonymously. But we make the remark that if the respondent decides to omit their company's name, they will remain completely anonymous. We could not send them the results of our study and they cannot participate in a draw of a tablet. Moreover, respondents were asked if they had a different E-mail address to send them the research results.

- **Section B** addresses the use and helpfulness of cost management methods. Before beginning this section, respondents were reminded that all questions were related to the "organisation" (see section 6.2.1). The measurement instrument in section B covers 15 different cost management methods. For each one, two questions were introduced. One served to assess the extent to which a particular cost management method[17] is used for product development and an additional one to measure to which extent this method is considered helpful for product development. At the end of this section we provided a box for comments.

- **Section C** deals with our explanatory variables, which consist of collaborative competences and strategic priority. Thus, this section is divided in two parts. The first part addresses the level of collaborative competences within the organisation (Mishra & Shah, 2009) e.g., cross-functional, supplier and customer integration. The second part addresses the strategic priority (Boyer & Lewis, 2002) of the organisation e.g., cost leadership, quality leadership and flexibility. At the end of each part, a box for comments is also provided. Questions on section B and C are presented in a different random order[18] for each respondent.

6.2.3 Measurement instrument of the dependent variables

This current research examines two different variables consisting of the use of cost management methods and its helpfulness perceived for product development. Each variable is measured through a single item that assesses each method within a product development context (see the list of methods in Table 1, Chapter 2).

6.2.3.1 Measurement item: *use of*

The item to measure the "*use* of" certain cost management methods was developed based on other authors's work such as Duh et al. (2009), Guilding et al. (2000) and Swink (2003) as indicated in Table 12. A relevant adaptation for our questionnaire was to specify the operational area for which the method needed to be applied which in this case was for new product development (Ettlie & Elsenbach, 2007a). Hence, the survey participants were asked the following question: "indicate to which extent your organisation uses each of the following cost management methods for product development". To answer this question, respondents had a five-point Likert-type scale with the anchors: 1= not at all, to 5= always. Additionally, they had the option of answering "I don't know" as presented in Eatock et al. (2009). Moreover, the definition of each cost management method was included for better understanding and to avoid personal interpretations of concepts (see similar research as for example: Ax et al., 2008; Dekker and Smidt, 2003).

[17] Definitions of each cost management practice were provided as well.

[18] To avoid misallocation patterns (Anderson & Gerbing, 1991).

6.2.3.2 Measurement item: *helpfulness*

Several items can be found in previous studies measuring how useful i.e. how helpful some methods are for product development. Hence, the perceptual measure of helpfulness was based on studies liested in Table 12. Similar to the format employed to measure the use of cost management methods, we used a single item to measure how helpful such methods are. We aimed for consistency between these two items. Therefore, we also included the operational area for which the method might or might not be considered helpful; in this case, for product development (Ettlie & Elsenbach, 2007). The participants could indicate on a five-point Likert-type scale (1= not at all, to 5= always) “to what extent the following cost management methods are helpful for product development at your organisation”. As before, we also included the option “I don’t know” (Eatock et al., 2009).

The next section introduces the instruments employed to measure the explanatory variables. These consisted of the strategic priorities: cost leadership, quality leadership and flexibility as well as the collaborative competences: cross-functional, supplier and customer integration.

6.2.4 Measurement instrument of the independent variables

6.2.4.1 Measuring the strategic priorities

The work of Boyer and Lewis (2002) provided us with a meaningful instrument that measures the strategic priority of an organisation. This instrument was originally adapted from the Boston University Manufacturing Futures Survey (J. Miller & Vollmann, 1984) and specified by Boyer and Lewis (2002) as the instrument which measures the presence of four strategic priorities in the organisation; namely, cost (four items), quality (three items), delivery (three items) and flexibility (six items). This instrument was previously validated by Ward, McCreery, Ritzmann and Sharma, (1998) obtaining a Cronbach’s alpha value of 0.80, 0.72, 0.79 and 0.70 for each priority respectively. This value indicates an acceptable level of internal consistency for the constructs. Subsequent research reported similar Cronbach’s alpha values (see Boyer 1998 and Wong et al., 2011).

We employed Boyer’s instrument to measure the strategic priority of an organisation. However, we excluded all three items with regard to the priority “delivery” and two[19] items with regard to “flexibility” due to their lack of connection with our research scope. Table 13 shows the 11 final items used to measure the emphasis on distinctive strategic priorities consisting of cost leadership, quality leadership and flexibility. Respondents were asked to rate on a seven-point Likert-type scale, as in Boyer’s instrument with the anchors: 1=not important, 4=very important and 7=absolutely critical, “how important is for their organisation the ability to…” The statements concerning the strategic priorities were given (Boyer & Lewis, 2002; Boyer & Pagell, 2000).

[19] Item x: “adjust capacity quickly” and item y: “make rapid volume changes”

Table 13: Items used in the current study to measure strategic priorities original items developed by Boyer and Lewis (2002).

Strategic priorities: measurement items	
Items	**Cost leadership**
Cost1	Increase labor productivity (Q*.29)
Cost2	Increase production capacity utilization (Q.31)
Cost3	Reduce production costs (Q.32)
Cost4	Reduce inventory (Q.37)
Items	**Quality leadership**
Q1	Improve conformance to design specifications (Q.30)
Q2	Provide high-performance products (Q.33)
Q3	Offer consistent, reliable quality (Q.36)
Items	**Flexibility**
Flex1	Make rapid design changes (Q.28)
Flex2	Offer a large number of product features (Q.34)
Flex3	Adjust product mix (Q.35)
Flex4	Offer a large degree of product variety (Q.38)

*The numbering of items corresponds to the questionnaire presented in Appendices D and E.

6.2.4.2 Measuring the collaborative competences

The selection of the measurement items to assess the level of cross-functional, supplier and customer integration were derived from an extensive literature review (Binder et al., 2008; Mishra & Shah, 2009; Swink et al., 2007; Wong et al., 2011). Consistent with Mishra and Shah (2009), we study the collaboration between product design teams and the organisation's suppliers, customers and further functional areas. Finally, we employed the measurement instrument created and validated by Mishra and Shah (2009) to assess the degree of supplier's integration (4 items), cross-functional teams integration (4 items), and customers' integration (4 items). The Cronbach's alpha value obtained by Mishra and Shah (2009) were 0.84, 0.75 and 0.80 for each comptence respectively. Hence, to assess collaborative competences, respondents were asked to indicate their "agreement with each one of the following statements in the organisation".Table 14 shows the twelve statements addressing the organization's actions and efforts in involving suppliers, cross-functional teams and customers with the development of new products. The degree of agreement was rated on a seven-point Likert-type scale through the anchors: 1= strong disagreement, to 7= strong agreement.

Table 14: Items used in the current study to measure collaborative competences (original items developed by Mishra and Shah (2009).

Collaborative competences: measurement items	
Items	**Supplier integration**
Supp1	Suppliers were frequently consulted about the design of this product (Q*.16)
Supp2	We partnered with suppliers for the design of this product *(Q.18)*
Supp3	Suppliers were involved early in the design efforts, in this project *(Q.22)*
Supp4	Suppliers were an integral part of the design effort *(Q.24)*
Items	**Cross-functional integration**
Cross1	The manufacturing function is involved in the creation of new product concepts (Q.17)
Cross2	New product design teams have frequent interaction with the manufacturing function (Q.19)
Cross3	Manufacturing is involved in the early stages of new product development *(Q.21)*
Cross4	New product concepts are developed as a result of the involvement of various functions (Q.27)
Items	**Customer integration**
Cuss1	We consulted customers early in the design efforts for this product *(Q.20)*
Cuss2	Customers were an integral part of the design effort for this project *(Q.23)*
Cuss3	Customers became involved in this project before the design was completed *(Q.25)*
Cuss4	We partnered with customers for the design of this product *(Q.26)*

*The numbering of items corresponds to the questionnaire presented in Appendices D and E.

6.3 Pilot study: testing the survey English version

The current study surveys the manufacturing industry in Germany. However, the first version of our questionnaire was written in English for clarity and to avoid any misinterpretation of the literature while developing the questionnaire. There are several reasons for working on the questionnaire in English. Firstly, the core literature for our research e.g., publications at international journals is mostly in English. These investigations served as a role model for developing the items on demographic data (questionnaire - Section A) and those with regard to the use and helpfulness of cost management methods (questionnaire - Section B). Secondly, the part of the questionnaire referring to the explanatory variables (questionnaire - Section C) included measurement items in which the original language was also English.

Once the English version of the questionnaire was finished, we tested the questionnaire before translating it into German. The questionnaire was e-mailed to a small group of ten professionals with different academic backgrounds within engineering areas. All respondents were working at large organisations in Germany or in German speaking countries (i.e., Switzerland and Austria) during the pilot study. Although the industrial branches were varied, most of respondents had had work experience in project management and product development.

Additionally, valuable feedback was gathered from this pilot study. We obtained feedback regarding the time needed to answer the questionnaire as well as remarks on the structure and comments on how understandable the questions and concepts' definitions were. The pilot study was of great value and helped to improve the questionnaire.

Finally, we decided to include a space for comments after each section of it as this was helpful to further understand the respondent's answers from a qualitative perspective. Furthermore, we made minor changes to the questionnaire structure such as the section order, wording of the instructions and definitions of various concepts. Once the questionnaire was revised we translated[20] it into German and prepared it for the data collection phase. The following section describes this phase in greater detail.

6.4 Sample selection criteria

The Kompass database consisted of approximately 255,000 German firms. From this sampling only 800 companies were selected based on the following criteria (see Appendix F):

Companies should belong to one of the six industry sectors considered to be the most important in Germany in terms of turnover in 2013 (see Table 15[21]).

- Manufacturing firms classified in Kompass database as “producer”.
- Company size of more than 10 employees.
- Companies that provide the full name of their R&D Manager.

We faced a few problems when working with the *Kompass* database. Firstly, we obtained the R&D manager´s complete name but personalized E-mail addresses were not provided because of legal reasons, such as data protection policies. Hence, we conducted a targeted internet search, looking at the web-page of each company for the E-mail addresses of the R&D managers. This search was intended to increase the response rate when conducting our survey. From the 800 German firms, 166 customised e-mails of their R&D managers were found. Further problems included the fact that the database was out of date leading to incorrect information on the companies and R&D managers´ contact information. Finally, our total list of participants[22] consisted of 787[23] German companies.

[20] The questionnaire was translated into German following a translation-back translation method.

[21] These are automotive engineering (24% turnover), mechanical engineering (15%), chemical industry (13 %), food industry21 (12%), electronic and electrical equipment (10%), metal production and processing (7%), and mineral oil processing (6%) source: STATISTA GmbH (2014).

[22] Participants refer to people who presumably were contacted.

[23] During this internet search, we exclude 13 of the 800 companies from our data base because of the lack of pertinent contact information (most of the cases was the dissolution of the company).

Table 15: Industry sector in Germany (source: STATISTA – 2014).

Turnover of the most important industry sector in Germany in the years 2008 to 2013 (in billion euros) Umsätze der wichtigsten Industriebranchen in Deutschland in den Jahren 2008 bis 2013 (in Milliarden Euro)							
	Automotive engineering	Mechanical engineering	Chemical industry	Food industry	Electronic and electrical equipment	Metals production and processing	Mineral oil processing
	Kraftfahr-zeugbau	Maschinen-bau	Chemie	Ernährung	Elektronik und Elektrotechnik	Metallerzeugung und -bearbeitung	Mineralölver-arbeitung
2008	334	222.4	169.3	156	159.6	110.4	92.5
2009	265.6	170.8	145.2	147.7	127.2	72.2	60.3
2010	319.3	186.3	171.1	151.8	150.3	94.2	80
2011	355.2	214.9	184.2	163.3	160.2	116.4	93.8
2012	359.8	223.6	186.8	169.3	153.2	108.7	99.7
2013	364.4	222.8	190.6	175.2	151.2	98.6	93.7
Anteil	24%	15%	13%	12%	10%	7%	6%
Cumulative percentage	24%	39%	52%	64%	74%	80%	86%
Cumulative percentage without food industry							75%

6.4.1 Data gathering process

We contacted the companies via E-mail[24] (see Appendix G) and invited them to participate in our web-based survey (see Appendix H). We addressed the E-mail invitation to the R&D managers of each selected company. This E-mail served to introduce our institute and to transmit the purpose of our research. It also highlighted the anonymity for the respondents and made remarks on the confidentiality for data gathered. Furthermore, the survey design included well-known principles to improve response rates, such promising rewards in the form of a summary of results and the participation in a draw of an electronic device[25] and further follow-up E-mails (Flynn & Sakakibara, 1990; Linsky, 1975). One week after the first mailing, a reminder in form of a postcard was mailed to each R&D manager. The postcard contained the internet address where the survey was hosted. Reminder E-mails and phone calls followed over the next weeks to encourage R&D managers to take part in our survey (see Table 16). The web-based survey was online for about 60 days.

Table 16: Survey timeline.

Course of actions of the web-based survey	
28 November 2014	E-mail invitation
5-10 December 2014	Reminder postcard (Christmas card)
12 January 2015	First reminder E-mail
19 January 2015	Second and last reminder E-mail
22 January 2015	Closed data collection phase

[24] We received 52 E-mail failures, thus E-mail addresses were corrected on our database and invitations were re-sented.
[25] iPad Air 2.

6.4.2 Sample description

The final sample reports on data from 82 R&D managers working at different companies. The software tool we used to conduct the web-based survey allowed us to identify 82 usable questionnaires and drop-out points (see the analysis of survey' desertions per survey page in Appendix I). In total 190 managers visited the web-page of our survey. Whereas 124 began to fill in the questionnaire but did not finish, 81 completed it. We found one questionnaire to be 97% completed[26] and decided to include it in our final sample. Finally, the sample consists of 82[27] usable responses which represent a response rate of 10.41% which is acceptable given the relatively lengthy questionnaire (the average time for completing the questionnaire was 16 minutes). This is comparable to several related studies with similar sample sizes. For example, research with such a similar response rate includes Swink (2003) with 10% and Tan (2001) with 10.33%. Further examples of a similar sample size include Ax et al. (2008); n= 57, Ettlie and Elsenbach (2007); n= 72, Afonso et al. (2008); n= 82, and Yeh et al. (2010); n= 88.

Industry type

The current survey addressed the German manufacturing industry. Thus, the questionnaire assessed the industry type by asking the companies which sector it belonged to. 11 industry sectors were highlighted as being the most important in Germany (see Table 15). The sample is divided into: automotive engineering 11%, electronic 19%, measuring and controlling instruments 9%, chemical industry 6%, rubber & plastics 11%, metal production & processing 11%, mechanical engineering 23% and others[28] 10%. A higher percentage of respondents from mechanical engineering can be found. The distribution of industries is illustrated in Figure 10.

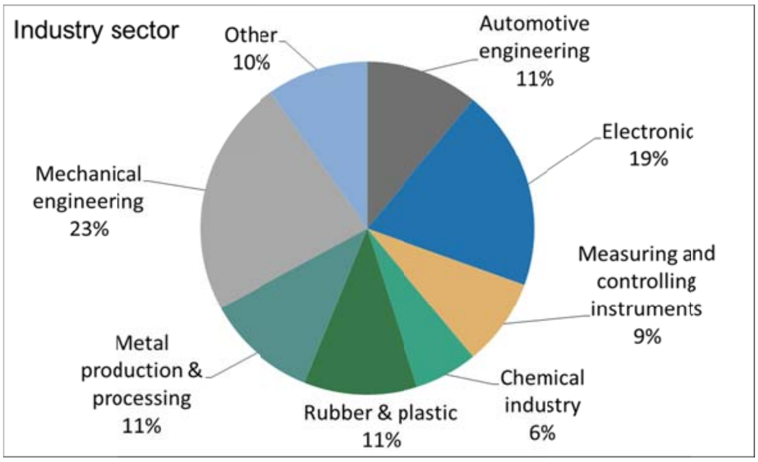


Figure 10: Sample distribution based on the industry type.

[26] Questionnaire was completed in SPSS using an average missing value.

[27] 71 respondents notify the name of their company (86.5%).

[28] Sanitary equipment for all types of vehicles, software, medical technology, shipbuilding, drive technology, glass industry and rail vehicles.

Respondents' profile

To highlight the focus of our research on R&D we looked for managers closely involved in product development. Therefore, we deliberately contacted managers of the R&D department to ensure we would achieve a large amount of knowledge on new product development processes. Respondents needed to have a particularly good overview of how the company deals with their product development costs. However, only 49 % of the respondents were shown to be working in the R&D department. The rest of the respondents were shown to be working in: production (41%), accounting (1%) and other[29] areas (9%). Likewise, to gain an insight into how familiar the respondents were with their R&D projects, we asked about the respondents' roles in NPD projects. They reported being involved in the development of new products either as directors of the company (4%) or department managers (65%), project managers (15%), team members (6%) and others[30] (11%). The distribution of functional areas is illustrated in Figure 11. We observed a high number of managers of R&D departments (65%). The distribution is shown in the Figure below. This is an important requirement for testing the hypotheses on the adoption of cost management methods within an NPD context.

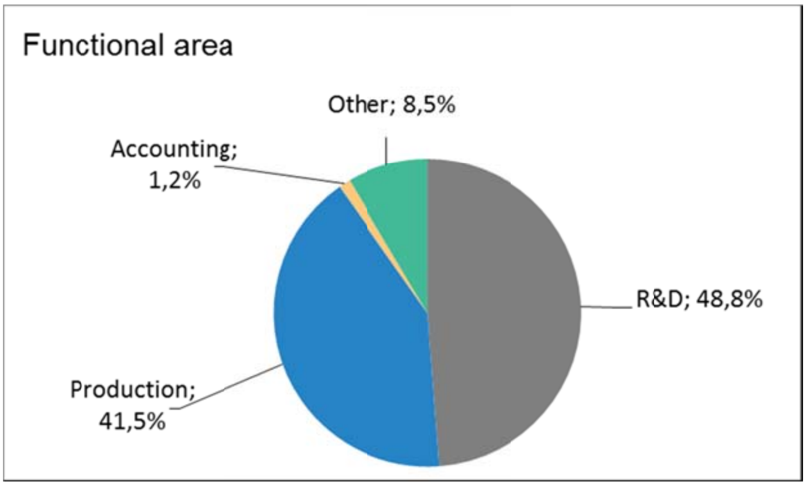


Figure 11: Sample distribution based on the respondents functional area.

We observed a high frequency of respondents being managers of a department (65%). The distribution shown below (Figure 12) illustrates the respondents' main roles in NPD projects. This is an important characteristic for testing the hypotheses on the use and helpfulness of cost management methods within the development of new products.

[29] Technische Leitung, Prototypen-Entwicklung und Fertigung, Vertrieb von Verbindungselementen und die dazugehörige Verarbeitungstechnik, Produkt Engineering, Technik incl. F&E, FuE, Produktion und Vertrieb und Produktmanagement
[30] Werkleiter, Konstrukteur, Entwicklung, Leiter Entwicklung, Innovation Manager, Technischer Leiter und Bereichsleiter

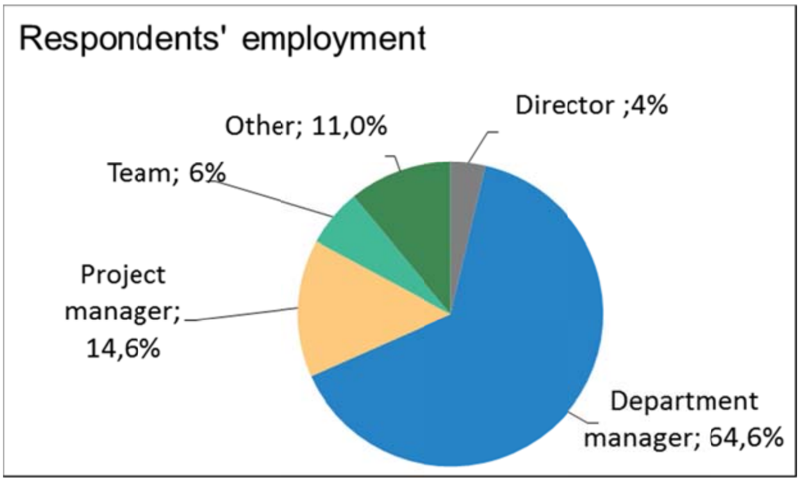


Figure 12: Sample distribution based on the respondents' employment.

Firm size

The size of the firm was measured by the number of employees working at the company. We assessed different intervals employees, namely, 10 – 19 (4.9%), 20 – 49 (18.3%), 50 – 99 (15.9%), 100 – 249 employees (20.7%), 250 – 499 (12.2%), 500 – 999 (14.6%), 1000 – 4999 (8.5%) and more than 5000 (4.9%). These eight groups later served to define small, medium and large firms. In summary, the respondent's classification by "Firm size" gives an average value of 5.2 on an eight-point scale, so that one can speak of a sample of relatively medium firms. The distribution of frequency is illustrated in Figure 13.

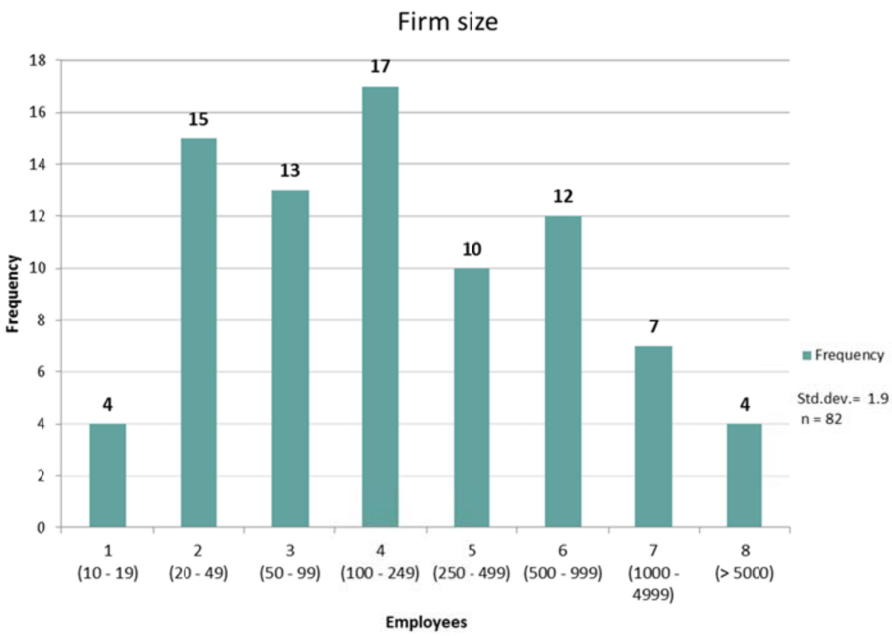


Figure 13: Sample distribution based on firm size.

7 Results

7.1 Introduction

In this chapter the results of the statistical analysis can be found. Data from 82 manufacturing firms forms the sample for studing the adoption of cost management methods (H1-H2) and the antecedents of the adoption (H3-H8). Spearman's correlation analyses were used for testing the esearch hypothesis with help of the IBM SPSS statistical software. Within this Chapter we also documented further analyses which consider different arrangements of the data sample (e.g., by firm's size).

7.2 Preliminary data analyses

The preliminary analyses include reliability tests of measurement instruments, non-response biases test and data set arrangements e.g. defining how to deal with missing data and compute new variables. These analyses are described in more detail in the sections below.

7.2.1 Reliability of measurement instruments

We assessed the reliability (i.e., the Cronbach's alpha) of the measurement items to verify the constructs quality. A relevant aspect in measuring this is the assessment of a construct's internal consistency. Finally, besides assessing the reliability of the scales, we checked the reliability of its indicators (i.e., of its items) by analysing the "item-to-total correlation" and performing a factor analysis. These were performed with the SPSS statistical software.

Reliability is the degree to which a scale (comprised by a set of items) might measure the same underlying attribute (Tinsley & Brown, 2000). Cronbach's coefficient alpha is the most common statistic to measure the reliability of items within a construct. This statistic provides an indication of the average correlation among all of the items that set a construct. The value of such correlation might range from 0 to 1, where a higher value indicates a stronger correlation and hence, a greater reliability (Nunnally & Bernstein, 1994). Considering that different levels of reliability are required depending on the nature and purpose of a scale, Nunnally and Bernstein (1994) recommend a minimum level of .7. However, Cronbach alpha values depend on the number of items in the scale (Pallant, 2013). Thus, in scales with a small number of items (e.g. less than 10) the mean inter-item correlation with acceptable values will range from .2 to .4 (Briggs & Cheek, 1986). The item-total correlation coefficient shows the correlation of each item based on the sum of all of them associated for the same construct. The higher the item-to-total correlation within items is, the greater its contribution to the reliability of the construct. The recommended value for the item-total correlation coefficient is above .3 (Nunnally & Bernstein, 1994; Yeh et al., 2010). For the evaluation of the scales employed, the statistic factor analysis was used as a technique to capture the variability in the patterns of correlations. A relevant issue that can be addressed through factor analysis concerned the strength of the inter-correlations among items, i.e., whether all items can be clearly assigned to a singular "factor" (i.e., the measured construct) and make sure that each group of items (i.e. the scale) measures a particular concept (Wong et al., 2011). Tabachnick and Fidell (2007) recommend an inspection of an inter-item correlation matrix for evidence of coefficients greater than .3

Strategic priority scales

As exposed in the theoretical part of this thesis, the concept of strategic priorities consist of three constructs, namely, *cost leadership*, *quality leadership* and *flexibility*. According to Ward et al. (1998) the measurement scales proposed by Boyer and Lewis (2002) have a good internal consistency with Cronbach alpha coefficients of .80 for cost leadership, .72 for quality leadership and .70 for flexibility. In this current study, the Cronbach alpha coefficients were .78, .50 and .55 respectively (see Table 17). Although these values are slightly different from the ones obtained by Ward et al. (1998), these coefficients also demonstrate that the reliability of the construct is acceptable.

Table 17: Measurement of strategic priorities (items developed by Boyer and Lewis, 2002).

Strategic priorities	Item-Total Correlation
Cost leadership (Cronbach alpha: .780)	
Cost1	.576
Cost2	.609
Cost3	.651
Cost4	.507
Quality leadership (Cronbach alpha: .500)	
Q1	.404
Q2	.323
Q3	.296
Flexibility (Cronbach alpha: .554)	
Flex1	.315
Flex2	.400
Flex3	.325
Flex4	.320

The item's description can be found in section 6.2.4 (see also Appendix D and Appendix E).

It is important to notice that some scales are reliable within some groups (e.g. adult with an English-speaking background), but are totally unreliable when used with other groups (e.g. children from a non-English-speaking background) (Pallant, 2013). In this particular case, our resulting Cronbach alpha values differed from those of Ward et al. (1998). Thus, we considered that the scales could be more reliable for a particular firm type. Large firms could interpret the questionnaire and report differently than small firms based on their environment at work. Table 17 presents the respective item-to-total correlation as well as the Cronbach's alpha revealed in our analysis. Overall, the reliability of all constructs regarding the “strategic priorities” are denoted as satisfactory, although the item-total correlations of the “quality leadership” and “flexibility” scales are close to the minimum requirements suggested by Nunnally and Bernstein (1994).

Collaborative competence scales

The collaborative competence comprehends three scales, namely, *supplier integration*, *cross-functional integration* and *customer integration*. According to Mishra and Shah (2009) these scales have a good internal consistency. Their Cronbach alpha coefficients values are .84, .75, .80 respectively. In this current study the resulting Cronbach alpha coefficients were .84 for supplier integration, .80 for cross-functional integration and .69 for customer integration (see Table 18).

Table 18: Measurement of collaborative competences (items were developed by Mishra & Shah, 2009).

Collaborative competences	Item-Total Correlation
Supplier integration (Cronbach Alpha: .840)	
Supp1	.798
Supp2	.549
Supp3	.764
Supp4	.627
Cross-functional integration (Cronbach Alpha: .796)	
Cross1	.714
Cross2	.545
Cross3	.650
Cross4	.528
Customer integration (Cronbach Alpha: .685)	
Cuss1	.611
Cuss2	.543
Cuss3	.380
Cuss4	.379

The item’s description can be found in section 6.2.4
(see also Appendix D and Appendix E).

Table 18 presents the respective item-to-total correlation as well as the Cronbach's alpha revealed for the construct. Hence, the constructs related to the concept of collaborative competences can be described as highly reliable, since the minimum requirements specified above were all met. Cronbach alpha coefficients which were above .70 on average and all values within the inter-item correlation matrix are positive. This indicates that all items measure the same characteristic.

7.2.2 Non-response bias

We tested for Non-response bias by using the extrapolations suggested by Armstrong and Overton (1977). These assume that data from late respondents are representative for non-respondents (Armstrong & Overton, 1977; Lambert & Harrington, 1990). In Table 19 the data from the first and last fifteen completed and usable questionnaires were compared[31] with each other using an independent samples test (Levene's test for equality of variances). All compared variables scored F-values below the reference F-value = 4.66 (Stock & Watson, 2012, p. 797). These results showed no statistical significant differences between early and late respondents across 15 dependent variables, significant at $p<0.05$. Hence, the Levene's test suggested non-response was not a problem in this study.

Table 19: Independent samples test for non-response bias.

Dependent variable: *Use of*	Levene's test for equality of variances								
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Target costing	1.423	0.244	1.704	25	0.101	0.835	0.490	-0.174	1.845
Value engineering	0.705	0.409	-0.124	25	0.902	-0.060	0.487	-1.064	0.944
Quality function deployment	0.669	0.421	0.154	24	0.879	0.077	0.500	-0.956	1.110
Functional cost analysis	2.453	0.130	0.268	25	0.791	0.154	0.575	-1.030	1.338
Kaizen costing	2.451	0.130	2.171	26	0.039	1.214	0.559	0.065	2.364
Life-cycle costing	0.382	0.542	0.133	28	0.895	0.067	0.501	-0.959	1.092
Total cost of ownership	0.036	0.852	0.634	26	0.532	0.357	0.563	-0.801	1.515
Stage-gate reviews	1.983	0.171	0.231	26	0.819	0.143	0.619	-1.129	1.415
Funnels	0.909	0.349	1.066	25	0.297	0.533	0.500	-0.497	1.563
Design for manufacturing	0.640	0.431	0.134	26	0.895	0.067	0.498	-0.957	1.091
Design for X	2.931	0.100	-0.344	23	0.734	-0.167	0.484	-1.169	0.835
Component commonality	2.591	0.120	0.975	26	0.339	0.571	0.586	-0.634	1.777
Modular design	0.709	0.408	0.469	24	0.643	0.231	0.492	-0.784	1.245
Product platform	0.208	0.652	0.681	25	0.502	0.319	0.468	-0.646	1.283
Technology roadmap	2.412	0.133	0.678	24	0.504	0.385	0.567	-0.786	1.555

Reference value (using an F Table for $\alpha = 0.05$) = 4.6672

7.2.3 Preparing the data set for the statistical analysis

This preliminary arrangement allows us to prepare the data set to conduct specific statistical techniques to address our research questions, for example, to determine how to deal with missing data and how did we compute the variables needed to test the hypotheses[32].

Dealing with missing data

[31] See similar research Wong et al. 2011.

[32] We also check for outliers based on the average *use of* cost management methods. Correlation tests were conducted with and without companies that could have been identified as an outlier due to their low average use. However, correlation coefficients showed that such "outlier" companies did not have a statistically significant influence on the test results.

When doing research, especially with human beings, it is rare to obtain complete data from every case (i.e., respondents). Hence, it is possible that two types of missing data occur in this current research. On the one hand, one type of missing data may occur because the information is incomplete. On the other hand, the type of data (i.e., raw data) obtained cannot be used for a specific statistical analysis.

The first is a common issue within social science research, thus we assume that some questionnaires might not be completed. This issue of missing data may occur either by the respondent withholding information (i.e., because they do not what to share particular information) or by mistake (e.g., distraction caused by time pressure, which may lead to skipping questions without realising). Therefore, to avoid incomplete questionnaires, our web-based survey only allowed the respondent to continue to the next question (or section) after completing the previous section.

The second issue of missing data relates to the lack of specific values needed for certain statistical analyses. Many of the IBM SPSS statistical procedures offer different choices on how to deal with missing data. It is important to choose carefully as it can have a powerful effect on the results. Foremost when a list of variables is included and the same analysis for all variables will be repeated e.g. correlations among a group of variables and t-tests for a series of dependent variables, which are precisely the type of statistical analyses conducted to evaluate the hypotheses of this current research. Therefore, the second section of our survey that measures the concept of adoption (section B) includes the opportunity for the respondent to acknowledge if they did not know how to evaluate the question. Hence, we defined such an answer "6 = I don't know" as a missing value and decided to deal with this by choosing to "exclude cases pairwise[33]". This option excludes these cases (i.e., firms' data) only if they are missing from the data required for the specific analysis. This leads to a higher accuracy among the correlations between the tested variables.

Computing the scores of variables

The raw data had to be analysed in greater depth. This included collapsing (i.e., grouping) categorical variables[34] and calculating the total score on scales by adding up the scores obtained on each of the individual items. Before any statistical analysis could be performed we needed to calculate the total scale scores for all variables used. This involved reversing any negatively worded items (which did not occur in this research[35]) and adding together the score from all the items that make up a scale. Finally, we created the variables that were used either as dependent as well as independent variables to test the hypothesis. For example, grouping the average use of only the methods: target costing, value engineering, QFD, functional cost analysis and Kaizen costing to create the variable: Group_I_U. Table 20 presents a complete list of all variables used and how they were computed.

[33] This explains as well the variation of sample size in the analysis (e.g. correlations) introduced in later sections.
[34] To create three data sets based on the eight categories of firm's size.
[35] All items were formulated in positive sentences.

Table 20: List of computed variables.

Abbreviation	Label	Calculation
Supp_scale	Supplier integration	mean value (μ), (Supp1, Supp2, Supp3, Supp4)
Cross_scale	Cross-functional integration	mean value (μ), (Cross1, Cross2, Cross3, Cross4)
Cus_scale	Customer integration	mean value (μ), (Cus1, Cus2, Cus3, Cus4)
Cost_scale	Cost leadership	mean value (μ), (Cost1, Cost2, Cost3,Cost4)
Q_scale	Quality leadership	mean value (μ), (Q1, Q2, Q3)
Flex_scale	Flexibility	mean value (μ), (Flex1, Flex2, Flex3, Flex4)
Use_CMM	Use of methods	mean value (μ) of the "use of "all 15 methods
Helpfulness_CMM	Helpfulness of methods	mean value (μ) of the "helpfulness of" all 15 methods
GroupI_U	Use of methods from group I	mean value (μ) methods: Target Costing, Value Engineering,Quality Function Deployment, Functional Cost Analysis, Kaizen Costing
GroupIII_U	Use of methods from group III	mean value (μ) methods: Life Cycle Costing, Total Cost of Ownership, Stage Gate Reviews, Funnels, DFM, DFX
GroupIV_U	Use of methods from group IV	mean value (μ) methods: Component Commonality, Modular Design, Product Platforms, Technology
GroupIII_IV_U	Use of methods from group III and IV	mean value (μ) methods in group III and IV
GroupV_U	Use of methods from group V	mean value (μ) methods: Quality Function Deployment
GroupVI_U	Use of methods from group VI	mean value (μ) methods: Technology Roadmaps
GroupVII_U	Use of methods from group VII	mean value (μ) methods: Target Costing, Value Engineering, Life Cycle Costing, Total Cost of Ownership
GroupVIII_U	Use of methods from group VIII	mean value (μ) methods: Stage-Gates Reviews, Modula Design, Technology Roadmaps
GroupIX_U	Use of methods from group IX	mean value (μ) methods: Value Engineering, Functional Cost Analysis, Kaizen Costing, Life Cycle Costing
GroupX_U	Use of methods from group X	mean value (μ) methods: Stage-Gates Reviews, Funnels, DFM, DFX, Component Commonality, Modular Design, Product Platforms
GroupI_H	Helpfulness of methods from group I	mean value (μ) methods: Target Costing, Value Engineering, Quality Function Deployment, Functional Cost Analysis, Kaizen Costing
GroupIII_H	Helpfulness of methods from group III	mean value (μ) methods: Life Cycle Costing, Total Cost of Ownership, Stage Gate Reviews, Funnels, DFM, DFX
GroupIV_H	Helpfulness of methods from group IV	mean value (μ) methods: Component Commonality, Modular Design, Product Platforms, Technology
GroupV_H	Helpfulness of methods from group V	mean value (μ) methods: Quality Function Deployment
GroupVI_H	Helpfulness of methods from group VI	mean value (μ) methods: Technology Roadmaps
GroupVII_H	Helpfulness of methods from group VII	mean value (μ) methods: Target Costing, Value Engineering, Life Cycle Costing, Total Cost of Ownership
GroupVIII_H	Helpfulness of methods from group VII	mean value (μ) methods: Stage-Gates Reviews, Modula Design, Technology Roadmaps
GroupIX_H	Helpfulness of methods from group IX	mean value (μ) methods: Value Engineering, Functional Cost Analysis, Kaizen Costing, Life Cycle Costing
GroupX_H	Helpfulness of methods from group X	mean value (μ) methods: Stage-Gates Reviews, Funnels, DFM, DFX, Component cmmonality, Modular Design, Product Platforms
NewFirm_size	Firm size	split data into three groups based on the nr. of employyes: 1. small (<100), 2. medium (100-499) and 3. large (>500)
Strategy	Strategic priority of a company	The variable splits the data in three samller samples based on their strategic priority. For example, to distinguish the sample (firms) in which "Cost_scale" score a higher mean value than "Q_scale" and "Flex_scale". Same for the firm with the higher mean value of "Q_scale" and "Flex_scale"

7.3 Descriptive statistics

The concept of adoption was defined as the extent to which the organisation applies a particular method for the purpose of cost management within new product development. Thus, we measured it through the variable "*use of*". Moreover, we examined as well how helpful such methods are trough the variable "helpfulness". This last variable had a twofold role within the statistical analysis. On the one hand, it served as an independent variable to evaluate hypotheses 1 and 2. On the other hand, it served as a dependent variable to evaluate hypotheses 3 to 8.

Finally, in order to explain the adoption of certain methods, we determined six independent variables within the framework of the organisation's strategic priority and its distinguished collaborative competences (see exact definitions in Chapter 5, Table 11). This section follows with descriptive statistics of both, the dependent as well as independent variables.

7.3.1 Dependent variables

The descriptive statistics of the dependent variables "*use of*" and "*helpfulness*" are presented in Table 21and Table 22. For the exploratory purpose of this analysis, the results were computed for each of the 15 surveyed cost management methods.

Table 21: Descriptive statistics of the dependent variable *"use of"* (methods are sorted by decreasing mean values).

	Variable: "*Use of*"						
Cost management methods	N-Valid	N-Missing	Mean	SD	Variance	Min.	Max.
Target costing	75	7	3.40	1.32	1.73	1	5
Product platform	76	6	3.36	1.03	1.06	1	5
Modular design	76	6	3.34	1.15	1.32	1	5
Design for manufacturing	76	6	3.28	1.32	1.75	1	5
Total cost of ownership	76	6	3.04	1.38	1.91	1	5
Kaizen costing	78	4	3.04	1.34	1.80	1	5
Functional cost analysis	78	4	3.03	1.26	1.58	1	5
Stage-gate reviews	74	8	3.01	1.49	2.21	1	5
Value engineering	74	8	2.95	1.11	1.23	1	5
Component commonality	75	7	2.77	1.36	1.85	1	5
Technology roadmap	72	10	2.61	1.27	1.62	1	5
Quality function deployment	75	7	2.49	1.27	1.60	1	5
Funnels	78	4	2.27	1.38	1.91	1	5
Design for X	71	11	2.21	1.22	1.48	1	5
Life-cycle costing	76	6	2.20	1.35	1.81	1	5

These items were evaluated from 1 to 5 (1= not at all, 2= rarely, 3= sometimes, 4= often and 5= always). N-missing values represent the number of managers who answered "I don't know" to the questions regarding the use of such methods.

Descriptive statistics of the variable *"use of"* shown in Table 21, demonstrated that while the **target costing** had the greater mean value of 3.63 (in a 5 points scale), the method **life-cycle costing** scored the lowest mean value of 2.20. Hence, target costing, through its average rank, could be interpreted as being "often" used in product development. In contrast to this, we can infer that life-cycle costing method is “rarely” used in product development. A further interesting result is that **product platform** score was second to target costing, with a mean value of 3.36. We also observed this method has the lowest variance value of 1.06 which means there was a consensus among all firms about level of use (“sometimes”) of product platforms as a cost management method in NPD.

In Table 22, the descriptive statistics of the variable *"helpfulness"* showed that while the **modular design** method had the greater mean value of 3.81 (in a 5 points scale), the **funnels** method had the lowest mean value of 2.59. On the one hand, modular designs, through its average rank, could be interpreted as being “often” considered helpful in product development. The Funnels method, on the other hand, was only considered to be “sometimes” helpful for product development. It is interesting to note the discrepancy between the methods identified as helpful and which are actually used (Table 21, Table 22). However, the consensus regarding the helpfulness of product platform seems to remain. The method scored again the lowest variance value of 1.09 which means a consistent evaluation on the helpfulness of this method.

Table 22: Descriptive statistics of the dependent variables “helpfulness” (methods are sorted by decreasing mean values).

	Variable: *"Helpfulness"*						
Cost management methods	N-Valid	N-Missing	Mean	SD	Variance	Min.	Max.
Modular design	73	9	3.81	1.16	1.35	1	5
Target costing	72	10	3.63	1.22	1.48	1	5
Design for manufacturing	72	10	3.63	1.22	1.48	1	5
Product platform	75	7	3.55	1.04	1.09	1	5
Value engineering	71	11	3.51	1.14	1.31	1	5
Functional cost analysis	75	7	3.48	1.23	1.52	1	5
Total cost of ownership	72	10	3.42	1.18	1.40	1	5
Stage-gate reviews	70	12	3.41	1.28	1.64	1	5
Kaizen costing	75	7	3.33	1.19	1.41	1	5
Component commonality	71	11	3.18	1.33	1.78	1	5
Quality function deployment	67	15	3.15	1.29	1.67	1	5
Technology roadmap	67	15	3.12	1.32	1.74	1	5
Design for X	64	18	2.66	1.22	1.50	1	5
Life-cycle costing	68	14	2.65	1.35	1.81	1	5
Funnels	69	13	2.59	1.46	2.13	1	5

These items were evaluated from 1 to 5 (1= not at all, 2= rarely, 3= sometimes, 4= often and 5= always). N-missing values represent the number of managers who answered “I don’t know” to the questions regarding the use of such methods.

Interesting observation from the descriptive statistics is the fact that when comparing the means values of the variables *"use of"* and *"helpfulness"*, no single method scored a higher use than is perceived helpfulness (see Table 23). Hence, we can conclude from these results that, the perception of how helpful is the employment of cost management methods during NPD, could be in fact higher than its actual use.

Table 23: Comparison of use and helpfulness of each cost management method (methods are arranged in decreasing order based on the mean values difference).

	Mean values			
List of methods	use of		helpfulness	Difference
Quality function deployment	2.49	<	3.15	0.66
Value engineering	2.95	<	3.51	0.56
Technology roadmap	2.61	<	3.12	0.51
Modular design	3.34	<	3.81	0.47
Functional cost analysis	3.03	<	3.48	0.45
Life-cycle costing	2.20	<	2.65	0.45
Design for X	2.21	<	2.66	0.44
Component commonality	2.77	<	3.18	0.41
Stage-gate reviews	3.01	<	3.41	0.40
Total cost of ownership	3.04	<	3.42	0.38
Design for manufacturing	3.28	<	3.63	0.35
Funnels	2.27	<	2.59	0.32
Kaizen costing	3.04	<	3.33	0.29
Target costing	3.40	<	3.63	0.23
Product platform	3.36	<	3.55	0.19
Total average	2.87	<	3.27	0.40

7.3.2 Independent variables

The descriptive statistics of all independent variables are presented in Table 24 and Table 25. These independent variables relate to the organisation´s collaborative competences (Table 24) and its strategic priorities (Table 25).

Table 24 shows the descriptive statistics of all item related to the concept of collaborative competence. The scales indicated in a 7 point scale, the following mean values of 4.10 for the *supplier integration* scale, 5.16 for *cross-functional integration* and 4.98 for *customer integration*. Here as well, the average values of all three collaborative competences are above the level "neutral". Their standard deviation values (SD) were followed by 1.26, 1.05 and 1.01 and a variance of 1.60, 1.11, and 1.02 respectively.

Table 24: **Descriptive statistics of the independent variables: collaborative competences scales and their items. The list of computed variables is provided in Table 20.**

Collaborative competences scales	N-Valid	N-Missing	Mean	SD	Variance	Min.	Max.
Supplier integration	82	0	4.10	1.26	1.60	1.00	6.25
Cross-functional integratior	82	0	5.16	1.05	1.11	2.00	7.00
Customer integration	82	0	4.98	1.01	1.02	2.75	6.75
Items							
Supp1	82	0	4.16	1.34	1.79	1	6
Supp2	82	0	4.04	1.71	2.92	1	7
Supp3	82	0	4.23	1.47	2.16	1	7
Supp4	82	0	3.96	1.61	2.58	1	7
Cross1	82	0	4.96	1.43	2.04	1	7
Cross2	82	0	5.26	1.27	1.60	2	7
Cross3	82	0	5.04	1.36	1.86	2	7
Cross4	82	0	5.39	1.27	1.62	2	7
Cus1	82	0	5.34	1.24	1.54	3	7
Cus2	82	0	5.17	1.39	1.95	2	7
Cus3	82	0	4.77	1.36	1.86	1	7
Cus4	82	0	4.65	1.61	2.58	1	7

These items were evaluated in a 7 points scale (1= strongly disagree, 2= disagree, 3= slightly disagree, 4= neutral, 5= slightly agree, 6= agree and 7= strongly agree). The item's description can be found in section 6.2.4 (see also Appendix D and Appendix E).

Table 25 presents the descriptive statistics from the measurement scales related to the organisation´s strategic priorities. The results showed in a 7 point scale, the mean values of 4.67 for *cost leadership*, 5.23 for *quality leadership* and 4.41 for *flexibility*. Hence, we can report that when analysing the whole sample (82 firms), the average values of the three priorities are above the level "very important". Furthermore, their standard deviation values (SD) showed 1.15, 0.95 and 1.10 as well as variance of 1.33, 0.91, and 1.00 respectively. Although, we can infer that there was a slightly higher emphasis on the *quality leadership* than on the other two priorities (i.e., cost leadership and flexibility), all three priorities scored very similar mean values. This challenges our understanding of the literature, which suggests that some priorities could contradict each other. We expected a higher preference for the strategic priority of flexibility, since the focus of our research lies on product development and by assuming that today's trends of innovation aims to rapidly fit the market requirements in a fast growing high-tech setting.

Table 25: Descriptive statistics of the independent variables: strategic priority scales and their items. The list of computed variables is provided in Table 20.

Strategic priority scales	N-Valid	N-Missing	Mean	SD	Variance	Min.	Max.
Cost leadership	82	0	4.67	1.15	1.33	1.50	7.00
Quality leadership	82	0	5.23	0.95	0.91	3.00	7.00
Flexibility	82	0	4.41	1.00	1.00	1.75	7.00
Items							
Cost1	82	0	5.02	1.45	2.10	2	7
Cost2	82	0	4.72	1.45	2.11	1	7
Cost3	82	0	5.07	1.53	2.34	1	7
Cost4	82	0	3.87	1.51	2.27	1	7
Q1	82	0	3.79	1.52	2.31	1	7
Q2	81	1	5.41	1.57	2.47	1	7
Q3	81	1	6.54	0.78	0.60	4	7
Flex1	82	0	4.38	1.65	2.73	1	7
Flex2	82	0	4.40	1.55	2.39	1	7
Flex3	82	0	4.67	1.37	1.88	2	7
Flex4	82	0	4.17	1.55	2.39	1	7

These items were evaluated in a 7 points scale (1=not important, 4= very important and 7= absolute critical). The item's description can be found in section 6.2.4 (see also Appendix D and Appendix E).

7.3.2.1 Spliting the data set based on the firms' strategic priority (cost – quality – flexibility)

It is important to note the belief that two priorities do not fit together within a single company (Boyer & Lewis, 2002). For example, cost leadership and flexibility contradict each other principles (see section 5.4.1). Hence, splitting the data set based on the firm's priority turns a requirement to test hypothesis 3 to 5. We defined the "strategic priority" of a firm based on the priority (cost, quality or flexibility) that scores, above the other two strategies, the highest mean value (see Table above). The evaluation of this data demonstrates the following groups: 25 firms show cost leadership, 57 show quality leadership and none show flexibility (see Figure 14).

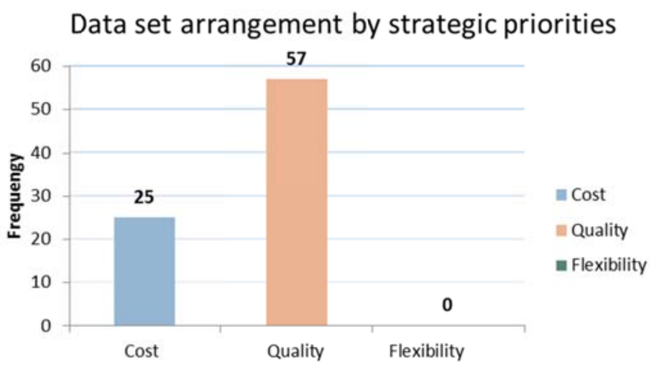


Figure 14: Sample distribution based on firms' strategic priority.

7.4 Hypotheses' evaluation

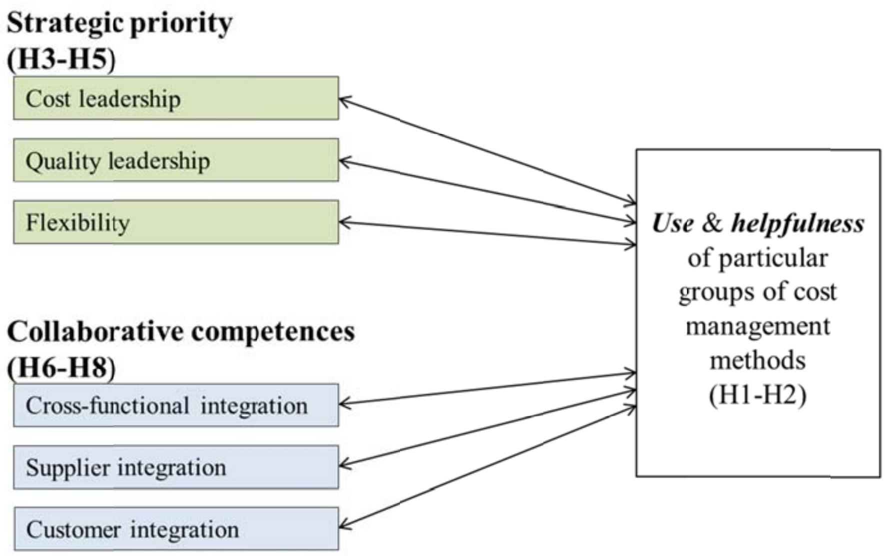


Figure 15: Conceptual model of all hypotheses.

The following sections are dedicated to examine the hypotheses within our framework as stated in Chapter 5 (see Figure 15). Here are three assumptions we tested within the German manufacturing industry:

- The use of cost management methods are perceived as being helpful for managing costs within new product development processes (Hypothesis 1 and 2).
- There is a relationship between the use and helpfulness of certain cost management methods and the organisation's strategic priority (Hypotheses 3 to 5).
- There is a relationship between the use and helpfulness of certain cost management methods and the organisation's collaborative competences (Hypotheses 6 to 8).

All in all, for researchers in the field of management accounting, we provide based on a large-scale investigation, the first empirical evidence of a relationship between certain cost management practices and particular company characteristics. Table 26 summarizes the results of the hypotheses testing. The support found for the Hypotheses relies on the results of Spearman's correlation analysis. Finally, this research found that in a R&D context, the use of cost management methods is strongly related to the perception of their helpfulness and provide empirical evidence that cost leadership, cross functional integrations and supplier integration explain the adoption of certain method during NPD.

Table 26: Summary of hypothesis testing results.

Hypo-thesis	Independent variable	Dependent variable	Result
H1	**Helpfulness of** all methods	**Use of** all methods	**Supported**
H2a	**Helpfulness of** methods in Group–I	**Use of** methods in Group–I	**Supported**
H2b	" methods in Group–III	" methods in Group–III	**Supported**
H2c	" methods in Group–IV	" methods in Group–IV	**Supported**
H3a	**Cost-leadership**	**Use of** methods in Group–I	Not supported
H3b	"	**Use of** methods in Group–III	**Supported**
H3c	"	**Helpfulness of** methods in Group–I	Not supported
H3d	"	**Helpfulness of** methods in Group–III	Not supported
H4a	**Quality-leadership**	**Use of** methods in Group–I	Not supported
H4b	"	**Use of** methods in Group–III	Not supported
H4c	"	**Helpfulness of** methods in Group–I	**Supported**
H4d	"	**Helpfulness of** methods in Group–III	**Supported**
H5a	**Flexibility**	**Use of** methods in Group–IV	*
H5b	"	**Helpfulness of** methods in Group–IV	*
H6a	**Cross-functional integration**	**Use of** methods in Group–IX	**Supported**
H6b	"	**Use of** methods in Group–X	**Supported**
H6c	"	**Helpfulness of** methods in Group–IX	**Supported**
H6d	"	**Helpfulness of** methods in Group–X	**Supported**
H7a	**Supplier integration**	**Use of** methods in Group–VIII	**Supported**
H7b	"	**Use of** methods in Group–VIII	**Supported**
H7c	"	**Helpfulness of** methods in Group–VII	**Supported**
H7d	"	**Helpfulness of** methods in Group–VIII	Not supported
H8a	**Customer integration**	**Use of** methods in Group–V	Not supported
H8b	"	**Use of** methods in Group–VI	Not supported
H8c	"	**Helpfulness of** methods in Group–V	Not supported
H8d	"	**Helpfulness of** methods in Group–VI	Not supported

* Hypotheses could not be tested due to the lack of data.

7.4.1 Correlation analysis

The eight hypotheses addressed in this study are evaluated through the statistical correlation analysis. A correlation analysis is used to describe the strength of the lineal relationship between the dependent and independent variables. The Pearson's correlation (p) analysis evaluates whether there is statistical evidence for a linear relationship among the same pairs of variables in the population represented by a population correlation coefficient. Unlike Pearson's correlation (ρ), Spearman's coefficient (rho) is commonly used in non-parametric tests[36] to measure the relationship between two continuous random variables[37], e.g., ordinal data based on the ranks of observations (Sprent & Smeeton, 2007). The hypothesis testing relies on Spearman's correlation coefficient. This is consistent to the type of data gathered (i.e., Likert scales) to measure the R&D manager's personal perception, i.e., a degree of agreement (Pallant, 2013).

Finally, we followed the guidelines suggested by Cohen (1988) on the interpretation of the correlation coefficient values. A correlation is considered "small" when values range between .10 - .29, "medium" with .30 - .49 and "large" for values above .50. Hence, we consider an acceptable correlation of all statistically significant coefficient (rho) values above .10.

7.4.2 Analysing the adoption of cost management methods

Hypothesis 1 tackles the relationship between the *"use of"* all methods (as measured with the variable Use_CMP) and their perceived *"helpfulness"* (as measured with the variable Helpfulness_CMP). This relationship is investigated using Spearman's rank order correlation[38] (rho). Table 27 shows the results of the correlation analysis, the sample (N) and the significance (2-tailed) value. The Scatterplot of this correlations analysis can be found in Appendix J. In this regard, we found a strong positive correlation coefficient (rho) between the two variables; *"use of"* and *"helpfulness"* of .611, which is statistically significant at $p < .01$ for a two-tailed test. Following the guidelines suggested by Cohen (1988) on the interpretation of the correlation coefficient values. A correlation is considered "large" for values above .50. Thus, as high use of all cost management methods increased, high perception of their helpfulness followed within a new product development context. Hence, we found support for **hypothesis 1**.

Moreover, as presented in the theoretical part of this research, there is a limited amount of empirical research which evaluates the adoption of certain cost management methods with regard to their perceived benefits i.e., how helpful they are within the new product development context. The main objective of our second hypothesis (H2) is to investigate this adoption when methods are arranged in different groups based on their scope. Group I included the methods used for individual products or services which considered the unit manufacturing costs. Group III also referred to the methods employed for individual products or services (see clustering of methods in Figure 5, Chapter 5).

[36] Spearman's correlation is a rank based measure, which is non-parametric and is not based on the assumption of normality (Sprent & Smeeton, 2007).
[37] Spearman's coefficients (rho) as well as Pearson's coefficient (r) are not a function of the number of observations. Hence, for n >2 rho (i.e. r) must equal +1 or -1 when each variable is perfectly predicted by the other. This provides the degree of relationship (Cohen & Cohen, 1975).
[38] Preliminary analyses were performed to ensure there was no violation of the correlation test requirements.

Table 27: Correlation analysis between the variables "u*se and helpfulness"* of cost management methods (Hypotheses 1 and 2). The list of computed variables is provided in Table 20.

			Variable: *"Helpfulness of"*			
			Helpfulness_ CMM	GroupI_H	GroupIII_H	GroupIV_H
Variable: *"Use of"*	Use_CMM	Correlation Coefficient	.611**	.569**	.471**	.449**
		Sig. (2-tailed)	.000	.000	.000	.000
		N	82	80	81	82
	GroupI_U	Correlation Coefficient	.386**	.516**	.308**	.181
		Sig. (2-tailed)	.000	.000	.005	.106
		N	81	80	80	81
	GroupIII_U	Correlation Coefficient	.504**	.510**	.608**	.287**
		Sig. (2-tailed)	.000	.000	.000	.009
		N	82	80	81	82
	GroupIV_U	Correlation Coefficient	.441**	.264*	.162	.784**
		Sig. (2-tailed)	.000	.018	.148	.000
		N	82	80	81	82

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
The grey areas highlight the corresponding hypotheses.

However, this group considered as well the entire costs for developing such products. Finally, the methods in group IV addressed a portfolio of products including the costs of development activities (detailed information about the clustering of methods was presented in section 5.3.1). In other words, we investigate through hypothesis 2a, if the use of methods classified in Group–I are also considered as helpful for NPD. Likewise, Hypothesis H2b and H2c analyse this relationship for the methods in Group–III and Group–IV respectively (see Figure 5, Chapter 5).

Table 27 shows as well the results of the correlation analysis between the variables "*use of*" and "*helpfulness*" when the methods were arranged by groups[39]. We conducted the correlation analyses for those methods classified in Group–I (i.e., Hypothesis 2a), Group–III (i.e., Hypothesis 2b) and Group–IV (i.e., Hypothesis 2c). We observed the coefficient (rho) values of .516, .608, and .784 respectively, all three being statistically significant ($p < .01$ for a two-tailed test). Hence, since all correlation values are above .500, we concluded a quite strong relationship between these variables (Cohen, (1975). Finally, we found support for **hypotheses H2a, H2b and H2c**. Scatterplots of these correlations analyses can be found in Appendix K.

[39] Samples may vary due to the statistical analysis configuration suggested by SPSS software to deal with the missing values (i.e., excluding cases pairwise).

7.4.3 Analysing the organisation's strategic priority as an antecedent of the adoption

One of the main objectives of this research is to explain the adoption of methods on the basis of six factors. The first three relate to the company strategic priority, namely, *cost leadership*, *quality leadership* and *flexibility*. These constitute the first three antecedents of the adoption i.e., H3-H5.

Most of the hypotheses are analysed using data from the sample of 82 German firms. An exception forms the current hypotheses H3, H4 and H5, where the data sample was split based on the organisations' strategic priority. This is shortly explained through the belief that some priorities do not fit together within a single company (Boyer & Lewis, 2002). For example, cost leadership and flexibility contradict each other´s principles. Thus, as aforementioned in section 7.3.2.1, it was necessary to identify the strategic priority of each firm (see Figure 14). Hence, Hypothesis 3 is tested by using the data from firms showing to have *cost leadership* as a strategic priority (25 firms). Hypothesis 4 is tested by using the data from firms showing to have *quality leadership* as a strategic priority (57 firms). Hypothesis 5 is tested by using the data from firms showing to have *flexibility* as a strategic priority (0 firms).

Variable: ***"use of"***

Once we had the samples arranged, we analysed the correlation between a particular organisation's strategic priority (as measured by Cost_scale, Q_scale and Flex_scale) and the use of certain groups of methods (as measured by GroupI_U, GroupIII_U, and GroupIV_U). This was investigated using the Spearman rank order correlation (rho). The results are shown in Table 28.

Firstly, hypotheses 3a and H3b deal with the relationships between the strategic priority *"cost leadership"* and the *"use of"* methods classified in Group–I (H3a) and Group–III (H3b). Here, only the correlation analysis for Group–III (H3b) yielded a statistically significant ($p < .05$ for a two-tailed test) coefficient (rho) value of .422 which means a quite strong relation among the variables. Hence, we found support for **hypothesis 3b** but not for **H3a**. This group (Group–III) includes the methods: life-cycle costing, total cost of ownership, stage-gates, funnels, DFM and DFX. We understand the stronger correlation to these methods in H3b, when we stress our sample selection criteria and remember that respondents were R&D managers. Thus, it seems to exist a higher emphasis in the R&D department (i.e., in a NPD context) to use these methods when the company follows the strategic priority of cost leadership.

Secondly, hypotheses 4a and H4b focuses on the strategic priority *"quality leadership"* and the relationship to the *"use of"* methods classified in Group–I (H4a) and Group–III (H4b). Here, the correlation analyses yielded no statistically significant ($p < .05$ for a two-tailed test) coefficient (rho) values. Thus, we found no support for **hypothesis 4a** nor for **H4b**. These results are quite interesting since 57 of 82 (70%) companies reported the quality leadership as their strategic priority.

Despite being the largest sub-sample, the correlation analyses demonstrate a lack of relationship between their strategic orientations and the use of methods, suggested in the literature, as suitable to support the development of high quality products.

Table 28: Correlation analysis between the organisation's strategic priorities and the "*use of*" cost management methods (Hypotheses 3 – 5). The list of computed variables is provided in Table 20.

			Strategic priorities		
			H3: *Cost leadership* (Cost_scale)	H4: *Quality leadership* (Q_scale)	H5: *Flexibility*
Use of	GroupI_U	Spearman's rho	.380	.106	-
		Sig. (2-tailed)	.061	.439	-
		N	25	55	0
	GroupIII_U	Spearman's rho	.422*	.154	-
		Sig. (2-tailed)	.036	.253	-
		N	25	57	0
	GroupIV_U	Spearman's rho	.136	.163	-
		Sig. (2-tailed)	.517	.225	-
		N	25	57	0

* Correlation is significant at the 0.05 level (2-tailed).
The grey areas highlight the corresponding hypotheses.

Finally, as shown in Table 28, the fact that no company within our sample reported "*flexibility*" as strategic priority represents an issue in this research. The lack of data of firms with this priority, impede the analysis of all hypotheses related to this priority i.e., **hypothesis 5a-d**. A reason for this can be the sample selection criteria. This research addressed manufacturing companies with an R&D department. However, we do not distinguish between manufacturing firms B2C (business-to-consumer) or B2B (business-to-business). Hence, based on the fact that no company within our sample seems to have the strategic priority of flexibility, we can assume that most of the companies are strongly ingrained into a supply chain, which leads to low flexibility in their development process when buyers would not allow supplier to take over innovations on their own.

In particular, hypotheses 5 a-d focus on the strategic priority *"flexibility"* and the relationship to the *"use"* and *"helpfulness"* methods classified in Group–IV. This group (Group–IV) includes the methods: component commonality, modular design, product platforms, technology roadmaps, DFM and DFX. In this context, it is important to mention that results from the descriptive statistics (see section 7.3) showed that while the methods – component commonality, modular design, product platforms – scored among the most used for NPD (see Table 21), the methods – modular design, design for manufacturing and product platforms – score to be the among the most helpful for NPD (see Table 22). However, we can not relate its adoption to the the strategic priority of flexibility.

Variable: "*helpfulness*"

We studied as well the relationship between a particular organisation's strategic priority (as measured by Cost_scale, Q_scale and Flex_scale) and the "*helpfulness*" of certain groups of methods (as measured by GroupI_U, GroupIII_U, and GroupIV_U). Likewise, these relationships were analysed using the Spearman rank order correlation (rho). The results are presented in Table 29.

Firstly, hypotheses 3c and H3d deal with the relationships between "*cost leadership*" and the "*helpfulness*" of the methods classified in Group–I (H3c) and Group–III (H3d). The correlation analyses yielded no statistically significant coefficient (rho) values. Thus, we found no support for neither **hypothesis 3c** nor **H3d**. We previously confirmed hypothesis H3b which claims a strong relationship between the use of methods classified, as well, in Group–III and the priority of "cost leadership". Thus, finding no support for hypothesis H3d is an unexpected result and it actually makes us think whether companies use these methods without believing on its benefits (i.e. helpfulness).

Table 29: Correlation analysis between the organisation's strategic priorities and the "*helpfulness*" of cost management methods (Hypotheses 3 – 5). The list of computed variables is provided in Table 20.

			Strategic priorities		
			H3: Cost leadership (Cost_scale)	H4: Quality leadership (Q_scale)	H5: Flexibility
Helpfulness	GroupI_H	Spearman's rho	.211	.365**	-
		Sig. (2-tailed)	.322	.006	-
		N	24	55	0
	GroupIII_H	Spearman's rho	.205	.284*	-
		Sig. (2-tailed)	.337	.032	-
		N	24	57	0
	GroupIV_H	Spearman's rho	.142	.191	-
		Sig. (2-tailed)	.497	.154	-
		N	25	57	0

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
The grey areas highlight the corresponding hypotheses.

Secondly, hypotheses 4c and H4d focus on the relationship between *"quality leadership"* and the "*helpfulness*" of the methods classified in Group–I (H4c) and Group–III (H4d). Here, the correlation analyses respectively yielded the coefficient (rho) values of .365 which is statistically significant ($p < .01$ for a two-tailed test) and .284 which is as well statistically significant ($p < .05$ for a two-tailed test). Following the guidelines suggested by Cohen (1988) on the interpretation of the correlation coefficient values. A correlation is considered "small" when values range between .10 - .29, "medium" with .30 - .49. Hence, we found support for both **hypotheses 4c** and **H4d**. While Group–I includes the methods – target costing, value engineering, QFD, functional cost analysis and Kaizen costing – Group–III includes – life-cycle costing, total cost of ownership, stage-gates, funnels, DFM and DFX. Hypotheses H4a and H4b which focus on relationship between the "use of" methods classified, as well, in these groups (Group–I and Group–III) and the priority of "quality leadership" were not supported.

Finally, as aforementioned, the fact that no company within our sample reported "*flexibility*" as strategic priority represents an issue in this research. Thus, the lack of data regarding firms with this priority, impede the analysis of the hypotheses related to this priority i.e., **hypothesis 5a-d**.

7.4.4 Analysing the organisation's collaborative competences as an antecedent of the adoption

As aforementioned, one of the main objectives of this research is to explain the adoption of methods on the basis of six factors. The first three related to the organisations' strategic priority. In this section we analyse the collaborative competences: *cross-functional integration*, *supplier integration* and *customer integration*. These constitute the last set of antecedents of the adoption i.e., hypotheses 6 to 8 which are analysed by using the data from a sample of 82 German manufacturing firms[40].

Variable: *"use of"*

We investigated the relationship between each organisation's collaborative competence (as measured by Cross_scale, Supp_scale and Cus_scale) and the "*use of*" methods arranged by groups (as measured by GroupV_U, GroupVI_U, GroupVII_U, GroupVII_U, and GroupVII_U). While Table 30 shows the results from the Spearman rank order correlation analyses, scatterplots of these correlations analyses can be found in Appendix L.

Firstly, hypotheses 6a and H6b deal with the relationships between "*cross-function integration*" and the "*use of*" methods classified in Group–IX (H6a) and Group–X (H6b). The correlation analyses yielded the respective coefficient (rho) values of .314, statistically significant ($p < .01$ for a two-tailed test) and the value .268, statistically significant ($p < .05$ for a two-tailed test). Following the guidelines suggested by Cohen (1988) on the interpretation of the correlation coefficient (rho) values. A correlation is considered "small" when values range between .10 - .29, "medium" with .30 - .49. Thus, we found support for **hypothesis 6a** and for **H6b**. The relationships between the use of methods in groups IX and X and the collaborative competence of cross-functional integration are quite close (i.e., coefficient values of .314 vs .268). Thus, we can interpret that both types of methods are relevant to the integration of functional areas when new products are been developed. Group–IX

[40] Samples may vary due to the statistical analysis configuration suggested by SPSS software to deal with the missing values (i.e., excluding cases pairwise).

includes methods with a scope on financial calculations: value engineering, functional cost analysis, Kaizen costing and life-cycle costing, Group–X includes non-financial guidelines: stage-gates, funnels, DFM, DFX, component commonality, modular design and product platforms.

Table 30: Correlation analysis between the organisation's collaborative competences and the "use of" cost management methods (Hypotheses 6 – 8). The list of computed variables is provided in Table 20.

			Collaborative competences		
			H6: Cross-functional integration (Cross_scale)	H7: Supplier integration (Supp_scale)	H8: Customer integration (Cus_scale)
Use of	GroupV_U	Spearman's rho	.072	.005	.063
		Sig. (2-tailed)	.539	.963	.591
		N	75	75	75
	GroupVI_U	Spearman's rho	.210	**.313****	.063
		Sig. (2-tailed)	.084	.009	.591
		N	69	69	75
	GroupVII_U	Spearman's rho	.214	**.253***	.168
		Sig. (2-tailed)	.053	.022	.132
		N	82	82	82
	GroupVIII_U	Spearman's rho	**.244***	**.269***	.071
		Sig. (2-tailed)	.027	.015	.524
		N	82	82	82
	GroupIX_U	Spearman's rho	**.314****	.158	.085
		Sig. (2-tailed)	.005	.162	.453
		N	80	80	80
	GroupX_U	Spearman's rho	**.268***	.214	.042
		Sig. (2-tailed)	.015	.054	.707
		N	82	82	82

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
The grey areas highlight the corresponding hypotheses.

Secondly, hypotheses 7a and H7b focus on the relationship between "*supplier integration*" and the "*use of*" methods classified in Group–VII (H7a) and Group–VIII (H7b). The correlation analyses yielded the respective coefficient (rho) values of .253 and .269 which are statistically significant ($p < .05$ for a two-tailed test). Following the guidelines suggested by Cohen (1988) on the interpretation of the correlation coefficient (rho) values, we found support for **hypothesis 7a** and for **H7b**. As in previous hypothesis, here both correlation values are as well quite close (i.e., .253 Vs. .269); this indicates that the use of methods of both scopes (financial calculations and non-financial guidelines) is relevant to the integration of suppliers when new products are being developed. Moreover, when comparing the results for H7a and H7b, in Table 30 we detected that Group–VI shows a statistically higher significant coefficient value of .313 for the relationship between the use of methods classified in this group and the competence "supplier integration" which was not hypothesized in our research. However, results yield no statistically significant correlation values (see Table 31) when analysing the perceived helpfulness of methods in this group. Thus, we can infer that supplier integration is a reason to use technology roadmaps for NPD although respondents do not believe it is beneficial in this context (i.e. involving supplier during NPD).

Finally, hypotheses 8a and H8b address the relationship between the competence "*customer integration*" and the "*use of*" methods classified in Group–V (H8a) and Group–VI (H8b). The correlation analyses yielded no statistically significant coefficient (rho) values. Hence, both **hypotheses 8a** and **H8b** were not supported. This is a particular case, in which Group–V only refers to the method; quality function deployment and Group–VI to technology roadmaps.

Variable: "helpfulness"

Furthermore, we studied the relationship between the organisation's collaborative competences (as measured by Cross_scale, Supp_scale and Cus_scale) and the "*helpfulness*" of certain groups of methods (as measured by GroupV_H, GroupVI_H, GroupVII_H, GroupVIII_H, and GroupIX_H). Likewise, these relationships were analysed using the Spearman rank order correlation. The results are presented in Table 31.

Firstly, hypotheses 6c and H6d deal with the relationships between "*cross-function integration*" and the "*helpfulness*" of the methods classified in Group–IX (H6c) and in Group–X (H6d). The correlation analyses yielded the coefficient (rho) values of .359 and .289 respectively at a significance level $p < .01$ (for a two-tailed test). Following the guidelines suggested by Cohen (1988), both coefficients (rho) values demonstrate a substantial correlation between variables. Thus, we found support for **hypothesis 6c** and for **H6d**. Previously we had the case that for a particular antecedent, the use of certain methods is confirmed but not their helpfulness or vice versa. The results of H6c and H6d are quite satisfactory since it is the only case in which all four related hypotheses were supported i.e., addressing the *"use of"* and the ones on *"helpfulness"* of cost management methods.

Secondly, hypotheses 7c and H7d focus on the relationship between "*supplier integration*" and the "*helpfulness*" of the methods classified in Group–VII (H7c) and in Group–VIII (H7d). Here, only the correlation analysis for Group–VII (H7c) yielded a statistically significant ($p < .05$ for a two-tailed test) coefficient (rho) a value of .285. This means a substantial correlation among the variables (Cohen, 1975). Thus, we found support for **hypotheses 7c** but not for **H7d**. This indicates that only the methods classified in Group–VII (i.e., target costing, value engineering, life-cycle costing and total cost of ownership) are identified as helpful during NPD development when efforts to involve suppliers in this process are been followed.

Table 31: Correlation analysis between the organisation's collaborative competences and the *"helpfulness"* of cost management methods (Hypotheses 6 – 8).

			Collaborative competences		
			H6: Cross-functional integration (Cross_scale)	H7: Supplier integration (Supp_scale)	H8: Customer integration (Cus_scale)
Helpfulness	GroupV_H	Spearman's rho	.079	.020	.007
		Sig. (2-tailed)	.520	.874	.957
		N	68	68	68
	GroupVI_H	Spearman's rho	.190	.171	-.073
		Sig. (2-tailed)	.131	.173	.566
		N	65	65	65
	GroupVII_H	Spearman's rho	.214	.285*	-.008
		Sig. (2-tailed)	.055	.010	.946
		N	81	81	81
	GroupVIII_H	Spearman's rho	.382**	.215	.004
		Sig. (2-tailed)	.000	.054	.968
		N	81	81	81
	GroupIX_H	Spearman's rho	.359**	.200	-.078
		Sig. (2-tailed)	.001	.077	.494
		N	79	79	79
	GroupX_H	Spearman's rho	.289**	.044	-.059
		Sig. (2-tailed)	.008	.693	.600
		N	82	82	82

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
The grey areas highlight the corresponding hypotheses.

Finally, hypotheses 8c and H8d address the relationship between the competence "*customer integration*" and the "*helpfulness*" of the methods classified in Group–V (H8c) and Group–VI (H8d). The correlation analyses yielded no statistically significant coefficient (rho) values. Hence, both hypotheses 8c and H8d were not supported.

7.5 Further analyses

In this section the results of further analyses are presented. The main objective of this research is to explain the adoption of cost management methods; this, in term of the organisation's strategic priorities and collaborative competences. However, in contrast to the analyses previously presented, this section covers in a greater detail additional perspectives such as variations on the samples based on the firm's size and the disaggregation of groups of methods to evaluate the hypotheses related to the antecedents (i.e., H3 - H8). These analyses partly focus on the hypotheses not supported and partly on those which resulting correlations yielded lower values than expected showing weak relationships between variables. Moreover, Spearman's correlation coefficient (rho) was used to develop the implications of the further analyses.

7.5.1 Further analyses on the organisation's strategic priority and the adoption of cost management methods when disaggregating the groups of methods

We previously analysed the strength of the relationship between the organisation's strategic priorities and the "use" and "helpfulness" of certain methods arranged by groups (i.e., Group–I, III and IV). In this section, the results of the correlation analysis when disaggregating those groups of methods are presented. Thus, we conduct correlation analyses for each one of the fifteen methods to study the relationship between their individual use and a particular strategic priority. Likewise, further analyses between the helpfulness and a particular strategic priority were conducted. Table 32 shows the results listed by methods.

Further results related to *"cost leadership"*

The correlation analysis showed that the relationship between the variables "use of" and "cost leadership" as well as "helpfulness" and "cost leadership" prevailed in two methods. Namely, design for manufacturing and life-cycle costing. For these methods, the correlation analyses yielded statistically significant coefficient (rho) values above .450, which means a strong relationship among the variables (Cohen, 1988). Certainly the fact, that the use and helpfulness of only two methods (out of 15) relate to cost leadership, might lay on the context of our research. Thus companies which main objective is to achieve cost leadership, can rely on using the methods life-cycle costing and design for manufacturing to develop new products. Moreover, there is the case in which we found relationship between the variable "use of" and the priority of "cost leadership" but not between "helpfulness" and "cost leadership". This is the case of methods: value engineering, Kaizen costing and stage-gates. All three coefficient (rho) values are above .400 at a statistically significant at $p< .05$ (see Table 32). From these results we can only infer that the adoption of these three methods is strongly related to this strategic priority, as well in a NPD context.

Table 32: Correlation analysis between the organisation's strategic priorities and the *"use and helpfulness"* of each cost management method.

Cost management methods		Cost leadership & Use of	Cost leadesrship & Helpfulness	Quality leadership & Use of	Quality leadership & Helpfulness
Target costing	Spearman's rho	.294	-.073	-.026	.000
	Sig. (2-tailed)	.173	.752	.857	.998
	N	23	21	50	49
Value engineering	Spearman's rho	.413*	.374	.158	.192
	Sig. (2-tailed)	.040	.078	.283	.190
	N	25	23	48	48
Quality function deployment	Spearman's rho	.271	.148	.239	.277
	Sig. (2-tailed)	.210	.533	.089	.057
	N	23	20	52	48
Functional cost analysis	Spearman's rho	.236	.203	-.064	.111
	Sig. (2-tailed)	.255	.342	.661	.454
	N	25	24	50	48
Kaizen costing	Spearman's rho	.440*	.313	.334*	.239
	Sig. (2-tailed)	.028	.146	.016	.087
	N	25	23	52	52
Life-cycle costing	Spearman's rho	.450*	.489*	.099	.177
	Sig. (2-tailed)	.027	.024	.494	.233
	N	24	21	50	47
Total cost of ownership	Spearman's rho	.130	.221	.165	.281
	Sig. (2-tailed)	.536	.311	.256	.056
	N	25	23	49	47
Stage-gate reviews	Spearman's rho	.506*	.402	.380**	.531**
	Sig. (2-tailed)	.016	.071	.005	.000
	N	22	21	52	51
Funnels	Spearman's rho	.278	-.015	.222	.189
	Sig. (2-tailed)	.188	.949	.110	.199
	N	24	20	53	48
Design for manufacturing	Spearman's rho	.546**	.484*	.005	.039
	Sig. (2-tailed)	.007	.026	.971	.788
	N	23	21	51	50
Design for X	Spearman's rho	.330	.175	.113	.155
	Sig. (2-tailed)	.115	.436	.455	.328
	N	24	22	46	42
Component commonality	Spearman's rho	-.012	.160	.134	.242
	Sig. (2-tailed)	.957	.477	.350	.094
	N	23	22	51	49
Modular design	Spearman's rho	-.028	.213	.180	.147
	Sig. (2-tailed)	.899	.340	.202	.307
	N	23	22	52	50
Product platform	Spearman's rho	.210	.352	.300*	.329*
	Sig. (2-tailed)	.335	.109	.032	.018
	N	23	22	51	51
Technology roadmap	Spearman's rho	.147	-.086	.060	.045
	Sig. (2-tailed)	.494	.696	.696	.776
	N	24	23	45	42

** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed).

Further results related to *"quality leadership"*

The results of correlation analyses showed that the relationship between the variables *"use of"* and *"quality leadership"* as well as *"helpfulness"* and *"quality leadership"* prevailed in two methods, namely, stage-gates reviews and product platforms (see Table 32). For these two methods, the correlation analyses between yielded statistically significant coefficient (rho) values above .300, this means a substantial relationship among the variables (Cohen, 1988). Here as well the fact that the use and helpfulness of only two methods (out of 15) relate to the strategic priority of cost leadership, might lay on the context of our research. Thus, companies which main objective, in this case, is to achieve quality leadership in the market, can rely on using the methods stage-gates reviews and product platforms to develop new products. Furthermore, results showed in Table 32 demonstrate that the use of Kaizen costing is also related to this strategic priority (with a statistically significant coefficient (rho) value of .334). However, there is a lack of correlation between the *"helpfulness"* of this method and *"quality leadership"*.

Further results related to *"flexibility"*

Finally, as aforementioned, the fact that no company within our sample reported "*flexibility*" as strategic priority represents an issue in this research. Thus, the lack of data regarding firms with this priority, impede the analysis as well as further analysis of all hypotheses related to this priority (i.e., Hypothesis 5a-d).

7.5.2 Further analyses related to the firm's size

Prior research supports the idea that the size of the organisation would not relate to the adoption of accounting practices. Al Chen et al. (1997) showed that most of the U.S.-based Japanese firms are similar to Japanese domestic firms in their use of management accounting methods regardless of the differences of characteristics in term of firm's size. Likewise, Hopper, Koga, and Goto (1999) find that cost management practices of small and medium sized (SME) companies are similar to those of larger Japanese firms. However, this research has been challenged by empirical studies showing that firm's size has an impact on the use and design of cost management systems (Chenhall & Langfield-Smith, 1998; Duh et al., 2009; Joshi, 2001, Joshi et al., 2011). For example, Guilding (1999) has found competitor accounting practices to be related to company size, competitive strategy and strategic mission. Drury and Tayles (1994) as well as Hoque and James (2000) reported that adoption rates for management accounting practices are much higher in larger firms. Likewise, there is research claiming a distinction on a NPD context. Kessler (2000) indicates that DFM does not necessarily lead to decreased development cost in large company and Eatock et al. (2009) suggest that large companies use a wider range of cost management methods (e.g., quality function deployment, stage-gates and design for manufacturing) during NPD processes.

Table 33 presents the correlation analysis between the independent variable "*Firm's size*" and the dependent variables "use of" and "helpfulness of". In this regard, we only found relationship between the variables; "*Firm's size*" and "*helpfulness*". This shows a positive coefficient (rho) of .306 statistically significant at p< .01 for a two-tailed test.

Table 33: Correlation analysis between "firm's size" and the variables "use" and "helpfulness".

		Firm's size
Use of	Spearman's rho	0.185
	Sig. (2-tailed)	.097
	N	82
Helpfulness	Spearman's rho	.306**
	Sig. (2-tailed)	.005
	N	82

** Correlation is significant at the 0.01 level (2-tailed).

7.5.2.1 Further analysis related to the adoption of cost management methods within small, medium and large firms

The adoption of cost management methods might be different for small than for large firms. Thus, we divided the data set based on the number of employees to analyse groups of firms independently. Thus, we introduce three types[41]: small (10 to 99[42]), medium (100 to 499[43]) and large (500 to more than 5000[44]) firms. This procedure was conducted in SPSS by using a new variable called "newFirmsize" (see Table 20). Finally, Figure 16 shows the data sample arreanged by firm's size.

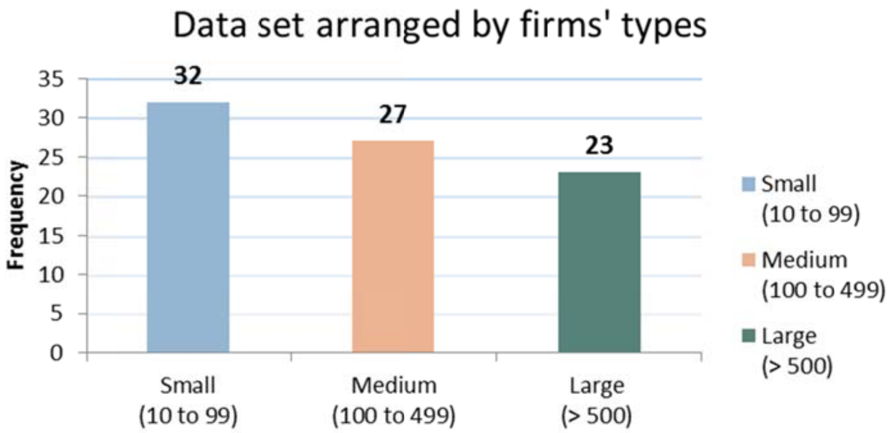


Figure 16: Firms'size groups based on number of employees.

[41] Notice: another grouping of medium (100-990) and large (1000-<5000) firms was tested. This did not led to better results i.e., higher correlations or meaningful interpretations.
[42] Questionnaire answer code for 1 to 4.
[43] Questionnaire answer code for 5 to 6.
[44] Questionnaire answer code for 7 to 9.

We observed that when analysing the whole sample as in Hypothesis 1 (N=82), the correlation analysis yielded statistically significant coefficient (rho) value of .611, this means a strong relationship among the variables (Cohen, 1988) *"use"* and *"helpfulness"*. Moreover, the results of further analysis conducted on the three sub-samples (small, medium and large firms) show as well a strong relationship between the "use of" all methods and their "helpfulness" during NPD. The correlation analysis yielded statistically significant coefficient (rho) values above of .500 (see Table 34). These relationships seem to assume a slightly stronger influence in medium firms. Although all coefficient (rho) values are quite high, it is an interesting notice that large companies have the "lowest" value.

Table 34: Correlation analysis between the variables "u*se and helpfulness"* of cost management methods (Hypothesis 1) within different firm's size.

		Helpfulness of all methods			
		All firms (H1)	Small	Medium	Large
Use of all methods	Spearman's rho	.611**	.559**	.705**	.536**
	Sig. (2-tailed)	.000	.001	.000	.008
	N	82	32	27	23

** Correlation is significant at the 0.01 level (2-tailed).

7.5.2.2 Further analysis on the adoption of cost management methods and the organisation's collaborative competences within small, medium and large firms

The hypotheses 6 to 8 address the "*use*" and "*helpfulness*" of certain groups of methods and its relationships to the organisation's collaborative competences. In this section we present the results when correlation analyses are conducted differently. Firstly, we analyse the relationships between each collaborative competence and each cost management method. Secondly, we present the correlation analyses when the data set is divided according to the firm's size (see description above).

We previously analysed the strength of the relationship between the organisation's collaborative competences and the "use" and "helpfulness" of certain methods arranged by groups (i.e., Group–V, to Group–X). Table 35 shows the results of the correlation analysis when disaggregating those groups. Likewise, further analyses between the helpfulness and a particular collaborative competence were conducted on this deeper level. Our research relies on Spearman's correlation coefficient. In terms of both variables i.e., the use and helpfulness, there are few cases in which for a partuclar method, a relationship between a competence and use as well as a competence and helfullnes can be supported (see for example target costing and supplier integration).

Table 35: Correlation analysis between the organisation's collaborative competences and the *"use and helpfulness"* of each cost management method.

Cost management methods		Cross-functional & Use of	Cross-functional & Helpfulness	Supplier integration & Use of	Supplier integration & Helpfulness	Customer integration & Use of	Customer integration & Helpfulness
Target costing	Spearman's rho	.204	.127	.342**	.306*	.193	.052
	Sig. (2-tailed)	.083	.296	.003	.010	.101	.669
	N	73	70	73	70	73	70
Value engineering	Spearman's rho	.162	.213	.045	.074	.219	.180
	Sig. (2-tailed)	.170	.075	.702	.539	.062	.132
	N	73	71	73	71	73	71
Quality function deployment	Spearman's rho	.072	.079	.005	.020	.063	.007
	Sig. (2-tailed)	.539	.520	.963	.874	.591	.957
	N	75	68	75	68	75	68
Functional cost analysis	Spearman's rho	.222	.186	.001	-.048	.163	.077
	Sig. (2-tailed)	.056	.118	.991	.692	.162	.520
	N	75	72	75	72	75	72
Kaizen costing	Spearman's rho	.362**	.384**	.102	.110	.110	-.005
	Sig. (2-tailed)	.001	.001	.380	.346	.341	.965
	N	77	75	77	75	77	75
Life-cycle costing	Spearman's rho	.078	.202	.141	.181	-.029	-.207
	Sig. (2-tailed)	.512	.098	.229	.139	.809	.091
	N	74	68	74	68	74	68
Total cost of ownership	Spearman's rho	.334**	.329**	.212	.158	.320**	.228
	Sig. (2-tailed)	.004	.005	.070	.193	.005	.057
	N	74	70	74	70	74	70
Stage-gate reviews	Spearman's rho	.231*	.231	.277*	.219	.034	.056
	Sig. (2-tailed)	.048	.051	.017	.064	.773	.643
	N	74	72	74	72	74	72
Funnels	Spearman's rho	.034	-.018	-.037	-.136	.198	.119
	Sig. (2-tailed)	.771	.881	.748	.268	.084	.332
	N	77	68	77	68	77	68
Design for manufacturing	Spearman's rho	.357**	.299*	.200	.121	-.109	-.251*
	Sig. (2-tailed)	.002	.011	.088	.316	.355	.035
	N	74	71	74	71	74	71
Design for X	Spearman's rho	.385**	.355**	.419**	.142	-.018	.052
	Sig. (2-tailed)	.001	.004	.000	.262	.879	.686
	N	70	64	70	64	70	64
Component commonality	Spearman's rho	.140	.016	.053	-.039	.045	.033
	Sig. (2-tailed)	.234	.891	.655	.744	.702	.785
	N	74	71	74	71	74	71
Modular design	Spearman's rho	.151	.404**	-.057	.008	-.106	.044
	Sig. (2-tailed)	.195	.000	.628	.948	.368	.713
	N	75	72	75	72	75	72
Product platform	Spearman's rho	.063	.116	-.004	-.068	.168	.047
	Sig. (2-tailed)	.595	.327	.971	.569	.151	.694
	N	74	73	74	73	74	73
Technology roadmap	Spearman's rho	.210	.190	.313**	.171	-.029	-.073
	Sig. (2-tailed)	.084	.131	.009	.173	.814	.566
	N	69	65	69	65	69	65

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Moreover, we study the reasons for adopting cost management methods from another perspective. Thus, for the second further analyses regarding collaborative competences, the data set was divided according to the firm's size (see description above). We used the Spearman's correlation coefficient to analyse the strength of these relationships within small, medium and large firms. The results of all correlations analyses can be found in Appendix M. These showed changes on the correlation values when arranging the data-set by firm's size. However, we believe it is more insightful to only present the results in case the (statistically significant) value had increased, which means a stronger relationship between variables and higher support for hypotheses 6 to 8. This occurred in three cases:

- Hypothesis 6 using data from small firms
- Hypothesis 7 using data from medium sized firms
- Hypothesis 7 using data from large firms

These further analyses showed that Hypothesis 6 only applies for small firms. Table 36 shows the correlation (rho) values of H6 and compare these to the results obtained from analysing the data of small firms (N=32). Thus, the study of small firms in more detail suggested a stronger relationship between *"cross-functional integration"* and the *"use of"* methods classified in Group–IX and Group–X, but not between this competence and the *"helpfulness"* of those methods. Hence, we can infer that the adoption of methods in Group–IX (i.e., value engineering, functional cost analysis, Kaizen costing and life-cycle costing) and Group–X (i.e., stage-gates, funnels. DFM, DFX, component commonality, modular design and product platforms) is highly likely to happen in small companies when these seek to involve other function areas besides R&D (such as manufacturing, marketing, etc.) for the development of new products.

Table 36: Comparison of correlation analysis for Hypothesis 6 with data of all firms versus small firms. The list of computed variables is provided in Table 20.

		Cross-functional integration & Use of			Cross-functional integration & Helpfulness		
		Small firms		All firms (H6)	Small firms		All firms (H6)
Group IX	Spearman's rho	.496**	Vs.	.314**	.349	Vs.	.359**
	Sig. (2-tailed)	.004		.005	.054		.001
	N	32		80	31		79
Group X	Spearman's rho	.465**		.268*	.219		.289**
	Sig. (2-tailed)	.008		.015	.228		.008
	N	31		82	32		82

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Furthermore, when analysing medium firms, the correlation (rho) values notably increased within the supplier integration framework (H7). Yet this increase is almost twice of the correlation value when sample consist of 82 firms. Hence, the relationships between this collaborative competence and the variables *"use"* and *"helpfulness"* are quite stronger (Cohen, 1988) within medium sized firms. Table 37 shows the results of H7 and compares to the results obtained from analysing the data from medium firms (N=27). This could mean that for medium size firms, the adoption of the methods classified in Group–VII (target costing, value engineering, life-cycle costing and total cost of ownership) and Group–VIII (stage-gates, modular design and technology roadmaps) is highly dependent of the company's efforts to involve suppliers to develop new products. Finally, when analysing large firms, only one correlation (rho) value changed. This is as well related to the relationship between the collaborative competence "supplier integration" and the "use of" of methods classified in Group–VII (see Table 38). Hence, we can interpret that for large firms, supplier integrations is an antecedent of adoption of methods: target costing, value engineering, life-cycle costing and total cost of ownership, this within the context of NPD.

Table 37: Comparison of correlation analysis for Hypothesis 7 with data of all firms versus medium size firms. The list of computed variables is provided in Table 20.

.

		Supplier integration & Use of			Supplier integration & Helpfulness		
		Medium firms		All firms (H7)	Medium firms		All firms (H7)
Group VII	Spearman's rho	**.419***	Vs.	**.253***	**.488***	Vs.	**.285***
	Sig. (2-tailed)	.030		.022	.011		.010
	N	27		82	26		81
Group VIII	Spearman's rho	**.502****		**.269***	**.468***		.215
	Sig. (2-tailed)	.008		.015	.014		.054
	N	27		82	27		81

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 38: Comparison of correlation analysis for Hypothesis 7 with data of all firms versus large firms. The list of computed variables is provided in Table 20.

		Supplier integration & Use of			Supplier integration & Helpfulness		
		Large firms		All firms (H7)	Large fims		All firms (H7)
Group VII	Spearman's rho	**.466***	Vs.	**.253***	.287	Vs.	**.285***
	Sig. (2-tailed)	.025		.022	.184		.010
	N	23		82	23		81
Group VIII	Spearman's rho	.304		**.269***	.266		.215
	Sig. (2-tailed)	.159		.015	.232		.054
	N	23		82	22		81

* Correlation is significant at the 0.05 level (2-tailed).

8 Discussion and implications

Firms need to manage the costs of products in relation to their performance and functionality and, thereby, the value they offer to customers. One of the key opportunities for cost management arises during the development phase of new products when there are still many degrees of freedom regarding the decisions that crucially impact cost, performance and functionality. Thus, management accounting as well as other research fields within management and engineering have developed approaches that support such cost management during NPD and empirical research has addressed the adoption of such methods. Hence, it is important to identify the antecedents of the adoption of cost management methods.

This present study investigated the adoption of 15 different cost management methods within the context of NPD. It addressed a gap in the literature because to our knowledge no previous studies have examined the cause of use of cost management methods in this context in depth nor specified which of them have been perceived as helpful for product development. 800 R&D managers were invited to participate in a web-based survey. Thus, using multi-industry, organisation level data from 82 manufacturing firms, we analysed the correlations between the use and helpfulness of cost management methods (dependent variables) and particular characteristics of the firms (independent variables). These were the organisation's strategic priority (i.e., cost leadership, quality leadership or flexibility) and the collaborative competences (i.e., cross-functional integration, supplier integration and customer integration).

8.1 The adoption of cost management methods

The main objective of this doctoral thesis was to study the adoption of cost management methods during NPD. For this research we defined the concept "use of" as the extent to which the organisation applies a particular method for the purpose of cost management in new product development. Furthermore, we examined how helpful such methods are and thereby the construct "helpfulness" was defined as the perception of advantages in applying a particular method within an organisation to achieve its goals in a new product development context.

Many of our selected methods can be employed to manage costs during product development (Afonso et al., 2008; Eatock et al., 2009; Ettlie & Elsenbach, 2007; Salvador & Villena, 2013; Swink, 2003; Yeh et al., 2010). In this regard, the descriptive statistics of the variable "use of" demonstrate that while the target costing is the most used method, life-cycle costing is the least used among the studied firms. Hence, target costing, through its average rank, can be interpreted as being "often" used in product development. In contrast to this, we can infer that the life-cycle costing method is "rarely" used for the same purpose. A further interesting result is that product platform score second after target costing and that for this particular method there is the strongest consensus among all firms about the level of its use, "sometimes", during NPD. All methods show usage range from "not at all" to "always", this suggests that R&D managers in German firms have considerable leeway in choosing their organisation's cost management practices. Moreover, looking at the average rank of methods based on the helpfulness, modular design can be interpreted as being "often" helpful while the funnels method was only considered to be "sometimes" helpful for product development. However, the consensus regarding the helpfulness of product platform seems to remain.

When observing descriptive statistics a comparison of variables shows that all mean values of "helpfulness" are slightly higher than the values of "use". This is consistent with the remarks provided by some respondents on the box for comments (see questionnaire structure in Section 6.2.2). We observed an emphasis on the methods' helpfulness, including those not being used in product development per se. Respondents expressed that at this stage cost reductions are decisive for the production since the largest costs arise from the development and engineering services. On the one hand, these differences show that the methods are used. On the other hand, it suggests that R&D managers would want to use them more often. There could be many reasons for this discrepancy between "use" and "helpfulness". For example, company characteristics such as firm size (Chenhall & Langfield-Smith, 1998; Duh et al., 2009; Joshi, 2001, Joshi et al., 2011). Large companies are more complex and therefore would need more time to implement new methods and procedures. Small firms have their difficulties and they could lack the resources to adopt formal cost management methods. Moreover, strategic orientation is also relevant in this context. If a company has not clearly defined its strategic orientation or this is not well known within the organisation (i.e., in all departments including R&D), it can be very difficult to achieve consensus on which methods are suitable and need to be adopted. These same arguments are valid for managerial approaches such as the collaborative competences. Thus, the collaborative competences of a company should be aligned to the use of cost management methods which promote the integration among cross-functional teams, suppliers and customers.

In our first hypothesis (H1), we expected that the adoption of cost management methods relates to the acknowledgement of its helpfulness during product development, while the second hypothesis (H2) focused on the same kind of relationship between use and helpfulness but for particular groups of methods. Both hypotheses were supported. Prior research highlighted how difficult it was to study the adoption of cost management practices and how this might improve the organisation's performance (Baines & Langfield-Smith, 2003; Cadez & Guilding, 2008; Duh et al., 2009). However, the perception from obtaining benefits from practising certain methods plays a significant role in its adoption (Chenhall & Langfield-Smith, 1998a; Duh et al., 2009; Guilding et al., 2000; Wu et al., 2007). For example, the research from Joshi (2001) and Joshi et al. (2011) suggest that the adoption rate of traditional cost management practices is strongly related to the perception of its benefits. Our findings agree with these previous studies' results. Moreover, as expressed by our respondents: "Cost-management methods provide higher structure for risk reduction and for traceability of decision, although, these strongly formalised methods may neglect innovation". In this regard, findings show that R&D managers perceived cost management methods as beneficial to support NPD process and, hence, the adoption of cost management methods is related to this perception of their helpfulness.

Furthermore, the decision on which method should be adopted to support NPD processes should be based on the method's scope. Therefore, we kept in mind that certain cost management methods could be applied distinctively to individual products or to a portfolio of products. Hence, organisations may employ methods from different scope-groups. This research also addressed the adoption on a deeper level i.e., a group classification based on the method's scope. In other words, we investigated if certain groups of methods were considered as helpful for NPD as well. Results demonstrated that companies perceived benefits from using group of cost management methods to support their NPD. However, it is important to highlight that this perception varied among the different groups of methods. In conclusion, the strongest relationship between "use of" and "helpfulness" was assigned to methods which addressed a portfolio of products including the costs of development activities i.e., component commonality, modular design, product platforms, technology roadmaps, DFM and DFX. When analysing the methods used for individual products and services we found that the ones which consider the entire costs for the development of products have a higher evaluation than those which only consider the unit manufacturing costs.

The results of further analysis conducted on three sub-samples (small, medium and large firms) show a strong relationship between the "use of" all methods and the R&D managers' perceptions of their "helpfulness" during product development as well. What is interesting here is how these relationships seem to be slightly stronger in medium-sized firms (100 to 499 employees). Although all coefficient (rho) values are quite high (see Chapter 7), it is interesting to notice that large companies (with more than 500 employees) have the "lowest" value. These findings highlight a further research question of whether a practical explanation for this perception exists. Maybe case-studies on this matter should follow to compare different types of companies (i.e., small, medium and large).

8.2 Strategic priorities as antecedents of the adoption

The accounting literature suggests that management control systems should match the strategy of the company (Boyer et al., 1997; Boyer & Lewis, 2002; Boyer & McDermott, 1999; M. Joshi, 2003). Control systems, methods and techniques are chosen according to the company strategy (Bisbe & Otley, 2004; Chenhall & Langfield-Smith, 1998b; Daniel & Reitsperger, 1991; Ferdows & Meyer, 1990; Govindarajan & Fisher, 1990; Van der Stede, 2000). These findings lead us to believe that specific methods are required for a company to carry out its strategic priority successfully. For example, the target costing method is adequate for fulfilling the strategic priority of cost leadership (Chenhall & Langfield-Smith, 1998b). Hence, a strong relationship between cost management methods and the strategic priority of the organisation is congruent with previous studies and the nature of our set of methods.

The first analysis regarding strategic priorities was conducted to identify the organisation’s emphasis on cost leadership, quality leadership and flexibility. Although results showed that German manufacturing firms have a slightly higher emphasis on the quality leadership than on the other two priorities (i.e., cost leadership and flexibility), all three strategic priorities were described on average as “very important”. These results challenge our understanding of the literature, which suggests that some priorities contradict each other (Boyer & Lewis, 2002).

Addressing the second objective of this research, the adoption of cost management methods is explained on the basis of six factors. The first three relate to the company strategic priority and constitute the first set of antecedents of adoption, namely, cost leadership, quality leadership and flexibility (H3-H5). To enable the analysis of the organisation's priority, it was necessary to identify the strategic priority of each firm. This is shortly explained by the assumption that some priorities do not fit together within a single company (Boyer & Lewis, 2002). For example, cost leadership and flexibility contradict each other´s principles (for detailed information see Chapter 6). This arrangement shortened the data set into three smaller samples. Finally, 25 firms show to pursuit a cost leadership strategy, 57 firms a quality leadership and none show flexibility as a strategic priority.

Strategic priority: flexibility

The fact that no company within our sample reported “flexibility” as a strategic priority was an issue in this research. Thus, the lack of data regarding firms with this priority impeded the analysis of the hypotheses 5a-d. A reason for this could be the sample selection criteria. This research surveyed the R&D departments of German manufacturing companies. However, we did not distinguish between manufacturing firms B2C (business-to-consumer) or B2B (business-to-business). Therefore, we can assume that most of these companies are rooted in a supply chain, which leads to low flexibility in their development process when buyers would not allow suppliers to take over innovations on their own.

Moreover, we expected a high preference within our sample for the strategic priority of flexibility since the focus of this research lies on the NPD context and based on the assumption that today’s trends of innovation aims to rapidly adapt the market requirements in a fast growing high-tech setting (Germeraad, 2010; U. Lichtenthaler, 2008; Parasuraman, 2000; Sanchez, 1999). In contrast, no single firm reported this as being a priority, which is quite unlikely for R&D departments. This result could be influenced by the quality of the measurement instrument. Although the measurement instrument was validated by Ward et al. (1998), we tested the reliability of scales using the data from our sample as well. Surprisingly, values were different from the ones obtained by Ward et al. (1998). In particular for the priorities: quality leadership (Cronbach alpha: .500) and flexibility (Cronbach alpha: .554) which showed acceptable but very low values. Thus, it is important to notice that some scales are reliable within some groups, but are totally unreliable when used by other groups (Pallant, 2013). For example, based on their environment at work large firms could interpret the questionnaire and report differently than small firms. Perhaps, the lack of firms in our sample striving for flexibility as a priority is explained by the reliability of our measurement instrument.

Despite the lack of data to evaluate all the hypotheses related to the strategic priority of flexibility (H5), we observed that the methods assigned to "correlate" to the strategic priority of flexibility did not related to cost leadership nor quality leadership. This strengthens our theoretical framework which can be used in future research to study the strategic priority of flexibility as an antecedent of the adoption of cost management methods. However, we recommend attempting to achieve a higher reliability values on the measurement instrument for flexibility.

Furthermore, we must see the differences between being "customer driven" and "customer oriented". Being "customer driven" may lead organisations to having little or no flexibility within their R&D processes and applying lead-used methods whereas being "customer oriented" may highlight the importance of customers for the company. Few respondents expressed being "customer driven", which offers no room for major changes on product design. They pointed out their commitment to increase the products' quality through qualified customer service and delivery reliability. Hence, this "customer driven orientation" is consistent with the results of the questionnaire as no firm focused on the strategic priority of "flexibility" whereas the majority of the firms emphasised quality leadership.

Strategic priority: cost leadership

Even though there is no "universal" management accounting practice (Tomkins & Carr, 1996), the adoption of certain practices are influenced by certain factors such as strategy choice (Cadez & Guilding, 2008). Hence, certain methods for cost management purposes may be more likely to be used if they match the strategic priority of the company. This strategic priority of cost leadership was identified in this current research as an antecedent of the adoption of particular cost management methods (H3). Thus, when analysing this adoption of certain groups of methods, we found a strong relationship between cost leadership and the use of the methods applied on individual products or services which also take into account the entire costs for developing such products. These findings are consistent with previous research claiming that the strategic priority of cost leadership is related to the successful use of cost management methods and which suggests that the reduction of production costs can also be achieved during the early stages of product development (Anderson & Dekker, 2009; R. Cooper & Slagmulder, 1999; Davila et al., 2008; Davila & Wouters, 2004). Hence, with the adoption of these methods an efficient resource allocation can be extended to other departments besides the manufacturing stage (Degraeve et al., 2005; Parker, 2000) thereby expanding the product supply chain (Arping & Lóránth, 2006) and supporting the company strategic priority of cost leadership as a competitive advantage.

As previously mentioned, this research stresses the relationship between the organisation's strategic priorities and the "use" and "helpfulness" of certain methods arranged by groups (i.e., Group–I, III and IV). We also conducted correlation analyses for each one of the 15 methods to study the relationship between their individual use and a particular strategic. The results showed that the relationship between the variables "use of" and "cost leadership" as well as "helpfulness" and "cost leadership" prevailed in two methods, namely, life-cycle costing and design for manufacturing. We observed a strong relationship among the variables for these two methods. Certainly the fact that the use and helpfulness of only two methods (out of 15) relate to the strategic priority of cost leadership may be influenced by the context of our research. Thus, companies whose main objective is to achieve cost leadership in the market, can rely on using the life-cycle costing and design for manufacturing methods in developing new products.

Life-cycle costing provides a framework for cost analysis while tracking the costs which attribute to a product or service throughout its entire life-cycle. It is used for "specifying the estimated total incremental cost of developing, producing, using and retiring a particular item" (Asiedu & Gu, 1998, p. 883). Hence, life-cycle costing can be seen as being separate from other cost management methods used in product development. This is due to its very encompassing scope as upstream activities like technology evaluation and research are reflected in the cost figures. Subsequent activities like product support, maintenance, repair, upgrades or disposal are also included (Goh et al., 2010). Likewise, the design for manufacturing method is identified as a relevant method to integrate production requirements into their development. This method particularly relies on the idea that decisions made during the design phase of a product may severely affect it during its entire life-cycle and will determine significant portions of a it's life-cycle costs even long before its launch (Dowlatshahi, 1992). Hence, manufacturability requirements and guidelines need to be considered and carefully evaluated in the product's design phase. Thus, the products designed "in such a way as to reduce the total cost of production and assembly to a minimum" (Trygg, 1993, p. 412) support the strategic priority of cost leadership.

Moreover, we found a relationship between the variable "use of" and the priority of "cost leadership" but we did not find any between "helpfulness" and "cost leadership". This was also the case with the methods: value engineering, Kaizen costing and stage-gates. From these results we can only infer that the adoption of these three methods is strongly related to this strategic priority in an NPD context. Thus, we understand the stronger correlation to these methods when we stress the sample selection criteria and take into consideration that respondents are R&D managers. Thus, there seems to be a greater emphasis on the R&D department for using these methods when the company follows the strategic priority of cost instead of quality leadership. However, results showed no support for a relationship between "cost leadership" and the "helpfulness" of the same methods, which is an unexpected finding and actually raises the question of whether companies use these methods without having confidence in its benefits.

Strategic priority: quality leadership

Whereas it is in the best interests of the whole company to profit from market recognition of their high quality products, companies may focus on the most suitable cost management methods that in achieving such quality leadership. For example, management accounting methods become more meaningful to foster communication between customers, marketing, engineering, and manufacturing departments to ensure that customers recognise the quality of products (J. J. Cristiano, Liker, & White, 2000; Govers, 1996; Griffin & Hauser, 1992; Khoo & Ho, 1996; Swink, 2003). Moreover, quality may be interpreted as the pursuit of a viable project to develop a new product. Hence, further cost management techniques support the design of such projects (Ding & Eliashberg, 2002; Fuchs & Kirchain, 2010). Lastly, quality control may be reinforced by assessing purchasing activities avoiding costs related to poor quality (Wouters et al., 2005).

Despite these previous findings, the correlation analyses in this research demonstrate a lack of any relationship between quality leadership and the use of methods which are supported in the literature as being important in the development of high quality products (H4). Moreover, although the majority of the companies showed quality leadership as their priority (i.e., a 70% of the sample) this could not be identified as an antecedent of the adoption of cost management methods.

However, "quality leadership" was associated with the perceived "helpfulness" of the methods whose scope deal with individual products and services. Thus, although it seems that they do not really used for this purpose, we could see that companies (i.e., their R&D department) recognise benefits in terms of quality from using cost management methods. This is consistent with the respondents' comments. They expressed that "Quality is more important than cost reduction" which shows a greater emphasis on the strategic priority "quality leadership" than "cost leadership".

Furthermore, results showed that the relationship between the variables "use of" and "quality leadership" as well as "helpfulness" and "quality leadership" prevailed only in two methods, namely, stage-gates reviews and product platforms. The fact that only two methods out of 15 are associated with the strategic priority of quality leadership might be influenced by the context of the research.

Thus, companies whose main objective is to achieve quality leadership in the market can rely on using the methods stage-gates reviews and product platforms in developing new products.

One the one hand, stage-gates reviews were expected to be related to quality leadership. Boardman and Clegg (2001) propose the integration of the stage-gates approach with the balance scorecard to achieve company strategic objectives. Thus, once the project has been specified, the "quality" may be interpreted as an efficient process to develop products. Thus, the stage-gates review provides the necessary structure to evaluate project performance at each stage (Davila et al., 2009; Ettlie & Elsenbach, 2007; Hertenstein & Platt, 2000). Moreover, R. G. Cooper and Kleinschmidt (1991) reported how this method improves performance results in terms of product success rates and customer satisfaction, as well as the compliance of cost, time and quality objectives (Boardman & Clegg, 2001; Kumar & Wellbrock, 2009). Finally, a positive influence on financial performance is confirmed with a significant relationship between a high-quality new product process and profitability (R. G. Cooper & Kleinschmidt, 2007; Ozer & Cebeci, 2010). On the other hand, product platforms provide the flexibility for companies with a portfolio of products to focus on directing production processes to react quickly to the changing market needs (W. C. Kim & Mauborgne, 1997; Krishnan & Ulrich, 2001; Simpson, et al. 2001; Muffatto & Roveda, 2000; Robertson & Ulrich, 1998). Therefore, the adoption of product platforms was not expected to be explained through the strategic priority of quality leadership.

Results also demonstrate that the use of Kaizen costing is related to this strategic priority. However, there is a lack of correlation between the "helpfulness" of this method and "quality leadership" which makes us reflect on whether companies use Kaizen costing without believing in its benefits for product development processes when striving for quality leadership.

8.3 Collaborative competences as antecedents of the adoption

Research addressing different phases of the supply chain, including the product design stage or later in the manufacturing process, suggest that particular departments benefit in different ways from such an integration (Ettlie & Elsenbach, 2007; Fullerton et al., 2013; Hoque & James, 2000; Ulrich, Sartorius et al., 1993) by claiming that organisations gain operational advantages after combining efforts from several cross-functional teams (Ahmad et al., 2010; Ahmad, Mallick, & Schroeder, 2013; X. M. Song, Montoya-Weiss, & Schmidt, 1997) and increase their performance when they collaborate with customers in developing new products (Arping & Lóránth, 2006; Kahn, 2001;Kahn et al., 2012; Lamore, Berkowitz, & Farrington, 2013; Narver et al., 2004). Hence, companies looking into full supply chain integration (SCI) are more likely to achieve a profitable trade-off when efforts are made to involve suppliers and customers into their development processes. For example, sharing technological information and external expertise during early NPD stages generates benefits such as higher technical and financial performance. (Lawson et al., 2009; Petersen et al., 2003; Salvador & Villena, 2013; Schiele, 2010; Tan, 2001). In this regard cost management practices provide the structure to control the costs incurred in a company which may be influenced by inter-organisational as well as intra-organisational issues (Davis & Eisenhardt, 2011; Mouritsen et al., 2001). The 15 cost management methods studied in this research were classified in new groups, with the objective of investigating three collaborative competences as antecedents of adoption, namely, cross-functional integration, supplier integration and customer integration. These constitute the last set of hypotheses (H6 to H8) which were analysed using the data from 82 German manufacturing firms

The first analysis regarding collaborative competences was conducted to identify the organisation's emphasis on cross-functional, supplier and customer integration. R&D managers reported a low but existing emphasis on these three managerial approaches. However, a slightly higher emphasis was detected on the cross-functional integration than the other two competences. A much higher involvement of cross-functional teams from the manufacturing industry was expected due to its recognition by the academic literature as being highly beneficial for the development of new products. Likewise, the reported low emphasis in integrating customers and the even lower (almost neutral) emphasis on supplier integration during NPD processes was unexpected. This could influence the hypothesis testing when analysing the relationship of these competences in the adoption of certain cost management methods.

Cross-functional integration

Intra-organisational involvement has been seen as one of the most popular collaborative competences for the success of product development processes (Mishra & Shah, 2009; Narasimhan & Kim, 2002; Wong et al., 2011). Cross-functional integration was identified as an antecedent of the adoption of cost management methods for new product development (H6). We found a relationship between this competence and the use of methods, of which internal cost data sources are sufficient when being employed. This applies to both the methods' scopes of monetarisation i.e., financial calculations and non-financial analysis and guidelines. Our findings are consistent with previous research suggesting that the use of accounting methods promotes the integration of functions to achieve target costs (Dekker & Smidt, 2003; Tani, et al., 1994) by ensuring, common understanding of cost structures within product development (Ellram, 2002, 2000) in which internal data sources are crucial for such development processes i.e., gathering information from different departments such as marketing, manufacturing and R&D (Bouwens & Abernethy, 2000; Sherman et al., 2005; X. Song et al., 1998).

As previously mentioned, this research hypothesised the relationships between the organisation's collaborative competences and the "use" and "helpfulness" of certain methods arranged by groups (i.e., Group–IX and X). In this research there are cases in which the use of certain methods is confirmed but not their helpfulness or vice versa. The results regarding cross-functional integration are satisfactory since it is the only case in which all four related hypotheses were supported i.e., about "use of" and on "helpfulness". Hence, we can interpret "cross-function integration" as an antecedent of the adoption of cost management methods.

Furthermore, we also stressed the relationship between the individual use of methods and a particular collaborative competence on a deeper level. The results of further correlation analyses showed that the relationship between the variables "use of" and "cross-functional integration" as well as "helpfulness" and "cross-functional integration" prevailed in four methods. Surely, the fact that the use and helpfulness of four methods (out of 15) relate to cross-functional integration might be caused by the research R&D context. Thus, companies whose main objective is to exploit this collaborative competence in developing new products can rely on using the Kaizen costing, total cost of ownership, design for manufacturing and design for X methods. Similar findings in the literature support our results, highlighting how Kaizen costing aims for simple improvements which are quick and easy to implement at low cost and which involve several departments of a company (Imai, 2012). In manufacturing plants Kaizen costing is geared toward the reduction of variable costs (particularly direct and labour costs), whereas in indirect departments such as R&D, fixed cost reduction is sought (Monden & Hamada, 1991). Moreover, previous research emphasises how design for manufacturing constantly requires the participation of several departments i.e., cross-functional teams to improve product design (Ettlie, 1995). Jayaram and Malhotra (2010) recommend DFM as a proactive method to foster cross-functional coordination, which influences time-to-market performance.

Supplier integration

The concept of supplier involvement is essentially attributed to the commitment between an organisation and its suppliers in amalgamating a successful development of new products (Swink et al., 2007). Previous research analyses the adoption of cost management practice to involve suppliers in product development (Caglio & Ditillo, 2008; R. Cooper & Slagmulder, 2003; Tan, 2001). Our findings are consistent with previous research suggesting that the adoption of these methods is strongly related to the involvement of suppliers in manufacturing processes (Agndal & Nilsson, 2009, 2010; C. Carr & Ng, 1995; R. G. Cooper, 2004; Dekker, et al., 2013; Seal et al., 2004; Wijewardena & De Zoysa, 1999). Regarding the perception of helpfulness from using cost management methods, we found only for one group of methods a relationship between their helpfulness and the competence of supplier integration. The methods within this group had a common scope of financial calculations. Thus, contradictory is why the "helpfulness" of methods which were classified as non-financial guidelines would not relate to "supplier integration" when their use does. Hence, future research should examine this in a more detailed manner through case-studies.

Moreover, the use of stage-gates, design for X and technology roadmaps is associated with supplier integration. However, results did not yielded any significant correlation when analysing the perceived helpfulness of these three methods.

Lastly, target costing is the single method for which the analyses on use and helpfulness relate to the collaborative competence of supplier integration. This is consistent with the early field studies of C. Carr and Ng (1995) who show how target costing principles are used to support a company's efforts in integrating their suppliers. This is achieved by providing the structure to "open-book suppliers" for delivering a complete breakdown of the price of their products, i.e., material, packaging and shipping costs. In many companies, this practice has become a necessity, when improving supplier-customer relationships within the automotive industry for instance, where competitive bidding has been replaced by target prices set by the customer (Ro et al., 2007). Within a R&D framework target costing practices are relevant for the success of an NPD process (Cooper & Slagmuide, 1999). Target costing encourages information sharing regarding costs and technology (Liker et al., 1996; Petersen et al., 2003; Plank & Ferrin, 2002; Ro et al., 2007). This improves collaborative competences, namely, the inter-organisational collaboration between the company's different functions and the intra-organisational collaboration among NPD teams and their suppliers or customers.

In particular, target pricing has been used in early stages of product development cycle, encouraging buyer-seller teams who work jointly on alternative technical solutions to meet a target cost (Petersen et al., 2003). Likewise, the target costing method guides product development processes in fulfilling customer requirements while providing the functionality corresponding to the target price set at the desired quality level.

Results from Ro et al. (2007) showed that suppliers feel oppressed and constrained by their customers' target pricing or costing activities. Thus, future research should focus on finding a balance where both the organisation and suppliers can benefit from a process based on target costing.

Customer integration

Customer integration is commonly related to the collaboration between a company and its customers to develop new products. This includes the involvement of customers' ideas, needs and wants during the early stages of product design. The MA literature also lends itself to research development within collaboration between organisations and their customers (Bajaj et al., 2004; Bhimani, 2003; Dunk, 2004; Nixon, 1998). Empirical evidence suggests the adoption of certain cost management practices occur when the organisation is willing to involve customers in their development process. For example, quality function deployment stimulates the team consciousness about customers' needs and instance market information (Burchill & Fine, 1997; Swink, 2003; Griffin & Hauser, 1992). Hence, this method can be used to understand the customer´s environment, converting this understanding into technical requirements and, most importantly, operationalising customers' input (Burchill & Fine, 1997).

Moreover, when technology roadmaps are used, organisations extend their development efforts to cover the entire supply chain e.g. in exploiting a partnership between both suppliers and customers (Jordan et al., 2013; P. Miller et al., 2008; P. Miller & O'Leary, 2007). Whereas manufacturing companies adapt such methods to their needs, customers´ input remain key requirements when applying certain cost management methods. Hence, current and potential customers can provide detailed data needed to use certain techniques to manage their cost structures for product development.

This study focused on the relationship between customer integration and the use of certain groups of cost management methods (H8). However, the results of correlation analyses do not support this relationship. This result may be explained by methodological flaws. The limited sample size reduces the statistical power of test performed. Moreover, it should be noted that correlation coefficient was not significant for any other group of methods (i.e., not hypothesized). Perhaps, a larger sample with more statistical power would yield different results. Likewise, results could be influenced by the fact, that no company standout for it's strategic priority of flexibility (see Hypothesis 5). Within both contexts, the customer (i.e. the market) is central for the business orientation. Hence, it seems that partnerships with customers and considering market trends and desires during new product development are not antecedents of the adoption of cost management methods.

Looking at a deeper level of analysis, we found a relationship between the variables "use of" and "customer integration" only when analysing the method of total cost of ownership and a relationship between the variables "helpfulness" and "customer integration" with in the analysis of design for manufacturing. The last result is congruent with research stating that the consumption of resources is moved to the design phase through the design for manufacturing method. Hence, a regulated interaction with customers is of paramount importance when applying this method (Bajaj et al., 2004).

Discussion of the influence of the firm's size on the adoption of cost management methods

The influence of the firm's size on the adoption of accounting practices is a widely-discussed topic with contradictory outcomes. Prior research supports the idea that the size of the organisation would not relate to the adoption of accounting practices. Al Chen et al. (1997) showed that most of the U.S.-based Japanese firms are similar to Japanese domestic firms in their use of management accounting methods regardless of the differences of characteristics in term of the firm's size. Likewise et al., (1999), find that cost management practices of small and medium sized (SME) companies are similar to those of larger Japanese firms. However, this research has been challenged by empirical studies showing that the firm's size has an impact on the use and design of cost management systems (Chenhall & Langfield-Smith, 1998; Duh et al., 2009; Joshi, 2001, Joshi et al., 2011). For example, Guilding (1999) has found competitor accounting practices to be related to company size, competitive strategy and strategic mission. Drury and Tayles (1994) as well as Hoque and James (2000) reported that adoption rates for management accounting practices are much higher in larger firms. Likewise, there is research claiming a distinction on a new product development context. Kessler (2000) indicates that DFM does not necessarily lead to decreased development costs in large companies and Eatock et al. (2009) suggest that large companies use a wider range of cost management methods such as quality function deployment, stage-gates and design for manufacturing during NPD processes.

These controversial results aroused our curiosity. Therefore, further analyses were conducted in which data set was re-arranged according to the firm's size, although this is not the main research objective. Due to data limitations, these further analyses could only be conducted on the hypotheses related to the collaborative competences. As a result, the findings partly conflict with the outcomes of early work.

Results changed particularly in three cases. The first of these related to "cross-functional integration" as an antecedent of the adoption (H6) using data from small firms. The second involved "supplier integration" as an antecedent of the adoption (H7) using data from medium-sized firms and the third involved also "supplier integration" as an antecedent of the adoption however when analysing data from large firms.

On the one hand, when analysing 32 small, 27 medium and 23 large firms, results showed that H6 only applies to small firms. Hence, we can infer that the adoption of methods in Group–IX (i.e., value engineering, functional cost analysis, Kaizen costing and life-cycle costing) and Group–X (i.e., stage-gates, funnels, DFM, DFX, component commonality, modular design and product platforms) is probable in small companies when they seek to involve other function areas such as manufacturing, marketing, etc. within the development of new products. Our findings support the work from Zengin and Ada (2010), in which the introduced QFD-Target costing process was proved to be reliant on cross-functional integration suggesting that QFD-TC could be a suitable solution for SMEs to manage their NPD processes.

On the other hand, correlation values changed notably within the framework of supplier integration. Firstly, values for medium sized firms increased almost twice as much as the value obtained when analysing the whole sample (i.e. 82 firms). This could mean that for medium size firms the adoption of the methods classified in Group–VII (target costing, value engineering, life-cycle costing and total cost of ownership) and Group–VIII (stage-gates, modular design and technology roadmaps) was highly dependent of the company's efforts to involve suppliers in developing new products. Secondly, we observed a change of correlation values when analysing large firms only for the adoption of methods classified in Group–VII. Therefore, we can interpret the results and suggest that for large firms, "supplier integration" is an antecedent of the adoption of the methods: target costing, value engineering, life-cycle costing and total cost of ownership.

The results of further analyses contradicted the expectations that large firms use a wider range of cost management methods during new product development. Guidelines for future research as well as the research limitations are discussed in the section below.

8.4 Limitations and future research

It should be noted that this study does not presume a consensus on adopted cost management methods among manufacturing firms. Instead, it is an effort to document the relevance of management accounting practices during new product development (NPD) whilst identifying the organisation's characteristics that determine the adoption of these methods.

This study has several limitations. Firstly, the reliability of constructs was rather weak for two of the strategic priorities of quality leadership and flexibility. The measurement of the organisation's orientation towards a particular strategic priority (Boyer et al., 2002) has been practised in engineering research (M. Joshi, 2003; Swink et al., 2007; Wong et al., 2011). However, these instruments were originally developed in English. Thus, the translation of the instrument has not been tested before and care should be taken when interpreting the findings and comparing them to previous research. Further studies may wish to add to the body of knowledge in this area by refining the instrument for the German speaking countries. Perhaps the constructs could be tested with new data and possibly refined with additional items.

Secondly, data collected for this study involved manufacturing firms within the technology sector operating at one point in time. Research issues like these illustrate the complexity of the phenomenon and stress the need to expand both the range of research methods and the scope of inquiry. Surveys have limited ability in revealing the nature of the processes or in addressing issues of "how" and "why". Further research in this area could be improved by a close survey of R&D departments to greater description of our findings on the antecedents of adoption in a cause-effect framework. Such a study could be conducted through case-studies over a longer period of time.

Thirdly, the sample was drawn from German manufacturing firms. We have no knowledge about how the industry and country affect the findings of the study so any generalisation from the results needs to be viewed cautiously. Moreover, previous research stress that besides varying the industry structure (Chang et al. 2003), adoption of cost control systems varied as well from country to country (Chenhall & Langfield-Smith, 1998; Wijewardena & De Zoysa, 1999). Therefore, future studies could replicate our research with data from other industries and countries.

Lastly, future research may also attempt to investigate the hypotheses neglected in this study (H3 and H8) using alternative approaches e.g., case-studies, experiments. Thus, this research should focus on which cost management methods are employed by companies with the strategic priority of flexibility. They should also study which ones are used when companies involve their customers in developing new products. Moreover, a larger sample could be use in order to overcome these limitations and should consider adding more methods and factors that might influence the adoption of such practices. For example, the factors mentioned by respondents as being relevant for their organisation such as being customer driven, risk reductions as well as the methods reported as being in use at their organisations such as the budgeting of R&D projects, key performance indicators, risk analyses and the concurrent engineering method. These concepts may serve as starting point for future research. Moreover, since this research did not included any variables related to the organisation's performance or NPD success. Further research could consider linking the use of cost management methods under different contingencies to organisational and NPD performance in order to shed light on its efficient and inefficient use.

9 Conclusions

Globalisation, economic and technological developments, as well as changes in market expectations, affect firms' NPD processes including design, manufacturing and launching processes. Management accounting can substantially contribute to a focused and effective NPD within this context. Thus, the antecedents of the adoption of accounting methods specially to support NPD processes might differ among firms. This research provides new empirical evidence not only on the adoption of 15 cost management methods but also on the antecedents for such adoption, overcoming some of the typical data limitations by using a unique survey data set of 82 German manufacturing firms.

Firstly, we studied 15 different cost management methods through a systematic literature review. This addressed not just the management accounting (MA) literature but also the innovation and operation management (IOM) literature.

On the one hand, the MA literature covered 37 journals suggested by Bonner et al. (2006) as being the most influencial ones in academic accounting. Three more journals were added based on our personal judgement, namely, *European Accounting Review*, *Management Accounting Research* and *Journal of Cost Management*. Within this selection of journals we used a variety of search terms published in the period from 1990 to 2013. The search yielded a sample of 113 different papers. Many contained information about more than one method and this yielded 149 references to specific methods, including constantly recurring combinations which involved target costing, value engineering and Kaizen costing. Further combinations involved product platforms, modular design and component commonality. These topics also form a coherent set of cost management methods that can be used and studied together.

On the other hand, 23 different journals from the IOM literature were selected based on different rankings. The search resulted in 208 unique papers published in the period from 1990 to 2014. Findings also contained information about more than one method yielding to 275 results. Three cost management methods clearly received the majority of the results. 42% of all results consisted of modular design, component commonality and product platforms methods together. Moreover, *International Journal of Production Research*, *Journal of Product Innovation Management, International, Journal of Production Economics* and *IEEE Transactions on Engineering Management* included the greatest number of results.

The literature review highlighted the importance of cost management methods for business organisations and related entities such as suppliers, shareholders and customers (Anderson & Dekker, 2009; Woods et al., 2012). These methods are recognised as worthwhile methods that companies implement to improve their business performance. Organisations might use different methods to achieve specific goals, i.e., designs of profitable products, costs reductions and project management. Practices such as value engineering (Al Chen et al., 1997), quality function deployment (Easton & Pullman, 2001; Karmarkar & Pitbladdo, 1997) and functional cost analysis (T Yoshikawa et al., 1995) assist organisations in allocating their resources efficiently during the manufacturing of products. Furthermore, with the use of target costing, companies can work better on their cost structures to achieve pre-determined goals in terms of allowable costs (Ansari et al., 2007; Ansari & Bell, 1997; R. Cooper & Slagmulder, 1999). Kaizen costing helps to establish a continuous achievement of the company's goals in terms of cost expectations (Agndal & Nilsson, 2009). Moreover, product development projects can be managed over time and throughout diverse stages of progress. Stage-gate reviews (Jørgensen & Messner, 2009) and funnels (Ding & Eliashberg, 2002) provide key guidelines to pursue a clearer structure for these projects.

Prior research in the field of management accounting addresses several areas of interest. However, most of the research looked at in the literature review did not explain the company's reasons for the adoption of cost management methods. The current research questions whether there is a relationship between the organisation's characteristics and the use of certain groups of cost management methods. We defined six organisations' characteristics as antecedents of the adoption of certain groups of cost management methods. Hypotheses were developed based on the idea that cost management methods are aligned to the organisation's structure supporting the strategy of the company as well as the collaborative competences pursued.

This investigation contributes to the literature because, to our knowledge, no previous studies have examined the reasons for adopting cost management methods in an NPD context. The first three antecedents relate to the company's strategic priority, namely, cost leadership, quality leadership and flexibility. This is followed by three antecedents concerning the organisation's collaborative competences, namely, cross-functional integration, supplier integration and customer integration.

Consequently, an empirical study was conducted to assess the adoption of these methods where 800 R&D managers were invited to participate in the web-based survey. The survey results can be interpreted as a practitioner's assessment of academic theories pertaining to manufacturing firms. Through this research we attempt to fill the gap in the literature by proving which group of cost management methods are used for NPD processes within the German manufacturing industry. We aimed to contribute to the academic knowledge by presenting the reasons for their adoption and examining the extent to which these are considered helpful.

Lastly, the hypotheses were evaluated using data from 82 German manufacturing firms in the technology sector. We can determine that real data is difficult to obtain from the results of our survey and because of this there appears to be little literature giving detailed explanations on the adoption of cost management methods to support the development of new products. This research has provided us with a picture of the R&D framework and allowed the identification of some interesting areas for future research. The findings can be classified into five categories which include “expected and supported”, “not supported”, “interesting observations”, “results of further analyses” and “areas for future research”. The key findings from the survey are listed below according to the aforementioned categories.

(1) Expected and supported findings

- The adoption of cost management methods by R&D departments strongly relates to the perception of their helpfulness for NPD (H1-H2).
- The strategic priority of **cost leadership** was identified as antecedent of the adoption (**H3**).
  - We found a strong relationship between cost leadership and the use of the methods employed for individual products or services which consider the entire costs for developing new products (Group–III in Figure 5).

- The integration of **cross-functional teams** was identified as antecedent of the adoption (**H6**).
  - The relationships exist for both, the methods used for financial calculations (Group–IX in Figure 9) and for non-financial analysis and guidelines (Group–X in Figure 9). These groups were also identified as helpful in developing new products.

- The **integration of suppliers** was identified as antecedent of the adoption (**H7**).
  - The relationships exist for both, the methods used for financial calculations (Group–VII in Figure 9) and for non-financial analysis and guidelines (Group–VIII in Figure 9). However, only Group–VII was identified as helpful during NPD.

(2) Not supported findings

- There were no firms within sample committed to the strategic priority of **flexibility**.
  - Therefore, this strategic priority could no be studied as antedecent of the adoption of certain cost management methods (**H5**).

- **Quality leadership** was not identified as antecedent of adoption (**H4**).
  - However, this priority was associated with the perception of “helpfulness” of the same methods, which its application focuses on individual products and services (Group–I and III in Figure 5).

- **Customer integration** was not identified as antecedent of adoption (**H8**).

(3) Interesting observations

- For each one of the studied methods, the perception of how helpful they are in developing new products is higher than their actual use.

- Target costing is the most used method in a R&D context although modular design is the method perceived as most helpful to support NPD-processes.

- The method product platform showed the strongest consensus among all firms regarding its level of use and helpfulness.

- The integration of suppliers was identified as antecedent of the adoption (H7).
    - However, only the methods with the common scope on financial calculations were identified as helpful.

- We found statistical support for 3 relationships to which no hypothesis was developed due to the lack of empirical evidence within the literature. These findings included the following relationships:
    - Cross-functional integration & the use of methods in Group–VIII (Figure 9).
    - Cross-functional integration & the helpfulness of methods in Group–VIII (Figure 9).
    - Supplier integration & the use of methods in Group–VI (Figure 9).

(4) Findings of further analyses

- The strategic orientation of cost leadership is highly related to the use and helpfulness especially of the methods design for manufacturing and life-cycle costing.

- The strategic orientation of quality leadership is highly related to the use and helpfulness especially of the methods of stage-gates reviews and product platforms.

- The strength of the relationship between the use and the helpfulness of all cost management methods is stronger among medium-sized firms.

- The organisation's characteristic "firm's size" had an impact on the hypotheses regarding the antecedents of the adoption of cost management methods. This impact could be seen in the following cases:
    - We identifed cross-functional integration as an antecedent of the adoption of methods classified in Group–IX and X within <u>small firms</u>, while no support was found for the same relation within Medium and large firms.
    - We identified supplier integration as an antecedent of the adoption of methods classified in Group–VII and VIII within <u>medium</u> and <u>large firms</u>, while no support was found for the same relation within small firms.

(5) Areas for future research

- We experience a lack of data to evaluate the hypotheses related to the strategic priority of flexibility. Future research should study this strategic priority as antecedent of the adoption. However, it is necessary to strive for higher reliability values on the measurement instrument.

- Also intriguing is why the helpfulness of methods which were classified in Group-VIII (non-financial analysis and guidelines) does not relate to the company's competence of supplier integration, when its use does. Future research should examine this finding in a detailed manner, as for example, through case-studies.

- The results of the further analysis conducted based on the firm's size showed strong relationship between the use of all methods and the R&D managers' perceptions of its helpfulness. Although all correlation values were quitesimilar, it is interesting to notice that these values were slightly higher within medium-sized firms while lower within large firms. These findings question whether there is a practical explanation for this perception. May be case-studies on this matter and a comparison of type of companies should follow.

- Further studies could use a larger sample in order to overcome data limitations and may consider adding more methods and other factors that influence the adoption of such practices. For example, the factors mentioned by respondents as being relevant for their organisation such as being customer driven, risk reductions as well as the methods reported as being in use at their organisations such as the budgeting of R&D projects, key performance indicators, risk analyses and the concurrent engineering method.

- Finally, further research could consider linking the use of cost management methods under different contingencies to organisational and NPD performance in order to shed light on its efficient and inefficient use.

Finally, we presented a comprehensive literature review addressing research fields besides management accounting and provided the first empirical evidence of the relationships between certain cost management methods and particular company characteristics for researchers in the field of management accounting based on a large-scale investigation. This research proved that the use of cost management methods is strongly related to the perception of its helpfulness and gives empirical evidence that cost leadership, cross-functional integration and supplier integration explain the adoption of certain methods during NPD. These results imply that firms with these characteristics should evaluate which methods they use to support their NPD-processes.

Furthermore, results did not provide any support in defining either quality leadership or customer integration as antecedents of the adoption of cost management methods. However, it should be noted that the unexpected results could have been affected by the measurement instrument used or by other factors such as the sample selection. Thus, more research should be conducted in various settings using different measurement instruments to confirm the results.

List of references

Abdel-Kader, M., & Luther, R. (2008). The impact of firm characteristics on management accounting practices: A UK-based empirical analysis. *The British Accounting Review*, *40*(1), 2–27. doi:10.1016/j.bar.2007.11.003

Abdel-Maksoud, A., Dugdale, D., & Luther, R. (2005). Non-financial performance measurement in manufacturing companies. *The British Accounting Review*, 37(3), 261–297. doi:10.1016/j.bar.2005.03.003

Adam, E. E. (1989). Assessing operations management from a strategic perspective. *Journal of Management*, 15(2), 181–203. doi:10.1177/014920638901500204

Afonso, P., Nunes, M., Paisana, A., & Braga, A. (2008). The influence of time-to-market and target costing in the new product development success. *International Journal of Production Economics*, 115(2), 559–568. doi:10.1016/j.ijpe.2008.07.003

Agard, B., & Bassetto, S. (2013). Modular design of product families for quality and cost. *International Journal of Production Research*, 51(6), 1648–1667. doi:10.1080/00207543.2012.693963

Agard, B., & Penz, B. (2009). A simulated annealing method based on a clustering approach to determine bills of materials for a large product family. *International Journal of Production Economics*, 117(2), 389–401. doi:10.1016/j.ijpe.2008.12.004

Agndal, H., & Nilsson, U. (2009). Interorganizational cost management in the exchange process. *Management Accounting Research*, 20(2), 85–101. doi:10.1016/j.mar.2008.07.001

Agndal, H., & Nilsson, U. (2010). Different open book accounting practices for different purchasing strategies. *Management Accounting Research*, 21(3), 147–166. doi:10.1016/j.mar.2010.04.001

Agrawal, T., Sao, A., Kiran, J. F., Tiwari, M. K., & Kim, D. Y. (2013). A hybrid model of component sharing and platform modularity for optimal product family design. *International Journal of Production Research*, 51(2), 614–625. doi:10.1080/00207543.2012.663106

Ahmad, S., Mallick, D. N., & Schroeder, R. G. (2013). New product development: Impact of project characteristics and development practices on performance. *Journal of Product Innovation Management*, 30(2), 331–348. doi:10.1111/j.1540-5885.2012.01002.x

Ahmad, S., Schroeder, R. G., & Mallick, D. N. (2010). The relationship among modularity, functional coordination, and mass customization: Implications for competitiveness. *European Journal of Innovation Management*, 13(1), 46–61. doi:10.1108/14601061011013221

Akçay, Y., & Xu, S. H. (2004). Joint inventory replenishment and component allocation optimization in an assemble-to-order system. *Management Science*, 50(1), 99–116. doi:10.1287/mnsc.1030.0167

Al Chen, Romocki, T., & Zuckerman, G. (1997). Examination of US-based Japanese subsidiaries: Evidence of the transfer of the Japanese strategic cost management. *The International Journal of Accounting*, 32(4), 417–440.

Albright, R. E., & Kappel, T. a. (2003). Roadmapping in the corporation. *Research-Technology Management*, 46(2), 31–40.

Alkaraan, F., & Northcott, D. (2006). Strategic capital investment decision-making: A role for emergent analysis tools? *The British Accounting Review*, 38(2), 149–173. doi:10.1016/j.bar.2005.10.003

Al-Omiri, M., & Drury, C. (2007). A survey of factors influencing the choice of product costing systems in UK organizations. *Management Accounting Research*, 18(4), 399–424. doi:10.1016/j.mar.2007.02.002

Anderson, J. C., & Gerbing, D. (1991). Predicting the performance of measures in a confirmatory factor analysis with a pretest assessment of their substantive validities, *Journal of Applied Psychology*, 76(5), 732–740.

Anderson, S. W., & Dekker, H. C. (2009). Strategic cost management in supply chains, part 1: Structural cost management. *Accounting Horizons*, 23(2), 201–220. doi:10.2308/acch.2009.23.2.201

Anderson, S. W., & Sedatole, K. (1998). Designing quality into products: the use of accounting data in new product development. *Accounting Horizons*, 12(3), 213–233.

Ansari, S., & Bell, J. (1997). Target Costing - The Next Frontier in Strategic Cost Management. Austin, TX 78746 USA: Mountain Valley Publishing , LLC.

Ansari, S., Bell, J., & Okano, H. (2007). Target costing: Uncharted research territory. In C. S. Chapman, A. G. Hopwood, & M. D. Shields (Eds.), *Handbook of Management Accounting Research* (pp. (507–530, Vol.2). United Kingdom: Oxford.

Anthony, T. (2000). Supply chain collaboration: Success in the new internet economy. In A. Wharton & N. Mulani (Eds.), Achieving Supply Chain Excellence Through Technology (2nd. ed., pp. 41–44). San Francisco, CA: B. Jacobs & N. Smith.

Armacost, R. L., Componation, P. J., Mullens, M. A., & Swart, W. W. (1994). An AHP Framework for prioritizing customer requirements in QFD: An industrialized housing application*. IIE Transactions*, 26(4), 72–79. doi:10.1080/07408179408966620

Armstrong, J. S., & Overton, T. S. (1977). Estimating nonresponse bias in mail surveys. *Journal of Marketing Research*, 14(3), 396–402. doi:10.2307/3150783

Arping, S., & Lóránth, G. (2006). Corporate leverage and product differentiation strategy. *The Journal of Business*, 79(6), 3175–3206.

Asiedu, Y., & Gu, P. (1998). Product life cycle cost analysis: State of the art review. *International Journal of Production Research*, 36(4), 883–908. doi:10.1080/002075498193444

Ax, C., Greve, J., & Nilsson, U. (2008). The impact of competition and uncertainty on the adoption of target costing. *International Journal of Production Economics*, 115(1), 92–103. doi:10.1016/j.ijpe.2008.04.010

Ayanso, A., & Mokaya, B. (2013). Efficiency evaluation in search advertising. Decision Sciences, 44(5), 877–913. doi:10.1111/deci.12038

Badir, Y. F., & O'Connor, G. C. (2015). The formation of tie strength in a strategic alliance's first new product development project: The influence of project and partners' characteristics. *Journal of Product Innovation Management*, 32(1), 154–169. doi:10.1111/jpim.12222

Bai, H., & Kwong, C. K. (2003). Inexact genetic algorithm approach to target values setting of engineering requirements in QFD. *International Journal of Production Research*, 41(16), 3861–3881. doi:10.1080/0020754031000138367

Baiman, S., Fischer, P., & Rajan, M. (2001). Performance measurement and design in supply chains. *Management Science*, 47(1), 173–188.

Baines, A., & Langfield-Smith, K. (2003). Antecedents to management accounting change: A structural equation approach. Accounting, *Organizations and Society*, 28(7), 675–698. doi:10.1016/S0361-3682(02)00102-2

Bajaj, A., Kekre, S., & Srinivasan, K. (2004). Managing NPD: Cost and schedule performance in design and manufacturing. *Management Science*, 50(4), 527–536. doi:10.1287/mnsc.l030.0177

Baker, M., & Bourne, M. (2014). A Governance framework for the idea-to-launch process. *Research-Technology Management*, 57(1), 42–49. doi:10.5437/08956308X5701105

Baldwin, C, & Clark, K. (1997). Managing in an age of modularity. *Harvard Business Review*, 85, 84–93.

Bard, J. F. (1992). A comparison of the analytic hierarchy process with multiattribute utility theory: A case study. *IIE Transactions*, 24(5), 111–121. doi:10.1080/07408179208964251

Bard, J. F., & Sousk, S. F. (1990). A tradeoff analysis for rough terrain cargo handlers using the AHP: an example of group decision making. *IEEE Transactions on Engineering Management*, 37(3), 222–228. doi:10.1109/17.104292

Basu, A., Blanning, R., & Shtub, A. (1997). Metagraphs in hierarchical modeling. *Management Science*, 43(5), 623–639.

Ben-Arieh, D., Easton, T., & Choubey, a. M. (2009). Solving the multiple platforms configuration problem. *International Journal of Production Research*, 47(7), 1969–1988. doi:10.1080/00207540701561520

Benton, W. C., & Krajewski, L. (1990). Vendor performance and alternative manufacturing environments. *Decision Sciences*, 21(2), 403–415. doi:10.1111/j.1540-5915.1990.tb01693.x

Bernstein, F., & DeCroix, G. a. (2004). Decentralized pricing and capacity decisions in a multitier system with modular assembly. Management Science, 50(9), 1293–1308. doi:10.1287/mnsc.1040.0255

Bernstein, F., DeCroix, G. a., & Wang, Y. (2011). The impact of demand aggregation through delayed component allocation in an assemble-to-order system. *Management Science*, 57(6), 1154–1171. doi:10.1287/mnsc.1110.1340

Bevilacqua, M., Ciarapica, F. E., & Giacchetta, G. (2007). Development of a sustainable product lifecycle in manufacturing firms: a case study. *International Journal of Production Research*, 45(18-19), 4073–4098. doi:10.1080/00207540701439941

Bhandare, S., & Allada, V. (2009). Scalable product family design: case study of axial piston pumps. *International Journal of Production Research*, 47(3), 585–620. doi:10.1080/00207540701441913

Bhimani, A. (2003). A study of the emergence of management accounting system ethos and its influence on perceived system success. *Accounting, Organizations and Society*, 28(6), 523–548. doi:10.1016/S0361-3682(02)00025-9

Binder, M., Gust, P., & Clegg, B. (2008). The importance of collaborative frontloading in automotive supply networks. *Journal of Manufacturing Technology Management*, 19(3), 315–331. doi:10.1108/17410380810853759

Bisbe, J., & Malagueño, R. (2009). The choice of interactive control systems under different innovation management modes. *European Accounting Review*, 18(2), 371–405. doi:10.1080/09638180902863803

Bisbe, J., & Otley, D. (2004). The effects of the interactive use of management control systems on product innovation. *Accounting, Organizations and Society*, 29(8), 709–737. doi:10.1016/j.aos.2003.10.010

Bjørnenak, T., & Olson, O. (1999). Unbundling management accounting innovations. *Management Accounting Research*, 10(June), 325–338.

Blecker, T., & Abdelkafi, N. (2007). The development of a component commonality metric for mass customization. *IEEE Transactions on Engineering Management*, 54(1), 70–85. doi:10.1109/TEM.2006.889068

Boardman, J. T., & Clegg, B. T. (2001). Structured engagement in the extended enterprise. *International Journal of Operations & Production Management*, 21(5/6), 795–811. doi:10.1108/01443570110390471

Boer, F. P. (2003). Risk-adjusted valuation of R&D projects. *Research-Technology Management*, 46(5), 50–58.

Boer, M., & Logendran, R. (1999). A methodology for quantifying the effects of product development on cost and time. *IIE Transactions*, 31(4), 365–378. doi:10.1080/07408179908969840

Bonner, S. E., Hesford, J. W., Van der Stede, W. a., & Young, S. M. (2006). The most influential journals in academic accounting. *Accounting, Organizations and Society*, 31(7), 663–685. doi:10.1016/j.aos.2005.06.003

Bordoloi, S., & Guerrero, H. H. (2008). Design for control: A new perspective on process and product innovation. *International Journal of Production Economics*, 113(1), 346–358. doi:10.1016/j.ijpe.2007.02.043

Bouwens, J., & Abernethy, M. (2000). The consequences of customization on management accounting system design. *Accounting, Organizations and Society*, 25(3), 221–241. doi:10.1016/S0361-3682(99)00043-4

Bovea, M. D., & Wang, B. (2007). Redesign methodology for developing environmentally conscious products. *International Journal of Production Research*, 45(18-19), 4057–4072. doi:10.1080/00207540701472678

Boyer, K. K. (1998). Longitudinal linkages between intended and realized operations strategies. *International Journal of Operations & Production Management*, 18(4), 356–373. doi:10.1108/01443579810199739

Boyer, K. K., Leong, G. K., Ward, P. T., & Krajewski, L. J. (1997). Unlocking the potential of advanced manufacturing technologies. *Journal of Operations Management*, 15(4), 331–347. doi:10.1016/S0272-6963(97)00009-0

Boyer, K. K., & Lewis, M. W. (2002). Competitive priorities: investigating the need for trade-offs in operations strategy. *Production and Operations Management*, 11(1), 9–20. doi:10.1111/j.1937-5956.2002.tb00181.x

Boyer, K. K., & McDermott, C. (1999). Strategic consensus in operations strategy. *Journal of Operations Management*, 17(3), 289–305. doi:10.1016/S0272-6963(98)00042-4

Boyer, K. K., & Pagell, M. (2000). Measurement issues in empirical research: improving measures of operations strategy and advanced manufacturing technology. *Journal of Operations Management*, 18(3), 361–374.

Brad, S. (2009). Concurrent multifunction deployment (CMFD). *International Journal of Production Research*, 47(19), 5343–5376. doi:10.1080/00207540701564599

Bremser, W. G., & Barsky, N. P. (2004). Utilizing the balanced scorecard for R&D performance measurement. *R&D Management*, 34(3), 229–238. doi:10.1111/j.1467-9310.2004.00335.x

Briggs, S. R., & Cheek, J. M. (1986). The role of factor analysis in the development and evaluation of personality scales. *Journal of Personality*, 54(1), 106. doi:10.1111/j.1467-6494.1986.tb00391.x

Burchill, G., & Fine, C. (1997). Time versus market orientation in product concept development: Empirically-based theory generation. *Management Science*, 43(4), 465–478.

Cadez, S., & Guilding, C. (2008). An exploratory investigation of an integrated contingency model of strategic management accounting. *Accounting, Organizations and Society*, 33(7-8), 836–863. doi:10.1016/j.aos.2008.01.003

Caglio, A., & Ditillo, A. (2008). A review and discussion of management control in inter-firm relationships: Achievements and future directions. *Accounting, Organizations and Society*, 33(7), 865–898. doi:10.1016/j.aos.2008.08.001

Caglio, A., & Ditillo, A. (2012). Opening the black box of management accounting information exchanges in buyer–supplier relationships. *Management Accounting Research*, 23(2), 61–78. doi:10.1016/j.mar.2012.03.001

Cao, Y., Luo, X., Kwong, C. K., & Tang, J. (2014). Supplier pre-selection for platform-based products: a multi-objective approach. *International Journal of Production Research*, 52(1), 1–19. doi:10.1080/00207543.2013.807376

Carr, C., & Ng, J. (1995). Total cost control: Nissan and its U.K. supplier partnerships. *Management Accounting Research*, 6(4), 347–365.

Carr, S., Mak, Y., & Needham, J. (1997). Differences in strategy, quality management practices and performance reporting systems between ISO accredited and non-ISO accredited companies. *Management Accounting Research*, 8(4), 383–403.

Caux, C., David, F., & Pierreval, H. (2006). Implementation of delayed differentiation in batch process industries: a standardization problem. *International Journal of Production Research*, 44(16), 3243–3255. doi:10.1080/00207540500521543

Chai, K. H., Wang, Q., Song, M., Halman, J. I. M., & Brombacher, A. C. (2012). Understanding competencies in platform-based product development: Antecedents and outcomes. *Journal of Product Innovation Management*, 29(3), 452–472. doi:10.1111/j.1540-5885.2012.00917.x

Chai, S. N. C., Sun, H. Y., & Lau, A. K. W. (2010). The impact of innovation management techniques on product innovation performance: An empirical study. In *Management of Innovation & Technology (ICMIT)*, 2010 IEEE International Conference on (pp. 432-437). IEEE (pp. 432–437). doi:10.1109/ICMIT.2010.5492782

Chakravarty, A. K. (1994). Assembly capacity mix planning with product-flexible technology and fixtures. *IIE Transactions*, 26(4), 19–35. doi:10.1080/07408179408966616

Chakravarty, A. K., & Balakrishnan, N. (2001). Achieving product variety through optimal choice of module variations. *IIE Transactions*, 33(7), 587–598. doi:10.1080/07408170108936856

Chan, D. S. K., & Lewis, W. P. (2000). The integration of manufacturing and cost information into the engineering design process. *International Journal of Production Research*, 38(17), 4413–4427. doi:10.1080/00207540050205190

Chan, T., Nickerson, J. A., & Owan, H. (2007). Strategic management of r&d pipelines with cospecialized investments and technology markets. *Management Science*, 53(4), 667–682. doi:10.1287/mnsc.1060.0676

Chang, S.-C., Yang, C.-L., Cheng, H.-C., & Sheu, C. (2003). Manufacturing flexibility and business strategy: An empirical study of small and medium sized firms. *International Journal of Production Economics*, 83(1), 13–26. doi:10.1016/S0925-5273(02)00263-3

Chang, S.-Y., & Yeh, T.-Y. (2013). Optimal order quantity and product modularity for a two-echelon returnable supply chain. *International Journal of Production Research*, 51(17), 5210–5220. doi:10.1080/00207543.2013.802051

Chao, G. H., Iravani, S. M. R., & Savaskan, R. C. (2009). Quality Improvement Incentives and Product Recall Cost Sharing Contracts. *Management Science*, 55(7), 1122–1138. doi:10.1287/mnsc.1090.1008

Chaudhuri, A., & Bhattacharyya, M. (2009). A combined QFD and integer programming framework to determine attribute levels for conjoint study. *International Journal of Production Research*, 47(23), 6633–6649. doi:10.1007/978-90-481-2860-0_13

Chen, Y., Fung, R. Y. K., & Tang, J. (2005). Fuzzy expected value modelling approach for determining target values of engineering characteristics in QFD. *International Journal of Production Research*, 43(17), 3583–3604. doi:10.1080/00207540500032046

Chen, Y. Z., & Ngai, E. W. T. (2008). A fuzzy QFD program modelling approach using the method of imprecision. *International Journal of Production Research*, 46(24), 6823–6840. doi:10.1080/00207540701463297

Chenhall, R. H. (2008). Accounting for the horizontal organization: A review essay. *Accounting, Organizations and Society*, 33(4), 517–550. doi:10.1016/j.aos.2007.07.004

Chenhall, R. H., & Langfield-Smith, K. (1998a). Adoption and benefits of management accounting practices: an Australian study. *Management Accounting Research*, 9(1), 1–19.

Chenhall, R. H., & Langfield-Smith, K. (1998b). The relationship between strategic priorities, management techniques and management accounting: an empirical investigation using a systems approach. *Accounting, Organizations and Society*, 23(3), 243–264.

Choi, S., Kim, H., Yoon, J., Kim, K., & Lee, J. Y. (2013). An SAO-based text-mining approach for technology roadmapping using patent information. *R&D Management*, 43(1), 52–74. doi:10.1111/j.1467-9310.2012.00702.x

Chung, B. Y. C. B. Y. Y., Syachrani, S., Jeong, H. S. J. H. S. S. (David), & Kwak, Y. H. K. Y. H. H. (2009). Applying Process Simulation Technique to Value Engineering Model: A Case Study of Hospital Building Project. *IEEE Transactions on Engineering Management*, 56(3), 549–559. doi:10.1109/TEM.2009.2013831

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2. ed. / X.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cohen, J., & Cohen, P. (1975). Applied multiple regression / correlation Analysis for the behovioral sciences. Hillsdale,. N.J.: Erlbaum.

Coldrick, S., Longhurst, P., Ivey, P., & Hannis, J. (2005). An R&D options selection model for investment decisions. *Technovation*, 25(3), 185–193. doi:10.1016/S0166-4972(03)00099-3

Cole, M. H. (2000). Review of: "Creating Quality"William J. Kolarik McGraw-Hill, Inc., 1995, 925 pp., ISBN 0-07-035217-8. *IIE Transactions*, 32(6), 570–570. doi:10.1080/07408170008963940

Cooper, M. J., & Budd, C. S. (2007). Tying the pieces together: A normative framework for integrating sales and project operations. *Industrial Marketing Management*, 36(2), 173–182. doi:10.1016/j.indmarman.2006.03.005

Cooper, R. (1996). Costing techniques to support corporate strategy: evidence from Japan. *Management Accounting Research*, 7(2), 219–246. doi:10.1006/mare.1996.0013

Cooper, R. G. (1988). The new product process: A decision guide for management. *Journal of Marketing Management*, 3(3), 238–255. doi:10.1080/0267257X.1988.9964044

Cooper, R. G. (1990). Stage-Gate Systems: A new tool for managing new products. *Business Horizons*, 33(3), 44–54.

Cooper, R. G. (1994). Perspective: Third-generation new product processes. *Journal of Product Innovation Management*, 11(1), 3–14. doi:10.1016/0737-6782(94)90115-5

Cooper, R. G. (2004). Benchmarking best NPD practices-II. *Research-Technology Management*, 47(3), 50–59.

Cooper, R. G. (2006). Managing technology development projects. *ResearchTechnology Management*, 49(6), 23–31.

Cooper, R. G. (2013). Where are all the breakthrough new products?: Using portfolio management to boost innovation. *Research-Technology Management*, 56(5), 25–33. doi:10.5437/08956308X5605123

Cooper, R. G. (2014). Invited article: What's next?: After Stage-Gate. *Research-Technology Management*, 57(1), 20–31. doi:10.5437/08956308X5606963

Cooper, R. G., & Edgett, S. J. (2012). Best practices in the idea-to-launch process and its governance. *Research-Technology Management*, 55(2), 43–54. doi:10.5437/08956308X5502022

Cooper, R. G., & Kleinschmidt, E. (1990). New product success factors: A comparison of "kills" versus successes and failures. *R&D Management*, 20(1), 47–63.

Cooper, R. G., & Kleinschmidt, E. J. (1991). New product processes at leading industrial firms. Industrial Marketing Management, 20(2), 137–147. doi:10.1016/0019-8501(91)90032-B

Cooper, R. G., & Kleinschmidt, E. J. (1995). Benchmarking the firm's critical success factors in new product development. *Journal of Product Innovation Management*, 12(5), 374–391.

Cooper, R. G., & Kleinschmidt, E. J. (2007). Winning businesses in product development: The critical success factors. *Research-Technology Management*, 50(3), 52–66.

Cooper, R., & Slagmulder, R. (1999). Develop profitable new products with target costing. *MIT Sloan Management Review*, 40(4), 23–33.

Cooper, R., & Slagmulder, R. (2003). Strategic cost management: expanding scope and boundaries. *Journal of Cost Management*, 17(1), 23–30.

Cooper, R., & Slagmulder, R. (2004a). Achieving full cycle cost management - five techniques. *MIT Sloan Management Review*, 46(1), 45 – 52.

Cooper, R., & Slagmulder, R. (2004b). Interorganizational cost management and relational context. *Accounting, Organizations and Society*, 29(1), 1–26. doi:10.1016/S0361-3682(03)00020-5

Cooper, R., & Yoshikawa, T. (1994). Inter-organizational cost management systems: The case of the Tokyo-Yokohama-Kamakura supplier chain. *International Journal of Production Economics*, 37(1), 51–62. doi:10.1016/0925-5273(94)90007-8

Cosner, R. R., Hynds, E. J., Fusfeld, A. R., Loweth, C. V, Scouten, C., & Albright, R. (2007). Integrating roadmapping into technical planning. *Research-Technology Management*, 50(6), 31–48.

Cousins, P. D., Lawson, B., Petersen, K. J., & Handfield, R. B. (2011). Breakthrough scanning, supplier knowledge exchange, and new product development performance. *Journal of Product Innovation Management*, 28(6), 930–942. doi:10.1111/j.1540-5885.2011.00854.x

Cristiano, J. J., Liker, J. K., & White, C. C. (2000). Customer-driven product development through quality function deployment in the US and Japan. *Journal of Product Innovation Management*, 17(4), 286–308. doi:10.1016/S0737-6782(00)00047-3

Curran, R., Gomis, G., Castagne, S., Butterfield, J., Edgar, T., Higgins, C., & McKeever, C. (2007). Integrated digital design for manufacture for reduced life cycle cost. *International Journal of Production Economics*, 109(1), 27–40. doi:10.1016/j.ijpe.2006.11.010

Dambrin, C., & Robson, K. (2011). Tracing performance in the pharmaceutical industry: Ambivalence, opacity and the performativity of flawed measures*. Accounting, Organizations and Society*, 36(7), 428–455. doi:10.1016/j.aos.2011.07.006

Danese, P., & Filippini, R. (2013). Direct and mediated effects of product modularity on development time and product performance. *IEEE Transactions on Engineering Management*, 60(2), 260–271. doi:10.1109/TEM.2012.2208268

Daniel, S., & Reitsperger, W. (1991). Linking quality strategy with management control systems: empirical evidence from Japanese industry. *Accounting, Organizations and Society*, 16(7), 601–618.

Das, K., & Chowdhury, A. H. (2012). Designing a reverse logistics network for optimal collection, recovery and quality-based product-mix planning. *International Journal of Production Economics*, 135(1), 209–221. doi:10.1016/j.ijpe.2011.07.010

Das, S., & Kanchanapiboon, A. (2011). A multi-criteria model for evaluating design for manufacturability. *International Journal of Production Research*, 49(4), 1197–1217. doi:10.1080/00207540903505267

Datar, S., Jordan, C., & Kekre, S. (1997). New product development structures and time-to-market. *Management Science*, 43(4), 452–464.

Davidson, J. M., Clamen, A., & Karol, R. A. (1999). Learning from the best new product developers. *Research-Technology Management*, 42(4), 12–18.

Davila, A. (2000). An empirical study on the drivers of management control systems' design in new product development. *Accounting, Organizations and Society*, 25(4-5), 383–409.

Davila, A., Foster, G., & Li, M. (2008). Reasons for management control systems adoption: Insights from product development systems choice by early-stage entrepreneurial companies. *Accounting, Organizations and Society*, 34(3-4), 322–347. doi:10.1016/j.aos.2008.08.002

Davila, A., Foster, G., & Oyon, D. (2009). Accounting and control, entrepreneurship and innovation: Venturing into new research opportunities. *European Accounting Review*, 18(2), 281–311. doi:10.1080/09638180902731455

Davila, A., & Oyon, D. (2009). Introduction to the special section on accounting, innovation and entrepreneurship. *European Accounting Review*, 18(2), 277–280. doi:10.1080/09638180902924522

Davila, A., & Wouters, M. (2004). Designing cost-competitive technology products through cost management. *Accounting Horizons*. 18(1), 13-26.

Davila, A., & Wouters, M. (2007). An empirical test of inventory, service and cost benefits from a postponement strategy. *International Journal of Production Research*, 45(10), 2245–2267. doi:10.1080/00207540600725002

Davis, J. P., & Eisenhardt, K. M. (2011). Rotating leadership and collaborative innovation: recombination processes in symbiotic relationships. *Administrative Science Quarterly*, 56(2), 159–201. doi:10.1177/0001839211428131

de Vries, M. J. (1994). Design process dynamics in an experience-based context: a design methodological analysis of the Brabantia corkscrew development. *Technovation*, 14(7), 437–448. doi:10.1016/0166-4972(94)90002-7

DeCroix, G. a., Song, J.-S., & Zipkin, P. H. (2009). Managing an assemble-to-order system with returns. *Manufacturing & Service Operations Management*, 11(1), 144–159. doi:10.1287/msom.1070.0209

Deegan, C. (2008). Environmental costing in capital investment decisions: electricity distributors and the choice of power poles. *Australian Accounting Review*, 18(1), 2–15. doi:10.1111/j.1835-2561.2008.0002.x

Degraeve, Z., Labro, E., & Roodhooft, F. (2005). Constructing a total cost of ownership supplier selection methodology based on activity-based costing and mathematical programming. *Accounting and Business Research*, 35(1), 3–27.

Degraeve, Z., & Roodhooft, F. (2000). A mathematical programming approach for procurement using activity based costing. *Journal of Business Finance & Accounting*, 27(1), 69–98.

Dekker, H., Sakaguchi, J., & Kawai, T. (2013). Beyond the contract: Managing risk in supply chain relations. *Management Accounting Research*, 24(2), 122–139. doi:10.1016/j.mar.2013.04.010

Dekker, H., & Smidt, P. (2003). A survey of the adoption and use of target costing in Dutch firms. *International Journal of Production Economics*, 84(3), 293–305. doi:10.1016/S0925-5273(02)00450-4

Delice, E. K., & Güngör, Z. (2011). A mixed integer goal programming model for discrete values of design requirements in QFD. *International Journal of Production Research*, 49(10), 2941–2957. doi:10.1080/00207541003720343

Delice, E. K., & Güngör, Z. (2013). Determining design requirements in QFD using fuzzy mixed-integer goal programming: application of a decision support system. *International Journal of Production Research*, 51(21), 6378–6396. doi:10.1080/00207543.2013.803625

Demeester, L., Eichler, K., & Loch, C. H. (2004). Organic production systems: What the biological cell can teach us about manufacturing. *Manufacturing & Service Operations Management*, 6(2), 115–132. doi:10.1287/msom.1030.0033

Desai, P., Kekre, S., Radhakrishnan, S., & Srinivasan, K. (2001). Product differentiation and commonality in design: Balancing revenue and cost drivers. *Management Science*, 47(1), 37–51.

Ding, M., & Eliashberg, J. (2002). Structuring the new product development pipeline. *Management Science*, 48(3), 343–363.

Ditillo, A. (2004). Dealing with uncertainty in knowledge-intensive firms: the role of management control systems as knowledge integration mechanisms. *Accounting, Organizations and Society*, 29(3-4), 401–421. doi:10.1016/j.aos.2003.12.001

Dowlatshahi, S. (1992). Product design in a concurrent engineering environment: an optimization approach. *International Journal of Production Research*, 30(8), 1803–1818. doi:10.1080/00207549208948123

Dowlatshahi, S. (1995). An integrated manufacturing system design: an applied approach. *International Journal of Production Economics*, 42(2), 187–199. doi:10.1016/0925-5273(95)00179-4

Drury, C., & Tayles, M. (1994). Product costing in UK manufacturing organizations. *European Accounting Review*, 3(3), 443–469.

Duh, R., Xiao, J. Z., & Chow, C. W. (2008). An overview and assessment of contemporary management accounting research in China. *Journal of Management Accounting Research*, 20(s1), 129–164. doi:10.2308/jmar.2008.20.s-1.129

Duh, R., Xiao, J. Z., & Chow, C. W. (2009). Chinese firms' use of management accounting and controls: facilitators, impediments, and performance effects. *Journal of International Accounting Research*, 8(1), 1–30. doi:10.2308/jiar.2009.8.1.1

Dunk, A. S. (2004). Product life cycle cost analysis: The impact of customer profiling, competitive advantage, and quality of IS information. *Management Accounting Research*, 15(4), 401–414. doi:10.1016/j.mar.2004.04.001

Durisin, B., Calabretta, G., & Parmeggiani, V. (2010). The intellectual structure of product innovation research: A bibliometric study of the journal of product innovation management, 1984-2004. *Journal of Product Innovation Management*, 27(3), 437–451. doi:10.1111/j.1540-5885.2010.00726.x

Dutta, S. K., & Lawson, R. A. (2008). A tale of two technologies: the financial chapter. *International Journal of Technology Management*, 42(3), 205–225. doi:10.1504/IJTM.2008.018104

Easton, F. F., & Pullman, M. E. (2001). Optimizing service attributes: the seller's utility problem. *Decision Sciences*, 32(2), 251–276. doi:10.1111/j.1540-5915.2001.tb00960.x

Eatock, J., Dixon, D., & Young, T. (2009). An exploratory survey of current practice in the medical device industry. *Journal of Manufacturing Technology Management*, 20(2), 218–234. doi:10.1108/17410380910929637

Elgh, F., & Cederfeldt, M. (2007). Concurrent cost estimation as a tool for enhanced producibility-System development and applicability for producibility studies. *International Journal of Production Economics*, 109(1), 12–26. doi:10.1016/j.ijpe.2006.11.007

Elimam, a. a., & Dodin, B. (1994). Optimum selection and operation of sludge dewatering processes. *IIE Transactions*, 26(3), 89–100. doi:10.1080/07408179408966611

Ellram, L. M. (1995). Total cost of ownership: an analysis approach for purchasing. *International Journal of Physical Distribution & Logistics Management*, 25(8), 4–23. doi:10.1108/09600039510099928

Ellram, L. M. (2000). Purchasing and supply m anagement's participation in the target costing process. *Journal of Supply Chain Management*, 36, 39–51.

Ellram, L. M. (2002). Supply management's involvement in the target costing process. *European Journal of Purchasing & Supply Management*, 8(4), 235–244. doi:10.1016/S0969-7012(02)00019-9

Ellram, L. M. (2006). The implementation of target costing in the United States: theory versus practice. *Journal of Supply Chain Management*, 42(1), 13–26.

Erat, S., & Kavadias, S. (2006). Introduction of new technologies to competing industrial customers. *Management Science*, 52(11), 1675–1688. doi:10.1287/mnsc.1060.0561

Ethiraj, S., & Levinthal, D. (2004a). Bounded rationality and the search for organizational architecture: An evolutionary perspective on the design of organizations and their evolvability. *Administrative Science Quarterly*, 49(3), 404–437. doi:10.2307/4131441

Ethiraj, S., & Levinthal, D. (2004b). Modularity and innovation in complex systems. *Management Science*, 50(2), 159–173. doi:10.1287/mnsc.1030.0145

Ethiraj, S., Levinthal, D., & Roy, R. R. (2008). The dual role of modularity: innovation and imitation. *Management Science*, 54(5), 939–955. doi:10.1287/mnsc.1070.0775

Ettlie, J. E. (1995). Product-process development integration in manufacturing. *Management Science*, 41(7), 1224–1237.

Ettlie, J. E., & Elsenbach, J. (2007a). Modified Stage-Gate regimes in new product development. *Journal of Product Innovation Management*, 24(1), 20–33.

Ettlie, J. E., & Elsenbach, J. M. (2007b). Modified Stage-Gate® regimes in new product development. *Journal of Product Innovation Management*, 24(1), 20–33. doi:10.1111/j.1540-5885.2006.00230.x

Ettlie, J. E., & Trygg, L. D. (1995). Design-manufacturing practice in the US and Sweden*. IEEE Transactions on Engineering Management*, 42(1), 74–81. doi:10.1109/17.366407

Everaert, P., & Bruggeman, W. (2002). Cost targets and time pressure during new product development. *International Journal of Operations & Production Management*, 22(12), 1339–1353. doi:10.1108/01443570210452039

Ewert, R., & Ernst, C. (1999). Target costing, co-ordination and strategic cost management. *European Accounting Review*, 8(1), 23–49.

Eynan, A., & Rosenblatt, M. J. (1996). Component commonality effects on inventory costs. *IIE Transactions*, 28(2), 93–104. doi:10.1080/07408179608966255

Ezzamel, M., Willmott, H., & Worthington, F. (2004). Accounting and management–labour relations: the politics of production in the “factory with a problem.” *Accounting, Organizations and Society*, 29(3-4), 269–302. doi:10.1016/S0361-3682(03)00014-X

Fallah, M. H., & Lechler, T. G. (2008). Global innovation performance: Strategic challenges for multinational corporations. *Journal of Engineering and Technology Management* - JET-M, 25(1), 58–74. doi:10.1016/j.jengtecman.2008.01.008

Fargnoli, M., De Minicis, M., & Tronci, M. (2013). Design management for sustainability: An integrated approach for the development of sustainable products*. Journal of Engineering and Technology Management*, 34, 29–45. doi:10.1016/j.jengtecman.2013.09.005

Farrell, R. S., & Simpson, T. W. (2010). Improving cost effectiveness in an existing product line using component product platforms 1. *International Journal of Production Research*, 48(11), 3299–3317. doi:10.1080/00207540802620753

Fayard, D., Lee, L. S., Leitch, R. a., & Kettinger, W. J. (2012). Effect of internal cost management, information systems integration, and absorptive capacity on inter-organizational cost management in supply chains. *Accounting, Organizations and Society*, 37(3), 168–187. doi:10.1016/j.aos.2012.02.001

Feitzinger, E., & Lee, H. (1997). Mass customization at Hewlett-Packard: the power of postponement. *Harvard Business Review*, 75, 116–123.

Ferdows, K., & Meyer, A. De. (1990). Lasting improvements in manufacturing performance: in search of a new theory. *Journal of Operations Management*, 9(2), 168–184.

Filomena, T. P., Neto, F. J. K., & Duffey, M. R. (2009). Target costing operationalization during product development: Model and application. *International Journal of Production Economics*, 118(2), 398–409. doi:10.1016/j.ijpe.2008.12.007

Fisher, M., Ramdas, K., & Ulrich, K. (1999). Component sharing in the management of product variety: A study of automotive braking systems. *Management Science*, 45(3), 297–315.

Flynn, B., & Sakakibara, S. (1990). Empirical research methods in operations management. *Journal of Operations Management*, 9(2), 250–284.

Folgado, R., Peças, P., & Henriques, E. (2010). Life cycle cost for technology selection: A case study in the manufacturing of injection moulds. *International Journal of Production Economics*, 128(1), 368–378. doi:10.1016/j.ijpe.2010.07.036

Fuchs, E., & Kirchain, R. (2010). Design for Location? The impact of manufacturing offshore on technology competitiveness in the optoelectronics industry. *Management Science*, 56(12), 2323–2349. doi:10.1287/mnsc.1100.1227

Fullerton, R. R., Kennedy, F. a., & Widener, S. K. (2013). Management accounting and control practices in a lean manufacturing environment. *Accounting, Organizations and Society*, 38(1), 50–71. doi:10.1016/j.aos.2012.10.001

Fung, R. Y. K., Tang, J., Tu, Y., & Wang, D. (2002). Product design resources optimization using a non-linear fuzzy quality function deployment model. *International Journal of Production Research*, 40(3), 585–599. doi:10.1080/00207540110061634

Gamba, A., & Fusari, N. (2009). Valuing modularity as a real option. *Management Science*, 55(11), 1877–1896. doi:10.1287/mnsc.1090.1070

Garud, R., & Munir, K. (2008). From transaction to transformation costs: The case of Polaroid's SX-70 camera. Research Policy, 37(4), 690–705. doi:10.1016/j.respol.2007.12.010

Gatenby, D. a, & Foo, G. (1990). Design for X (DFX): Key to competitive, profitable products. AT&T *Technical Journal*, 69(3), 2–13. doi:10.1002/j.1538-7305.1990.tb00332.x

Geissdörfer, K., Gleich, R., & Wald, A. (2009). Standardisierungspotentiale lebenszyklusbasierter Modelle des strategischen Kostenmanagements. Zeitschrift Für Betriebswirtschaft, 79(6), 693–715. doi:10.1007/s11573-009-0256-7

Germeraad, P. (2010). Integration of intellectual property strategy with innovation strategy. *Research-Technology Management*, 53(3), 10–18.

Gil, N. (2009). Project safeguards: Operationalizing option-like strategic thinking in infrastructure development. *IEEE Transactions on Engineering Management*, 56(2), 257–270. doi:10.1109/TEM.2009.2016063

Goffin, K. (1998). Evaluating customer support during new product development—An exploratory study. *Journal of Product Innovation Management*, 15(1), 42–56. doi:http://dx.doi.org/10.1016/S0737-6782(97)00067-2

Goffin, K. (2000). Design for supportability: An essential component of new product development. *Research-Technology Management*, 43(2), 40–47.

Goffin, K., & Micheli, P. (2010). Maximizing the value of industrial design in new product development. *Research-Technology Management*, 53(5), 29–37.

Goh, Y. M., Newnes, L. B., Mileham, A. R., McMahon, C. a., & Saravi, M. E. (2010). Uncertainty in through-life costing-review and perspectives. *IEEE Transactions on Engineering Management*, 57(4), 689–701. doi:10.1109/TEM.2010.2040745

Gorman, M. F., & Kanet, J. J. (2005). Evaluating operations management--related journals via the author affiliation index. *Manufacturing & Service Operations Management*, 7(1), 3–19. doi:10.1287/msom.1040.0062

Govers, C. (1996). What and how about quality function deployment (QFD). *International Journal of Production Economics*, 47(95), 575–585.

Govindarajan, V., & Fisher, J. (1990). Strategy, control systems, and resource sharing: Effects on business-unit performance. *Academy of Management Journal*, 33(2), 259–285.

Granlund, M., & Taipaleenmäki, J. (2005). Management control and controllership in new economy firms: a life cycle perspective. *Management Accounting Research*, 16(1), 21–57. doi:10.1016/j.mar.2004.09.003

Greenley, G. (1995). Market orientation and company performance: empirical evidence from UK companies. *British Journal of Management*, 6(1), 1–13.

Greiner, L. E. (1998). Evolution and revolution as organizations grow. *Harvard Business Review*, 76(3), 55–60, 62–6, 68.

Griffin, A. (1992). Evaluating QFD's use in US firms as a process for developing products. *Journal of Product Innovation Management*, 9(3), 171–187. doi:10.1111/1540-5885.930171

Griffin, A., & Hauser, J. (1992). Patterns of communication among marketing, engineering and manufacturing—A comparison between two new product teams. *Management Science*, 38(3), 360–373.

Grote, C., Jones, R., Blount, G., Goodyer, J., & Shayler, M. (2007). An approach to the EuP directive and the application of the economic eco-design for complex products. *International Journal of Production Research*, 45(18-19), 4099–4117. doi:10.1080/00207540701450088

Guilding, C. (1999). Competitor-focused accounting: an exploratory note. Accounting, Organizations and Society, 24(7), 583–595. doi:10.1016/S0361-3682(99)00007-0

Guilding, C., Cravens, K. S., & Tayles, M. (2000). An international comparison of strategic management accounting practices. *Management Accounting Research*, 11(1), 113–135. doi:10.1006/mare.1999.0120

Guiltinan, J. (2011). Progress and challenges in product line pricing. *Journal of Product Innovation Management*, 28(5), 744–756. doi:10.1111/j.1540-5885.2011.00837.x

Gupta, D., & Benjaafar, S. (2004). Make-to-order, make-to-stock, or delay product differentiation? A common framework for modeling and analysis. *IIE Transactions*, 36(6), 529–546. doi:10.1080/07408170490438519

Gutschelhofer, A., & Roberts, H. (1997). Anglo-Saxon and German life-cycle costing. *The International Journal of Accounting*, 32(1), 23–44. doi:10.1016/S0020-7063(97)90003-0

Halman, J. (2003). Platform-driven development of product families: linking theory with practice. *Journal of Product Innovation Management*,20(2), 149–162. doi:10.1111/1540-5885.2002007

Hansen, A. (2010). Nonfinancial performance measures, externalities and target setting: A comparative case study of resolutions through planning. *Management Accounting Research*, 21(1), 17–39. doi:10.1016/j.mar.2009.12.001

Harmancioglu, N., McNally, R. C., Calantone, R. J., & Durmusoglu, S. S. (2007). Your new product development (NPD) is only as good as your process: An exploratory analysis of new NPD process design and implementation. *R & D Management*, 37(5), 399–424. doi:10.1111/j.1467-9310.2007.00486.x

Hart, S., Hultink, E. J., Tzokas, N., & Commandeur, H. R. (2003). Industrial companies' evaluation criteria in new product development gates. *Journal of Product Innovation Management*, 20(1), 22–36. doi:10.1111/1540-5885.201003

Hatch, M., & Badinelli, R. D. (1999). A concurrent optimization methodology for concurrent engineering. *IEEE Transactions on Engineering Management*, 46(1), 72–86. doi:10.1109/17.740039

Hauser, J. R. (2001). Metrics thermostat. *Journal of Product Innovation Management*, 18(3), 134–153.

Hayes, R. H., Wheelwright, S. C., & Clark, K. B. (1988). Dynamic Manufacturing: Creating the Learning Organization. New York: Free Press.

He, D. W., & Kusiak, a. (1996). Performance analysis of modular products. *International Journal of Production Research*, 34(1), 253–272. doi:10.1080/00207549608904900

Heese, H. S., & Swaminathan, J. M. (2006). Product line design with component commonality and cost-reduction effort. *Manufacturing & Service Operations Management*, 8(2), 206–219. doi:10.1287/msom.1060.0103

Hegde, G. G. (1994). Life cycle cost: A model and applications. *IIE Transactions*, 26(6), 56–62. doi:10.1080/07408179408966638

Heilala, J., Helin, K., & Montonen, J. (2006). Total cost of ownership analysis for modular final assembly systems. *International Journal of Production Research*, 44(18-19), 3967–3988. doi:10.1080/00207540600806448

Heim, G. R. R., Mallick, D. N. N., & Peng, X. (2012). Antecedents and consequences of new product development practices and software tools: An exploratory study. *IEEE Transactions on Engineering Management*, 59(3), 428–442. doi:10.1109/TEM.2011.2172608

Henri, J.-F. (2006). Management control systems and strategy: A resource-based perspective. *Accounting, Organizations and Society*, 31(6), 529–558. doi:10.1016/j.aos.2005.07.001

Hertenstein, J. H. J., & Platt, M. M. B. (2000). Performance measures and management control in new product development. *Accounting Horizons*, 14(3), 303–323. doi:10.2308/acch.2000.14.3.303

Hillier, M. S. (2000). Component commonality in multiple-period, assemble-to-order systems. *IIE Transactions*, 32(8), 755–766. doi:10.1080/07408170008967433

Hoetker, G., Swaminathan, A., & Mitchell, W. (2007). Modularity and the impact of buyer–supplier relationships on the survival of suppliers. *Management Science*, 53(2), 178–191. doi:10.1287/mnsc.1060.0630

Holmes, C., & Ferrill, M. (2005). The application of operation and technology roadmapping to aid singaporean smes identify and select emerging technologies. *Technological Forecasting and Social Change*, 72(3), 349–357. doi:10.1016/j.techfore.2004.08.010

Hopp, W. J., & Xu, X. (2005). Product line selection and pricing with modularity in design. *Manufacturing & Service Operations Management*, 7(3), 172–187. doi:10.1287/msom.1050.0077

Hopper, T., Koga, T., & Goto, J. (1999). Cost accounting in small and medium sized Japanese companies: an exploratory study. *Accounting and Business Research*, 30(1), 73–86. doi:10.1080/00014788.1999.9728925

Hoque, M., Akter, M., & Monden, Y. (2005). Concurrent engineering: A compromising approach to develop a feasible and customer-pleasing product. *International Journal of Production Research*, 43(8), 1607–1624. doi:10.1080/00207540412331320490

Hoque, Z., & James, W. (2000). Linking balanced scorecard measures to size and market factors: impact on organizational performance. *Journal of Management Accounting Research*, 12(1), 1–17.

Hoyle, C. J., & Chen, W. (2009). Product attribute function deployment (PAFD) for decision-based conceptual design. *IEEE Transactions on Engineering Management*, 56(2), 271–284. doi:10.1109/TEM.2008.927787

Hu, B., Duenyas, I., & Beil, D. (2013). Does Pooling Purchases Lead to Higher Profits? *Management Science*, 59(7), 1576–1593.

Huang, T.-T. A., Stewart, R. A., & Chen, L. (2010). Identifying key enablers to improve business performance in Taiwanese electronic manufacturing companies. *International Journal of Operations & Production Management*, 30(2), 155–180. doi:10.1108/01443571011018699

Hyvönen, T. (2003). Management accounting and information systems: Erp Versus Bob. *European Accounting Review*, 12(1), 155–173. doi:10.1080/0963818031000087862

Ibusuki, U., & Kaminski, P. C. (2007). Product development process with focus on value engineering and target-costing: A case study in an automotive company. *International Journal of Production Economics*, 105(2), 459–474. doi:10.1016/j.ijpe.2005.08.009

Ijomah, W. L., McMahon, C. a., Hammond, G. P., & Newman, S. T. (2007). Development of robust design-for-remanufacturing guidelines to further the aims of sustainable development. *International Journal of Production Research*, 45(18-19), 4513–4536. doi:10.1080/00207540701450138

Imai, M. (2012). Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy. Library Journal (second edi., Vol. 122).

Innes, J., & Mitchell, F. (1995). A survey of activity-based costing in the UK's largest companies. *Management Accounting Research*, 6, 137–153.

Iranmanesh, H., & Thomson, V. (2008). Competitive advantage by adjusting design characteristics to satisfy cost targets. *International Journal of Production Economics*, 115(1), 64–71. doi:10.1016/j.ijpe.2008.05.006

Ismail, H., Reid, I., Mooney, J., Poolton, J., & Arokiam, I. (2007). How small and medium enterprises effectively participate in the mass customization game. *IEEE Transactions on Engineering Management*, 54(1), 86–97. doi:10.1109/TEM.2006.889069

Ittner, C., & Larcker, D. (1997). Product development cycle time and organizational performance. *Journal of Marketing Research*, 34(1), 13–23.

Izui, K., Nishiwaki, S., Yoshimura, M., Kariya, H., Ogihara, Y., & Hayashi, S. (2010). Switchgear component commonality design based on trade-off analysis among inventory level, delivery lead-time and product performance. *International Journal of Production Research*, 48(10), 2821–2840. doi:10.1080/00207540902791868

Jackson, J. A., Kloeber, J. M., Ralston, B. E., & Deckro, R. F. (1999). Selecting a Portfolio of Technologies: An Application of Decision Analysis. *Decision Sciences*, 30(1), 217–238. doi:10.1111/j.1540-5915.1999.tb01607.x

Jacobs, M., Droge, C., Vickery, S. K., & Calantone, R. (2011). Product and process modularity's effects on manufacturing agility and firm growth performance. *Journal of Product Innovation Management*, 28(1), 123–137. doi:10.1111/j.1540-5885.2010.00785.x

Jacobs, M., Vickery, S. K., & Droge, C. (2007). The effects of product modularity on competitive performance. *International Journal of Operations & Production Management*, 27(10), 1046–1068. doi:10.1108/01443570710820620

Jagle, A., & Jägle, A. J. (1999). Shareholder value, real options, and innovation in technology-intensive companies. *R&D Management*, 29(3), 271–287. doi:10.1111/1467-9310.00136

Jansen, B., & Schuster, S. (2011). Bidding on the buying funnel for sponsored search and keyword advertising. *Journal of Electronic Commerce Research*, 12(1), 1–18.

Jayaram, J., & Malhotra, M. K. (2010). The differential and contingent impact of concurrency on new product development project performance: a holistic examination. *Decision Sciences*, 41(1), 147–196. doi:10.1111/j.1540-5915.2009.00262.x

Jenkins, S., & Forbes, S. (1997). Managing the product development process. Part I: an assessment. *International Journal of Technology Management*, 13(4), 359–378.

Ji, P., Jin, J., Wang, T., & Chen, Y. (2014). Quantification and integration of Kano's model into QFD for optimising product design. *International Journal of Production Research*, 52(21), 6335–6348. doi:10.1080/00207543.2014.939777

Jiao, J. (Roger). (2012). Product platform flexibility planning by hybrid real options analysis. *IIE Transactions*, 44(6), 431–445. doi:10.1080/0740817X.2011.609874

John, G., Weiss, A., & Dutta, S. (1999). Marketing in technology-intensive markets: Toward a conceptual framework. *The Journal of Marketing*, 63(Special Issue), 78–91. doi:10.2307/1252103

Johnson, M. D., & Kirchain, R. (2010). Developing and assessing commonality metrics for product families: A process-based cost-modeling approach. *IEEE Transactions on Engineering Management*, 57(4), 634–648. doi:10.1109/TEM.2009.2034642

Johnson, M. D., & Kirchain, R. E. (2009). Quantifying the effects of product family decisions on material selection: A process-based costing approach. *International Journal of Production Economics*, 120(2), 653–668. doi:10.1016/j.ijpe.2009.04.014

Johnson, M. R., & Wang, M. H. (1995). Planning product disassembly for material recovery opportunities. *International Journal of Production Research*, 33(11), 3119–3142. doi:10.1080/00207549508904864

Jordan, S., Jørgensen, L., & Mitterhofer, H. (2013). Performing risk and the project: Risk maps as mediating instruments. *Management Accounting Research*, 24(2), 156–174. doi:10.1016/j.mar.2013.04.009

Jørgensen, B., & Messner, M. (2009). Management control in new product development: The dynamics of managing flexibility and efficiency. *Journal of Management Accounting Research*, 21(1), 99–124. doi:10.2308/jmar.2009.21.1.99

Jørgensen, B., & Messner, M. (2010). Accounting and strategising: A case study from new product development. *Accounting, Organizations and Society*, 35(2), 184–204. doi:10.1016/j.aos.2009.04.001

Joshi, M. (2003). Alignment of strategic priorities and performance: an integration of operations and strategic management perspectives. *Journal of Operations Management*, 21(3), 353–369. doi:10.1016/S0272-6963(03)00003-2

Joshi, P. (2001). The international diffusion of new management accounting practices: the case of India. *Journal of International Accounting, Auditing and Taxation*, 10, 85–109.

Joshi, P., Bremser, W. G., Deshmukh, A., & Kumar, R. (2011). Diffusion of management accounting practices in gulf cooperation council countries. *Accounting Perspectives*, 10(1), 23–53. doi:10.1111/j.1911-3838.2011.00018.x

Kahn, K. B. (2001). Market Orientation, interdepartmental integration, and product development performance. *Product Innovation Management*, 18(5), 314–323. doi:10.1016/S0737-6782(01)00101-1

Kahn, K. B., Barczak, G., Nicholas, J., Ledwith, A., & Perks, H. (2012). An examination of new product development best practice. *Journal of Product Innovation Management*, 29(2), 180–192. doi:10.1111/j.1540-5885.2011.00888.x

Kamrad, B., Schmidt, G. M., & Ülkü, S. (2013). Analyzing product architecture under technological change: Modular upgradeability tradeoffs. *IEEE Transactions on Engineering Management*, 60(2), 289–300. doi:10.1109/TEM.2012.2211362

Kang, C. M., Hong, Y. S., & Huh, W. T. (2012). Platform replacement planning for management of product family obsolescence. *IIE Transactions*, 44(12), 1115–1131. doi:10.1080/0740817X.2012.672791

Kaplan, R. S., & Norton, D. P. (2001). Transforming the balanced scorecard from performance measurement to strategic management: Part I. *Accounting Horizons*, 15(1), 87–104. doi:10.2308/acch.2001.15.1.87

Karim, S. (2006). Modularity in irganzational structure: The reconfiguration of internally developed and acquired business units. *Strategic Management Journal*, 27(9), 799–823. doi:10.1002/smj

Karim, S. (2009). Business unit reorganization and innovation in new product markets. *Management Science*, 55(7), 1237–1254. doi:10.1287/mnsc.1090.1017

Karmarkar, U. S., & Pitbladdo, R. C. (1997). Quality, class, and competiton. *Management Science*, 43(1), 27–39.

Karsak, E. E. (2004). Fuzzy multiple objective decision making approach to prioritize design requirements in quality function deployment. *International Journal of Production Research*, 42(18), 3957–3974. doi:10.1080/00207540410001703998

Kaski, T., & Heikkila, J. (2002). Measuring product structures to improve demand-supply chain efficiency. *International Journal of Technology Management*, 23(6), 578–598. doi:10.1504/IJTM.2002.003027

Kato, Y. (1993). Target costing support systems: lessons from leading Japanese companies. *Management Accounting Research*, 4, 33–47.

Kavanagh, M. H., & Drennan, L. (2008). What skills and attributes does an accounting graduate need? Evidence from student perceptions and employer expectations. *Accounting & Finance*, 48(2), 279–300. doi:10.1111/j.1467-629X.2007.00245.x

Keating, A., & McLoughlin, D. (2010). The entrepreneurial imagination and the impact of context on the development of a new venture. *Industrial Marketing Management*, 39(6), 996–1009. doi:10.1016/j.indmarman.2010.06.019

Kee, R. (2010). The sufficiency of target costing for evaluating production-related decisions. *International Journal of Production Economics*, 126(2), 204–211. doi:10.1016/j.ijpe.2010.03.008

Kerr, C., Phaal, R., & Probert, D. (2012). Cogitate, articulate, communicate: The psychosocial reality of technology roadmapping and roadmaps. *R&D Management*. doi:10.1111/j.1467-9310.2011.00658.x

Kessler, E. H. (2000). Tightening the belt: methods for reducing development costs associated with new product innovation. *Journal of Engineering and Technology Management*, 17(1), 59–92. doi:10.1016/S0923-4748(99)00020-X

Khoo, L. P., & Ho, N. C. (1996). Framework of a fuzzy quality function deployment system. *International Journal of Production Research*, 34(2), 299–311. doi:10.1080/00207549608904904

Kim, J.-Y., Wong, V., & Eng, T.-Y. (2005). Product variety strategy for improving new product development proficiencies. *Technovation*, 25(9), 1001–1015. doi:10.1016/j.technovation.2004.02.011

Kim, W. C., & Mauborgne, R. (1997). Value innovation. Harvard Business Review, 75(1), 1–12.

Kleinschmidt, E. J., de Brentani, U., & Salomo, S. (2007). Performance of global new Product development programs: A resource-based view. *Journal of Product Innovation Management*, 24(5), 419–441. doi:10.1111/j.1540-5885.2007.00261.x

Kleyner, A., & Sandborn, P. (2008). Minimizing life cycle cost by managing product reliability via validation plan and warranty return cost. *International Journal of Production Economics*, 112(2), 796–807. doi:10.1016/j.ijpe.2007.07.001

Kohlhase, N., & Birkhofer, H. (1996). Development of modular structures: the prerequisite for successful modular products. *Journal of Engineering Design*, 7(3), 279–291. doi:10.1080/09544829608907941

Kohli, A., & Jaworski, B. (1990). Market orientation: the construct, research propositions, and managerial implications. *The Journal of Marketing*, 54(2), 1–18.

Kolarik, W. J. (1995). Creating Quality: concepts, systems, strategies, and tools. New York: McGraw-Hill, Inc.

Kostoff, R. N., & Schaller, R. R. (2001). Science and technology roadmaps. *IEEE Transactions on Engineering Management*, 48(2), 132–143. doi:10.1109/17.922473

Krishnan, M., Kriebel, C., Kekre, S., & Mukhopadhyay, T. (2000). An empirical analysis of productivity and quality in software products. *Management Science*, 46(6), 745–759.

Krishnan, V., & Gupta, S. (2001). Appropriateness and impact of platform-based product development. *Management Science*, 47(1), 52–68. doi:10.1287/mnsc.47.1.52.10665

Krishnan, V., & Ramachandran, K. (2011). Integrated product architecture and pricing for managing sequential innovation. *Management Science*, 57(11), 2040–2053.

Krishnan, V., Singh, R., & Tirupati, D. (1999). A model-based spproach for planning and developing a family of technology-based products. *Manufacturing & Service Operations Management*, 1(2), 132–156. doi:10.1287/msom.1.2.132

Krishnan, V., & Ulrich, K. (2001). Product development decisions: A review of the literature. *Management Science*, 47(1), 1–21.

Kumar, S., & Wellbrock, J. (2009). Improved new product development through enhanced design architecture for engineer-to-order companies. *International Journal of Production Research*, 47(15), 4235–4254. doi:10.1080/00207540801939030

Kuo, T. C., Huang, S. H., & Zhang, H. C. (2001). Design for manufacture and design for "X": Concepts, applications, and perspectives. *Computers and Industrial Engineering*, 41(3), 241–260. doi:10.1016/S0360-8352(01)00045-6

Lager, T. (2005). The industrial usability of quality function deployment: A literature review and synthesis on a meta-level. *R&D Management*, 35(4), 409–426. doi:10.1111/j.1467-9310.2005.00398.x

Lambert, D. M., & Harrington, T. C. (1990). Measuring nonresponse bias in customer service mail surveys. *Journal of Business Logistics*, 11(2), 5–25. doi:Article

Lamore, P. R., Berkowitz, D., & Farrington, P. a. (2013). Proactive/responsive market orientation and marketing-research and development integration. *Journal of Product Innovation Management*, 30(4), 695–711. doi:10.1111/jpim.12024

Lau, A. K. W. (2014). Influence of contingent factors on the perceived level of supplier integration: A contingency perspective. *Journal of Engineering and Technology Management*, 33, 210–242. doi:10.1016/j.jengtecman.2014.07.002

Lau, A. K. W., Yam, R. C. M., & Tang, E. (2011). The impact of product modularity on new product performance: mediation by product innovativeness. *Journal of Product Innovation Management*, 28(2), 270–284. doi:10.1111/j.1540-5885.2011.00796.x

Lau, A. K. W., Yam, R. C. M., & Tang, E. P. Y. (2010). Supply chain integration and product modularity: An empirical study of product performance for selected Hong Kong manufacturing industries. *International Journal of Operations & Production Management*, 30(1), 20–56. doi:10.1108/01443571011012361

Lau Antonio, K. W., Yam, R. C. M., & Tang, E. (2007). The impacts of product modularity on competitive capabilities and performance: An empirical study. *International Journal of Production Economics*, 105(1), 1–20. doi:10.1016/j.ijpe.2006.02.002

Lawson, B., Petersen, K. J., Cousins, P. D., & Handfield, R. B. (2009). Knowledge sharing in interorganizational product development teams: The effect of formal and informal socialization mechanisms. *Journal of Product Innovation Management*, 26(2), 156–172. doi:10.1111/j.1540-5885.2009.00343.x

Lee, A. H. I., Kang, H.-Y., Yang, C.-Y., & Lin, C.-Y. (2010). An evaluation framework for product planning using FANP, QFD and multi-choice goal programming. *International Journal of Production Research*, 48(13), 3977–3997. doi:10.1080/00207540902950845

Lee, H., & Tang, C. (1997). Modelling the costs and benefits of delayed product differentiation. *Management Science*, 43(1), 40–53.

Lee, J. Y., & Monden, Y. (1996). An international comparison of manufacturing-friendly cost management systems. *The International Journal of Accounting*, 31(2), 197–212. doi:10.1016/S0020-7063(96)90004-7

Lee, S., Lee, S., Seol, H., & Park, Y. (2008). Using patent information for designing new product and technology: Keyword based technology roadmapping. *R&D Management*, 38(2), 169–188. doi:10.1111/j.1467-9310.2008.00509.x

Li, H., Wang, Y., Yin, R., Kull, T. J., & Choi, T. Y. (2012). Target pricing: Demand-side versus supply-side approaches. *International Journal of Production Economics*, 136(1), 172–184. doi:10.1016/j.ijpe.2011.10.002

Liao, S.-H., Chang, W.-J., Wu, C.-C., & Katrichis, J. M. (2011). A survey of market orientation research (1995–2008). *Industrial Marketing Management*, 40(2), 301–310. doi:10.1016/j.indmarman.2010.09.003

Lichtenthaler, E. (2004). Technology intelligence processes in leading European and North American multinationals. *R&D Management*, 34(2), 121–135. doi:10.1111/j.1467-9310.2004.00328.x

Lichtenthaler, U. (2008). Integrated roadmaps for open innovation. *Research-Technology Management*, 51(3), 45–49.

Liker, J. K., Collins, P. D., & Hull, F. M. (1999). Flexibility and standardization: test of a contingency model of product design-manufacturing integration. *Journal of Product Innovation Management*, 16(3), 248–267. doi:10.1016/S0737-6782(98)00049-6

Liker, J. K., Kamath, R. R., Wasti, S. N., & Nagamachi, M. (1996). Supplier involvement in automotive component design: Are there really large US Japan differences? *Research Policy*, 25(1), 59–89. doi:10.1016/0048-7333(95)00826-8

Lin, J. Z., & Yu, Z. (2002). Responsibility cost control system in China: a case of management accounting application. *Management Accounting Research*, 13(4), 447–467. doi:10.1006/mare.2002.0200

Lin, T., Lee, J.-W., & Bohez, E. L. J. (2012). New integrated model to estimate the manufacturing cost and production system performance at the conceptual design stage of helicopter blade assembly. *International Journal of Production Research*, 50(24), 7210–7228. doi:10.1080/00207543.2011.644818

Linsky, A. S. (1975). Stimulating responses to mailed questionnaires: A review. Public Opinion Quarterly, 39(1), 82–101. doi:10.1086/268201

Linton, J. D., & Thongpapanl, N. (Tek). (2004). PERSPECTIVE: Ranking the technology innovation management journals*. *Journal of Product Innovation Management*, 21(2), 123–139. doi:10.1111/j.0737-6782.2004.00062.x

Liu, Z., Wong, Y. S., & Lee, K. S. (2010). Modularity analysis and commonality design: a framework for the top-down platform and product family design. *International Journal of Production Research*, 48(12), 3657–3680. doi:10.1080/00207540902902598

Loch, C., Stein, L., & Terwiesch, C. (1996). Measuring development performance in the electronics industry. *Journal of Product Innovation Management*, 13(1), 3–20.

Lu, Q., & Wood, L. (2006). The refinement of design for manufacture: inclusion of process design. *International Journal of Operations & Production Management*, 26(10), 1123–1145. doi:10.1108/01443570610691102

Luo, X. G., Kwong, C. K., Tang, J. F., Deng, S. F., & Gong, J. (2011). Integrating supplier selection in optimal product family design. *International Journal of Production Research*, 49(14), 4195–4222. doi:10.1080/00207543.2010.544337

MacCormack, A., Rusnak, J., & Baldwin, C. Y. (2006). Exploring the structure of complex software designs: an empirical study of open source and proprietary code. *Management Science*, 52(7), 1015–1030. doi:10.1287/mnsc.1060.0552

Madan, J., Rao, P. V. M., & Kundra, T. K. (2007). System for early cost estimation of die-cast parts. *International Journal of Production Research*, 45(20), 4823–4847. doi:10.1080/00207540600789016

Magnusson, M., & Pasche, M. (2014). A contingency-based approach to the use of product platforms and modules in new product development. *Journal of Product Innovation Management*, 31(3), 434–450. doi:10.1111/jpim.12106

Mäkinen, S. J., Seppänen, M., & Ortt, J. R. (2014). Introduction to the special issue: Platforms, contingencies and new product development. *Journal of Product Innovation Management*, 31(3), 412–416. doi:10.1111/jpim.12104

Mangun, D., & Thurston, D. L. (2002). Incorporating component reuse, remanufacture, and recycle into product portfolio design. *IEEE Transactions on Engineering Management*, 49(4), 479–490. doi:10.1109/TEM.2002.807292

Marion, T. J., & Meyer, M. H. (2011). Applying industrial design and cost engineering to new product development in early-stage firms. Journal of Product Innovation Management, 28(5), 773–786. doi:10.1111/j.1540-5885.2011.00839.x

Marion, T. J., Thevenot, H. J., & Simpson, T. W. (2007). A cost-based methodology for evaluating product platform commonality sourcing decisions with two examples*. International Journal of Production Research*, 45(22), 5285–5308. doi:10.1080/00207540600710970

Martin, B. R., Nightingale, P., & Yegros-Yegros, A. (2012). Science and technology studies: Exploring the knowledge base. *Research Policy*, 41(7), 1182–1204. doi:10.1016/j.respol.2012.03.010

Mathews, S. (2010). Innovation portfolio architecture. *Research-Technology Management*, 53(6), 30–40.

Mathews, S. (2011). Innovation portfolio architecture—Part 2: Attribute selection and valuation. *Research-Technology Management*, 54(5), 37–46. doi:10.5437/08956308X5405005

Matzler, K., & Hinterhuber, H. H. (1998). How to make product development projects more successful by integrating Kano's model of customer satisfaction into quality function deployment. *Technovation*, 18(1), 25–38. doi:10.1016/S0166-4972(97)00072-2

McGrath, R. N., & Young, S. B. (2002). NASA's small aircraft costs versus automobile costs and the economic value of traveler time. *Technovation*, 22(5), 325–336. doi:10.1016/S0166-4972(01)00078-5

Meyer, A. De, & Nakane, J. (1989). Flexibility: the next competitive battle the manufacturing futures survey. *Strategic Management Journal*, 10(2), 135–144.

Meyer, M. H., & Dalal, D. (2002). Managing platform architectures and manufacturing processes for nonassembled products. *Journal of Product Innovation Management*, 19(4), 277–293. doi:10.1016/S0737-6782(02)00145-5

Meyer, M. H., & Mugge, P. C. (2001). Make platform innovation drive enterprise growth. *Research-Technology Management*, 44(1), 25–39. doi:10.1109/WiCom.2008.1409

Meyer, M. H., Tertzakian, P., & Utterback, J. M. (1997). Metrics for managing research and development in the context of the product family. *Management Science*, 43(1), 88–111.

Mihm, J. (2010). Incentives in new product development projects and the role of target costing. *Management Science*, 56(8), 1324–1344. doi:10.1287/mnsc.1100.1175

Mildenberger, U., & Khare, A. (2000). Planning for an environment-friendly car. *Technovation*, 20(4), 205–214. doi:10.1016/S0166-4972(99)00111-X

Miller, J., & Roth, A. (1994). A taxonomy of manufacturing strategies. *Management Science*, 40(3), 285–304.

Miller, J., & Vollmann, T. E. (1984). North american manu- facturers survey: Summary of survey responses. Boston, Mass.

Miller, P., Kurunmäki, L., & O'Leary, T. (2008). Accounting, hybrids and the management of risk. *Accounting, Organizations and Society*, 33(7-8), 942–967. doi:10.1016/j.aos.2007.02.005

Miller, P., & O'Leary, T. (2007). Mediating instruments and making markets: Capital budgeting, science and the economy. *Accounting, Organizations and Society*, 32(7-8), 701–734. doi:10.1016/j.aos.2007.02.003

Miranda González, F., & Banegil Palacios, T. (2002). The effect of new product development techniques on new product success in Spanish firms. *Industrial Marketing Management*, 31(3), 261–271.

Mishra, A. a., & Shah, R. (2009). In union lies strength: Collaborative competence in new product development and its performance effects. *Journal of Operations Management*, 27(4), 324–338. doi:10.1016/j.jom.2008.10.001

Moinzadeh, K., & Aggarwal, P. (1997). Analysis of a production/inventory system subject to random disruptions. *Management Science*, 43(11), 1577–1588.

Monden, Y., & Hamada, K. (1991). Target costing and kaizen costing in Japanese automobile companies. *Journal of Management Accounting Research*, 3(1), 16–34.

Moore, W. L., Louviere, J. J., & Verma, R. (1999). Using conjoint analysis to help design product platforms. *Journal of Product Innovation Management*, 16(1), 27–39. doi:10.1111/1540-5885.1610027

Mouritsen, J., Hansen, a., & Hansen, C. Ø. (2001). Inter-organizational controls and organizational competencies: episodes around target cost management/functional analysis and open book accounting. *Management Accounting Research*, 12(2), 221–244. doi:10.1006/mare.2001.0160

Muffatto, M. (1999). Introducing a platform strategy in product development. *International Journal of Production Economics*, 60-61, 145–153. doi:10.1016/S0925-5273(98)00173-X

Muffatto, M., & Roveda, M. (2000). Developing product platforms: *Technovation*, 20(11), 617–630. doi:10.1016/S0166-4972(99)00178-9

Mukhopadhyay, S. K., & Setoputro, R. (2005). Optimal return policy and modular design for build-to-order products. *Journal of Operations Management*, 23(5), 496–506. doi:10.1016/j.jom.2004.10.012

Müller-Seitz, G. (2012). Absorptive and desorptive capacity-related practices at the network level - the case of SEMATECH. *R&D Management*, 42(1), 90–99. doi:10.1111/j.1467-9310.2011.00668.x

Murthy, D. N. P., & Blischke, W. R. (2000). Strategic warranty management: A life-cycle approach. *IEEE Transactions on Engineering Management*, 47(1), 40–54. doi:10.1109/17.820724

Nagji, B., & Tuff, G. (2012). Managing your innovation portfolio. *Harvard Business Review*, 90(5), 66–74.

Narasimhan, R., & Kim, S. W. (2002). Effect of supply chain integration on the relationship between diversification and performance: evidence from Japanese and Korean firms. *Journal of Operations Management*, 20(3), 303–323. doi:10.1016/S0272-6963(02)00008-6

Narasimhan, R., Swink, M., & Kim, S. W. (2006). Disentangling leanness and agility: An empirical investigation. *Journal of Operations Management*, 24(5), 440–457. doi:10.1016/j.jom.2005.11.011

Narver, J. C., & Slater, S. F. (1990). The effect of a market orientation on business profitability. *The Journal of Marketing*, 54(4), 20–35.

Narver, J. C., Slater, S. F., & MacLachlan, D. L. (2004). Responsive and proactive market orientation and new-product success*. *Journal of Product Innovation Management*, 21(5), 334–347. doi:10.1111/j.0737-6782.2004.00086.x

Nepal, B., Monplaisir, L., & Singh, N. (2005). Integrated fuzzy logic-based model for product modularization during concept development phase. *International Journal of Production Economics*, 96(2), 157–174. doi:10.1016/j.ijpe.2004.03.010

Nixon, B. (1998). Research and development performance measurement: a case study. *Management Accounting Research*, 9(3), 329–355. doi:10.1006/mare.1998.0079

Nobelius, D., & Sundgren, N. (2002). Managerial issues in parts sharing among product development projects: A case study. *Journal of Engineering and Technology Management* - JET-M, 19(1), 59–73. doi:10.1016/S0923-4748(01)00046-7

Nunnally, J. C., & Bernstein, I. H. (1994). Psychometric theory (third edit.). Mcgraw-hill.

O'Connor, P. (1994). Implementing a Stage-Gate process: A multi-company perspective. *Journal of Product Innovation Management*, 11(3), 183–200. doi:10.1111/1540-5885.1130183

Olhager, J., & West, B. M. (2002). The house of flexibility: using the QFD approach to deploy manufacturing flexibility. *International Journal of Operations & Production Management*, 22(1), 50–79. doi:10.1108/01443570210412079

Onofrei, M., Hunt, J., Siemienczuk, J., Touchette, D. R., & Middleton, B. (2004). A first step towards translating evidence into practice: Heart failure in a community practice-based research network. Informatics in Primary Care, 12(3), 139–145. doi:Article

Ozer, M., & Cebeci, U. (2010). The role of globalization in new product development. *IEEE Transactions on Engineering Management*, 57(2), 168–180. doi:10.1109/TEM.2009.2025492

Page, A. L., & Schirr, G. R. (2008). Growth and development of a body of knowledge: 16 years of new product development research, 1989–2004. *Journal of Product Innovation Management*, 25(3), 233–248. doi:10.1111/j.1540-5885.2008.00297.x

Pallant, J. (2013). Survival Manual - A step by step guide to data analysis using IBM SPSS (5th. editi.). New York: Mcgraw-Hill.

Pandit, S. M., & Lin, G. (1991). Data dependent systems methodology for validation of simulation models illustrated by end-milling. *International Journal of Production Research*, 29(6), 1251–1261. doi:10.1080/00207549108930131

Parasuraman, a. (2000). Technology Readiness Index (TRI): A multiple-item scale to measure readiness to embrace new technologies. *Journal of Service Research*, 2(4), 307–320. doi:10.1177/109467050024001

Park, J., & Simpson, T. W. (2005). Development of a production cost estimation framework to support product family design. *International Journal of Production Research*, 43(4), 731–772. doi:10.1080/00207540512331311903

Park, J., & Simpson, T. W. (2008). Toward an activity-based costing system for product families and product platforms in the early stages of development. *International Journal of Production Research*, 46(1), 99–130. doi:10.1080/00207540600825240

Parker, L. (2000). Environmental costing: a path to implementation. *Australian Accounting Review*, 10(3), 43–51.

Parthasarthy, R., & Sethi, S. (1993). Relating strategy and structure to flexible automation: a test of fit and performance implications. *Strategic Management Journal*, 14(7), 529–549.

Patel, P. C., & Jayaram, J. (2014). The antecedents and consequences of product variety in new ventures: An empirical study. *Journal of Operations Management*, 32(1), 34–50. doi:10.1016/j.jom.2013.07.002

Perdue, R. K., McAllister, W. J., King, P. V., & Berkey, B. G. (1999). Valuation of R and D projects using options pricing and decision analysis models. *Interfaces*, 29(6), 57–74. doi:10.1287/inte.29.6.57

Perera, H. S. C., Nagarur, N., & Tabucanon, M. T. (1999). Component part standardization: a way to reduce the life-cycle costs of products. *International Journal of Production Economics*, 60-61, 109–116. doi:10.1016/S0925-5273(98)00179-0

Perlman, Y. (2013). The effect of risk aversion on product family design under uncertain consumer segments. *International Journal of Production Research*, 51(2), 504–514. doi:10.1080/00207543.2011.653013

Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (2003). A Model of supplier integration into new product development. *Journal of Product Innovation Management*, 20(4), 284–299. doi:10.1111/1540-5885.00028

Plank, R. E., & Ferrin, B. G. (2002). How manufacturers value purchase offerings. An exploratory study. *Industrial Marketing Management*, 31(5), 457–465. doi:10.1016/S0019-8501(01)00161-4

Porter, M. E. (1985). Competitive advantage: Creating and sustaining supe- rior performance. NewYork: The Free Press.

Porter, M. E. (1996). What is strategy. *Harvard Business Review*, 74(6), 61–78.

Pullan, T. T., Bhasi, M., & Madhu, G. (2012). Object-oriented modelling of manufacturing information system for collaborative design. *International Journal of Production Research*, 50(12), 3328–3344. doi:10.1080/00207543.2011.575096

Quan, X. Q. X., & Chesbrough, H. (2010). Hierarchical segmentation of R&D process and intellectual property protection: Evidence from multinational R&D laboratories in China. *IEEE Transactions on Engineering Management*, 57(1), 9–21. doi:10.1109/TEM.2009.2033043

Quariguasi Frota Neto, J., Walther, G., Bloemhof, J., van Nunen, J. a. E. ., & Spengler, T. (2010). From closed-loop to sustainable supply chains: the WEEE case. *International Journal of Production Research*, 48(15), 4463–4481. doi:10.1080/00207540902906151

Rabino, S. (2001). The accountant's contribution to product development teams — a case study. *Journal of Engineering and Technology Management*, 18(1), 73–90. doi:10.1016/S0923-4748(00)00034-5

Rai, R., & Allada, V. (2003). Modular product family design: Agent-based Pareto-optimization and quality loss function-based post-optimal analysis. *International Journal of Production Research*, 41(17), 4075–4098. doi:10.1080/0020754031000149248

Ramachandran, K., & Krishnan, V. (2008). Design architecture and introduction timing for rapidly improving industrial products. *Manufacturing & Service Operations Management*, 10(1), 149–171. doi:10.1287/msom.1060.0143

Ramdas, K., Fisher, M., & Ulrich, K. (2003). Managing variety for assembled products: Modeling component systems sharing. *Manufacturing & Service Operations Management*, 5(2), 142–156. doi:10.1287/msom.5.2.142.16073

Ramdas, K., & Randall, T. (2008). Does component sharing help or hurt reliability? An empirical study in the automotive industry. *Management Science*, 54(5), 922–938. doi:10.1287/mnsc.1070.0791

Ramdas, K., & Sawhney, M. (2001). A cross-functional approach to evaluating multiple line extensions for assembled products. *Management Science*, 47(1), 22–36.

Ray, P. K. P. K., & Ray, S. (2010). Resource-constrained innovation for emerging economies: The case of the Indian telecommunications industry. *IEEE Transactions on Engineering Management*, 57(1), 144–156. doi:10.1109/TEM.2009.2033044

Ray, S., & Kanta Ray, P. (2011). Product innovation for the peoples car in an emerging economy. *Technovation*, 31(5), 216–227. doi:10.1016/j.technovation.2011.01.004

Reitzig, M. (2011). ls your company choosing the best innovation ideas? *MIT Sloan Management Review*, 47–52.

Riggs, J. L., & Jones, D. (1990). Flowgraph representation of life cycle cost methodology - A new perspective for project managers. *IEEE Transactions on Engineering Management*, 37(2), 147–152. doi:10.1109/17.53719

Ro, Y. K., Liker, J. K., & Fixson, S. K. (2007). Modularity as a strategy for supply chain coordination: The case of U.S. auto. *IEEE Transactions on Engineering Management*, 54(1), 172–189. doi:10.1109/TEM.2006.889075

Roberts, J. (2004). The modern firm - organizational design for performance and growth. Oxford: Oxford University Press.

Roberts, P. W. (1999). Product innovation, product-market competition and persistent profitability in the U.S pharmaceutical industry. *Strategic Management Journal*, 20(7), 655–670.

Robertson, D., & Ulrich, K. (1998). Planning for product platforms. *Sloan Managament Review*, 39(4), 19–31. doi:Article

Romano, P., Formentini, M., Bandera, C., & Tomasella, M. (2010). Value analysis as a decision support tool in cruise ship design. *International Journal of Production Research*, 48(23), 6939–6958. doi:10.1080/00207540903352686

Romli, A., Prickett, P., Setchi, R., & Soe, S. (2014). Integrated eco-design decision-making for sustainable product development. *International Journal of Production Research*, 53(2), 1–23. doi:10.1080/00207543.2014.958593

Roslender, R., & Hart, S. J. (2003). In search of strategic management accounting: theoretical and field study perspectives. *Management Accounting Research*, 14(3), 255–279. doi:10.1016/S1044-5005(03)00048-9

Roy, R., Souchoroukov, P., & Griggs, T. (2008). Function-based cost estimating. *International Journal of Production Research*, 46(10), 2621–2650. doi:10.1080/00207540601094440

Ruekert, R. (1992). Developing a market orientation: an organizational strategy perspective. *International Journal of Research in Marketing*, 9(3), 225–245. doi:10.1016/0167-8116(92)90019-H

Rusinko, C. A. (1999). Exploring the use of design-manufacturing integration (DMI) to facilitate product development: A test of some practices. *IEEE Transactions on Engineering Management*, 46(1), 56–71. doi:10.1109/17.740038

Salvador, F., Rungtusanatham, M., Forza, C., & Trentin, A. (2007). Mix flexibility and volume flexibility in a build-to-order environment: Synergies and trade-offs. *International Journal of Operations & Production Management*, 27(11), 1173–1191. doi:10.1108/01443570710830584

Salvador, F., & Villena, V. (2013). Supplier integration and NPD outcomes: Conditional moderation effects of modular design competence. *Journal of Supply Chain Management*, 49(1), 87–113.

Sánchez, A. M., Pérez, M. P. P., Martínez Sánchez, A., & Pérez, M. P. P. (2003). Cooperation and the ability to minimize the time and cost of new product development within the Spanish automotive supplier industry. *Journal of Product Innovation Management*, 20(1), 57–69. doi:10.1111/1540-5885.201005

Sanchez, R. (1999). Modular architectures in the marketing process. *The Journal of Marketing*, 63(Special Issue), 92–111. doi:10.2307/1252104

Sanderson, S. W. (1991). Cost models for evaluating virtual design strategies in multicycle product families. *Journal of Engineering and Technology Management*, 8(3-4), 339–358. doi:10.1016/0923-4748(91)90017-L

Sanderson, S. W., & Uzumeri, M. (1995). Managing product families: The case of the Sony walkman. *Research Policy*, 24(5), 761–782. doi:10.1016/0048-7333(94)00797-B

Sarangee, K. R., Woolley, J. L., Schmidt, J. B., & Long, E. (2014). De-escalation mechanisms in high-technology product innovation. *Journal of Product Innovation Management*, 31(5), 1023–1038. doi:10.1111/jpim.12142

Sargent, R., & Som, T. (1992). Current issues in frequency domain experimentation. *Management Science*, 38(5), 667–687.

Scarbrough, P., Nanni Jr., A. J., & Sakurai, M. (1991). Japanese management accounting practices and the effects of assembly and process automation. *Management Accounting Research*, 2(1), 27–46.

Schiele, H. (2010). Early supplier integration: the dual role of purchasing in new product development. *R&D Management*, 40(2), 138–153. doi:10.1111/j.1467-9310.2010.00602.x

Schmeisser, W., Mohnkopf, H., Hartmann, M., & Metze, G. (2008). Innovationserfolgsrechnung. (H. Mohnkopf, M. Hartmann, G. Metze, & W. Schmeisser, Eds.). Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-540-78249-0

Schultz, C., Salomo, S., de Brentani, U., & Kleinschmidt, E. J. (2013). How formal control influences decision-making clarity and innovation performance. *Journal of Product Innovation Management*, 30(3), 430–447. doi:10.1111/jpim.12009

Seal, W., Berry, A., & Cullen, J. (2004). Disembedding the supply chain: institutionalized reflexivity and inter-firm accounting. *Accounting, Organizations and Society*, 29(1), 73–92. doi:10.1016/S0361-3682(02)00055-7

Sethi, R., & Iqbal, Z. (2008). Stage-Gate controls, learning failure, and adverse effect on novel new products. *Journal of Marketing*, 72(1), 118–134. doi:10.1509/jmkg.72.1.118

Settanni, E., Newnes, L. B., Thenent, N. E., Parry, G., & Goh, Y. M. (2014). A through-life costing methodology for use in product-service-systems. *International Journal of Production Economics*, 153, 161–177. doi:10.1016/j.ijpe.2014.02.016

Sherman, J. D., Berkowitz, D., & Souder, W. E. (2005). New product development performance and the interaction of cross-functional integration and knowledge management. *Journal of Product Innovation Management*, 22(5), 399–411. doi:10.1111/j.1540-5885.2005.00137.x

Shih, M. (1998). Corporate Hierarchy and goal attainability. *Accounting Review*, 73(4), 557–564.

Sik Oh, J., O'Grady, P., & Young, R. E. (1995). A constraint network approach to design for assembly. *IIE Transactions*, 27(1), 72–80. doi:10.1080/07408179508936718

Simons, R. (1995). Levers of control: how managers use innovative control systems to drive strategic renewal ([Nachdr.].). Boston, Mass.: Harvard Business School Press.

Simonse, L., Hultink, E., & Buijs, J. (2014). Innovation roadmapping: building concepts from practitioners' insights. *Journal of Product Innovation Management*, 32(6), 1–21. doi:doi: 10.1111/jpim.12208

Simpson, T. W., Maier, J. R., & Mistree, F. (2001). Product platform design: method and application. *Research in Engineering Design*, 13(1), 2–22. doi:10.1007/s001630100002

Sohn, S. Y., & Kim, Y. (2011). Economic evaluation model for international standardization of correlated technologies. *IEEE Transactions on Instrumentation and Measurement*, 58(2), 189–198.

Song, J.-S. (2002). Order-based backorders and their implications in multi-item inventory systems. *Management Science*, 48(4), 499–516.

Song, J.-S., & Zhao, Y. (2009). The value of component commonality in a dynamic inventory system with lead times. *Manufacturing & Service Operations Management*, 11(3), 493–508. doi:10.1287/msom.1080.0235

Song, L. Z., Song, M., & Di Benedetto, C. A. (2009). A staged service innovation model. *Decision Sciences*, 40(3), 571–599. doi:10.1111/j.1540-5915.2009.00240.x

Song, X. M., Montoya-Weiss, M. M., & Schmidt, J. B. (1997). Antecedents and consequences of cross-functional cooperation: a comparison of R&D, manufacturing, and marketing perspectives. *Journal of Product Innovation Management*, 14(1), 35–47. doi:10.1111/1540-5885.1410035

Song, X. M., Thieme, R. J., & Xie, J. (1998). The Impact of cross-functional joint involvement across product development stages: an exploratory study. *Journal of Product Innovation Management*, 15(4), 289–303. doi:10.1111/1540-5885.1540289

Sosa, M. M. E., Eppinger, S. D., & Rowles, C. M. (2004). The misalignment of product architecture and organizational structure in complex product development. *Management Science*, 50(12), 1674–1689. doi:10.1287/mnsc.1040.0289

Sprent, P., & Smeeton, N. C. (2007). Applied nonparametric statistical methods (4th. ed.). Boca Raton: Chapman & Hall/CRC.

Statista GmbH. (2014). Umsätze der wichtigsten Industriebranchen in Deutschland in den Jahren 2008 bis 2013 (in Milliarden Euro). Retrieved from http://de.statista.com/statistik/daten/studie/203580/umfrage/umsaetze-der-wichtigsten-industriebranchen-in-deutschland/

Steele, D. C., Berry, W. L., & Chapman, S. N. (1995). Planning and Control in Multi-Cell Manufacturing. *Decision Sciences*, 26(1), 1–34. doi:10.1111/j.1540-5915.1995.tb00835.x

Stevens, G., Burley, J., & Divine, R. (1999). Creativity + business discipline = higher profits faster from new product development. *Journal of Product Innovation Management*, 16(5), 455–468. doi:10.1016/S0737-6782(98)00070-8

Stock, J. H., & Watson, M. M. (2012). Introduction to econometrics (third edit.). Pearson Education, Limited.

Stonebraker, J. S., Gil, E., Kirkwood, C. W., & Handfield, R. B. (2012). Impact factor as a metric to assess journals where OM research is published. *Journal of Operations Management*, 30(1), 24–43. doi:10.1016/j.jom.2011.05.002

Sundgren, N. (1999). Introducing interface management in new product family development. *Journal of Product Innovation Management*, 16(98), 40–51. doi:10.1111/1540-5885.1610040

Swaminathan, J. M. (2001). Enabling customization using standardized operations*. California Management Review*, 43(3), 125–135.

Swaminathan, J., & Tayur, S. (1998). Managing broader product lines through delayed differentiation using vanilla boxes. *Management Science*, 44(12, part 2 of 2).

Swink, M. (2003). Completing projects on-time: how project acceleration affects new product development. *Journal of Engineering and Technology Management*, 20(4), 319–344. doi:10.1016/j.jengtecman.2003.08.002

Swink, M., & Nair, A. (2007). Capturing the competitive advantages of AMT: Design-manufacturing integration as a complementary asset. *Journal of Operations Management*, 25(3), 736–754. doi:10.1016/j.jom.2006.07.001

Swink, M., Narasimhan, R., & Wang, C. (2007). Managing beyond the factory walls: Effects of four types of strategic integration on manufacturing plant performance. *Journal of Operations Management*, 25(1), 148–164. doi:10.1016/j.jom.2006.02.006

Tabachnick, B. G., & Fidell, L. S. (2007). Using multivariate statistics (5. ed.). Boston, Mass. ; Munich [u.a.]: Pearson International.

Taipaleenmäki, J. (2014). Absence and variant modes of presence of management accounting in new product development – Theoretical refinement and some empirical evidence. *European Accounting Review*, 23(2), 291–334. doi:10.1080/09638180.2013.811065

Tan, K. (2001). A structural equation model of new product design and development. *Decision Sciences*, 32(2), 195–226.

Tang, Y., & Qiu, R. G. (2004). Integrated design approach for virtual production line-based reconfigurable manufacturing systems. *International Journal of Production Research*, 42(18), 3803–3822. doi:10.1080/00207540410001699372

Tani, T., Okano, H., & Shimizu, N. (1994). Target cost management in Japanese companies: current state of the art. *Management Accounting Research*, 5, 67–81.

Tatikonda, M. V. (1999). An empirical study of platform and derivative product development projects. *Journal of Product Innovation Management*, 16(1), 3–26. doi:10.1111/1540-5885.1610003

Taylor, G. D. (1997). Design for global manufacturing and assembly∗. *IIE Transactions*, 29(7), 585–597. doi:10.1080/07408179708966368

Terjesen, S., Patel, P. C., & Sanders, N. R. (2012). Managing differentiation-integration duality in supply chain integration. *Decision Sciences*, 43(2), 303–339. doi:10.1111/j.1540-5915.2011.00345.x

Thyssen, J., Israelsen, P., & Jørgensen, B. (2006). Activity-based costing as a method for assessing the economics of modularization-A case study and beyond. *International Journal of Production Economics*, 103(1), 252–270. doi:10.1016/j.ijpe.2005.07.004

Tinsley, H. E. A., & Brown, S. D. (2000). Handbook of applied multivariate statistics and mathematical modeling. San Diego: Academic Press.

Tipping, J. W., Zeffren, E., & Fusfeld, A. R. (1995). Assessing the value of your technology. Research-Technology Management (Vol. 38). Les Nouvelles.

Tomkins, C., & Carr, C. (1996). Reflections on the papers in this issue and a commentary on the state of Strategic Management Accounting. *Management Accounting Research*, 7(2), 271–280. doi:10.1006/mare.1996.0015

Troy, L., Hirunyawipada, T., & Paswan, A. (2008). Cross-functional integration and new product success: an empirical investigation of the findings. Journal of Marketing, 72(6), 132–146.

Trygg, L. (1993). Concurrent engineering practices in selected Swedish companies: A movement or an activity of the few? *Journal of Product Innovation Management*, 10(5), 403–415. doi:http://dx.doi.org/10.1016/0737-6782(93)90098-B

Tu, Q., Vonderembse, M. a., Ragu-Nathan, T. S., & Ragu-Nathan, B. (2004). Measuring modularity-based manufacturing practices and their impact on mass customization capability: A customer-driven perspective. *Decision Sciences*, 35(2), 147–168. doi:10.1111/j.00117315.2004.02663.x

Tubig, S. B., & Abetti, P. a. (1990). Variables influencing the performance of defense R&D contractors. *IEEE Transactions on Engineering Management*, 37(1), 22–30. doi:10.1109/17.45261

Tzokas, N., Hultink, E. J., & Hart, S. (2004). Navigating the new product development process. *Industrial Marketing Management*, 33(7), 619–626. doi:10.1016/j.indmarman.2003.09.004

Ülkü, S., Dimofte, C., & Schmidt, G. (2012). Consumer valuation of modularly upgradeable products. *Management Science*, 58(9), 1761–1776.

Ulrich, K. (1995). The role of product architecture in the manufacturing firm. *Research Policy*, 24(3), 419–440. doi:10.1016/0048-7333(94)00775-3

Ulrich, K., & Pearson, S. (1998). Assessing the importance of design through product archaeology. *Management Science*, 44(3), 352–369.

Ulrich, K., Sartorius, D., Pearson, S., & Jakiela, M. (1993). Including the value of time in design-for-manufacturing decision making. *Management Science*, 39, 429–447.

Usher, J. S., & Whitfield, G. M. (1993). Evaluation of used-system life cycle costs using fuzzy set theory. *IIE Transactions*, 25(6), 84–88. doi:10.1080/07408179308964330

Uskonen, J., & Tenhiälä, A. (2012). The price of responsiveness: Cost analysis of change orders in make-to-order manufacturing. *International Journal of Production Economics*, 135(1), 420–429. doi:10.1016/j.ijpe.2011.08.016

Vakharia, A. J., Parmenter, D. a., & Sanchez, S. M. (1996). The operating impact of parts commonality. *Journal of Operations Management*, 14(1), 3–18. doi:10.1016/0272-6963(95)00033-X

Van den Abbeele, A., Roodhooft, F., & Warlop, L. (2009). The effect of cost information on buyer–supplier negotiations in different power settings. *Accounting, Organizations and Society*, 34(2), 245–266. doi:10.1016/j.aos.2008.05.005

Van der Stede, W. A. (2000). The relationship between two consequences of budgetary controls: budgetary slack creation and managerial short-term orientation. *Accounting, Organizations and Society*, 25, 609–622.

Van Mieghem, J. a. (2004). Note—commonality strategies: value drivers and equivalence with flexible capacity and inventory substitution. *Management Science*, 50(3), 419–424. doi:10.1287/mnsc.1030.0197

van Oorschot, K. E., Akkermans, H., Sengupta, K., & Van Wassenhove, L. N. (2013). Anatomy of a decision trap in complex new product development projects. *Academy of Management Journal*, 56(1), 285–307. doi:10.5465/amj.2010.0742

Van Oorschot, K., Sengupta, K., Akkermans, H., & Van Wassenhove, L. (2010). Get fat fast: Surviving stage-gates in NPD. *Journal of Product Innovation Management*, 27(6), 828–839. doi:10.1111/j.1540-5885.2010.00754.x

Vanegas, L. V., & Labib, a. W. (2001). A fuzzy quality function deployment (FQFD) model for deriving optimum targets. *International Journal of Production Research*, 39(1), 99–120. doi:10.1080/00207540010005079

Verganti, R. (1999). Planned flexibility: linking anticipation and reaction in product development projects. *Journal of Product Innovation Management*, 16(4), 363–376. doi:10.1016/S0737-6782(98)00067-8

Voss, C. a., & Hsuan, J. (2009). Service architecture and modularity. *Decision Sciences*, 40(3), 541–569. doi:10.1111/j.1540-5915.2009.00241.x

Wagenhofer, A. (2006). Management accounting research in german-speaking countries. *Journal of Management Accounting Research*, 18(1), 1–19. doi:10.2308/jmar.2006.18.1.1

Walwyn, D. R., Taylor, D., & Brickhill, G. (2002). How to manage risk better. *Research-Technology Management*, 45(5), 37–42.

Wang, H. S., & Che, Z. H. (2008). A multi-phase model for product part change problems. *International Journal of Production Research*, 46(10), 2797–2825. doi:10.1080/00207540600999144

Wang, J.-H., & Trolio, M. (2001). Using clustered assembly elements in the estimation of potential design for assembly benefits. *International Journal of Production Research*, 39(9), 1885–1895. doi:10.1080/00207540010024087

Ward, P. T., McCreery, J. K., Ritzman, L. P., & Sharma, D. (1998). Competitive priorities in operations management. *Decision Sciences*, 29(4), 1035–1046. doi:10.1111/j.1540-5915.1998.tb00886.x

Wasserman, G. S. (1993). On how to prioritize design requirements during the QFD planning process. *IIE Transactions*, 25(3), 59–65. doi:10.1080/07408179308964291

Wheelwright, S. C., & Clark, K. B. (1992). Revolutionizing product development: quantum leaps in speed, efficiency, and quality. New York: Free Press.

Wheelwright, S. C., & Clark, K. B. (1992). Structuring the Development Funnel. In Revolutionizing Product Development (pp. 111–132).

Wijewardena, H., & De Zoysa, A. (1999). A comparative analysis of management accounting practices in Australia and Japan: An empirical investigation. *The International Journal of Accounting*, 34(1), 49–70. doi:10.1016/S0020-7063(99)80003-X

Wong, C. Y., Boon-itt, S., & Wong, C. W. Y. (2011). The contingency effects of environmental uncertainty on the relationship between supply chain integration and operational performance. *Journal of Operations Management*, 29(6), 604–615. doi:10.1016/j.jom.2011.01.003

Woods, M., Taylor, L., & Fang, G. C. G. (2012). Electronics: A case study of economic value added in target costing. *Management Accounting Research*, 23(4), 261–277. doi:10.1016/j.mar.2012.09.002

Wouters, M., & Anderson, J. C. (2009). Improving sourcing decisions in NPD projects: Monetary quantification of points of difference. *Journal of Operations Management*, 27(1), 64–77. doi:10.1016/j.jom.2008.07.001

Wouters, M., Anderson, J. C., & Wynstra, F. (2005). The adoption of total cost of ownership for sourcing decisions––a structural equations analysis. *Accounting, Organizations and Society*, 30(2), 167–191. doi:10.1016/j.aos.2004.03.002

Wouters, M., & Morales, S. (2014). The contemporary art of cost management methods during product development. In M. J. Epstein & J. Y. Lee (Eds.), *Advances in Management Accounting* (Vol. 24, pp. 259–346). Bingley, UK: Emerald Group Publishing Limited. doi:10.1108/S1474-787120140000024008

Wouters, M., Workum, M., & Hissel, P. (2011). Assessing the product architecture decision about product features - a real options approach. *R&D Management*, 41(4), 393–409. doi:10.1111/j.1467-9310.2011.00652.x

Wu, J., Boateng, A., & Drury, C. (2007). An analysis of the adoption, perceived benefits, and expected future emphasis of western management accounting practices in Chinese SOEs and JVs. *The International Journal of Accounting*, 42(2), 171–185. doi:10.1016/j.intacc.2007.04.005

Wu, L., De Matta, R., & Lowe, T. J. (2009). Updating a modular product: How to set time to market and component quality. *IEEE Transactions on Engineering Management*, 56(2), 298–311. doi:10.1109/TEM.2008.2005065

Xiao, T., Xia, Y., & Zhang, G. P. (2007). Strategic outsourcing decisions for manufacturers that produce partially substitutable products in a quantity-setting duopoly situation. *Decision Sciences*, 38(1), 81–106. doi:10.1111/j.1540-5915.2007.00149.x

Xu, Q. L., Ong, S. K., & Nee, a. Y. C. (2007). Evaluation of product performance in product family design re-use. *International Journal of Production Research*, 45(18-19), 4119–4141. doi:10.1080/00207540701440147

Xu, S. H., & Li, Z. (2007). Managing a single-product assemble-to-order system with technology innovations. *Management Science*, 53(9), 1467–1485. doi:10.1287/mnsc.1070.0709

Xu, S. X., Lu, Q., & Li, Z. (2012). Optimal modular production strategies under market uncertainty: A real options perspective. *International Journal of Production Economics*, 139(1), 266–274. doi:10.1016/j.ijpe.2012.05.009

Yalcin, S. (2012). Adoption and benefits of management accounting practices: An inter-country comparison. *Accounting in Europe*, 9(1), 95–110. doi:10.1080/17449480.2012.664394

Yazdifar, H., & Askarany, D. (2012). A comparative study of the adoption and implementation of target costing in the UK, Australia and New Zealand. *International Journal of Production Economics*, 135(1), 382–392. doi:10.1016/j.ijpe.2011.08.012

Yeh, T.-M., Pai, F.-Y., & Yang, C.-C. (2010). Performance improvement in new product development with effective tools and techniques adoption for high-tech industries. *Quality & Quantity*, 44(1), 131–152. doi:10.1007/s11135-008-9186-7

Yeung, J. H. Y., Wong, W. C. K., Ma, L., & Law, J. S. (1999). MPS with multiple freeze fences in multi-product multi-level MRP systems. *International Journal of Production Research*, 37(13), 2977–2996. doi:10.1080/002075499190383

Yoshikawa, T., Innes, J., & Mitchell, F. (1994). Applying functional cost analysis in a manufacturing environment. *International Journal of Production Economics*, 36(1), 53–64.

Yoshikawa, T., Innes, J., & Mitchell, F. (1995). A Japanese case study of functional cost analysis. *Management Accounting Research*, 6, 415–432.

Yura, K., Ishikura, H., & Hitomi, K. (2000). Parts-mix analysis in recycling-oriented manufacturing systems for multiple-item production. *International Journal of Production Research*, 38(2), 447–456. doi:10.1080/002075400189518

Zengin, Y., & Ada, E. (2010). Cost management through product design: target costing approach. *International Journal of Production Research*, 48(19), 5593–5611. doi:10.1080/00207540903130876

Zeschky, M., Daiber, M., Widenmayer, B., & Gassmann, O. (2014). Coordination in global R&D organizations: an examination of the role of subsidiary mandate and modular product architectures in dispersed R&D organizations. *Technovation*, 34(10), 594–604. doi:10.1016/j.technovation.2014.06.001

Zhang, X., & Huang, G. Q. (2010). Game-theoretic approach to simultaneous configuration of platform products and supply chains with one manufacturing firm and multiple cooperative suppliers. *International Journal of Production Economics*, 124(1), 121–136. doi:10.1016/j.ijpe.2009.10.016

Zhang, X., Huang, G. Q., & Rungtusanatham, M. J. (2008). Simultaneous configuration of platform products and manufacturing supply chains. *International Journal of Production Research*, 46(21), 6137–6162. doi:10.1080/00207540701324150

Zhang, Y. (1999, March). Green QFD-II: A life cycle approach for environmentally conscious manufacturing by integrating LCA and LCC into QFD matrices. *International Journal of Production Research*. doi:10.1080/002075499191418

Zhou, L., & Grubbström, R. W. (2004). Analysis of the effect of commonality in multi-level inventory systems applying MRP theory. *International Journal of Production Economics*, 90(2), 251–263. doi:10.1016/S0925-5273(03)00208-1

Zwerink, R., Wouters, M., Hissel, P., & Kerssens-van Drongelen, I. (2007). Cost management and cross-functional communication through product architectures. *R&D Management*, 37(1), 49–64. doi:10.1111/j.1467-9310.2007.00458.x

Appendices

Appendix A

Appendix A, Table 1a: Target Costing: Setting the Cost Target

Author, date, journal	**Cost management method(s)**	**Industry**	**Summary (regarding the focal cost management method)**	**Type of data**	**Field work**
Agndal & Nilsson (2009) *MAR*	Target costing Value engineering Kaizen costing	Automotive industry	The paper studies when and how when suppliers and buyers jointly utilize suppliers' management accounting data for interorganisational cost management. The paper focused on the use of such data in target costing, value engineering, and Kaizen. Kaizen (or value analysis) was seen as a simple form of target costing for use after the initiation of full-speed production, in order to find ongoing improvements. These techniques were used for price revisions and for product and process design. The deepest collaboration around cost management issues and the greatest joint use of suppliers' management accounting in three cases in the Swedish automotive industry typically occurred in earlier activities in the exchange process, including supplier selection, joint product design and joint manufacturing process development.	Empirical: qualitative	Case-Study
Agndal & Nilsson (2010) *MAR*	Target costing Value engineering Kaizen costing	Automotive, retailer and telecom	The paper studies, on the basis of three cases in Sweden, when and how suppliers and buyers jointly utilize suppliers' management accounting data for interorganisational cost management. The extent of sharing of management accounting data depended on the kind of relationship. With a transactional purchasing strategy, cost data primarily served to reduce purchase prices, so data disclosure was limited and forced by the buyer firm. With a relational purchasing strategy, cost data supported cost reduction, for example through joint development of cost efficient products and processes, using target costing, value engineering, and Kaizen costing.	Empirical: qualitative	Case-Study
Anderson & Dekker (2009) *AH*	Target costing Value engineering Kaizen costing	Not given	This is a literature review; structural cost management refers to tools of organisational design, product design, and process design to create a supply chain cost structure that is coherent with a firm's strategy. Several management accounting and engineering processes facilitate effective product design, including target costing, value engineering, and Kaizen costing. These enable the design of a low-cost product that nonetheless offers a fair return to each participant, and also the identification which participant has a comparative advantage in performing particular tasks.	Non-Empirical: Theoretical	None

Appendix A, Table 1a: Target Costing: Setting the Cost Target

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Baines & Langfield-Smith (2003) *AOS*	Target costing	Manufacturing firms	This paper reports on a survey of manufacturing companies, and uses structural equation modeling to examine management accounting change. The results indicate that an increasingly competitive environment has resulted in an increased focus on differentiation strategies. This, in turn, has influenced changes in organisational design, advanced manufacturing technology and advanced management accounting practices. These three changes have led to a greater reliance on non-financial accounting information which has led to improved organisational performance. Advanced management accounting practices (e.g., target costing) can assist employees to more easily focus on achieving differentiation priorities, such as quality, delivery and customer service.	Empirical: survey	None
Bjørnenak & Olson (1999) *MAR*	Life-cycle costing Target costing	Not given	The study identifies innovations in the management accounting literature, based on data from management accounting textbooks. It is found that life cycle costing and target costing changed concepts of accounting regarding time (from fixed calendar time to a more flexible concept of the life time of products; from ex post to ex ante) and regarding systems (from one or few to many systems).	Non-Empirical: Theoretical	None
Cadez & Guilding (2008) *AOS*	Target costing Life-cycle costing	Multiple industries	This study examines the effect of strategic choices, market orientation, and company size on two distinct dimensions of strategic management accounting and, in turn, the effect of strategic management accounting on company performance. Target costing and life cycle costing are mentioned as examples of strategic management accounting. The model is tested using structural equation modelling and data collected from a sample of 193 large Slovenian companies from all industrial sectors. Furthermore, the findings have been compared with qualitative data collected in ten exploratory interviews.	Empirical: mix (QQ)	None
Caglio & Ditillo (2008) *AOS*	TCO Target costing	Not given	The paper describes a review of the theoretical and empirical literature on management control in inter-firm contexts. Target costing and TCO are important management accounting techniques in this review. The management accounting literature has emphasised the application of TCO in sourcing decisions for the screening and management of suppliers, for example to quantify the costs involved in acquiring and using different offerings. Target costing is an approach for cost reduction and planning in an interorganisational setting. It involves a supplier in the buyer’s cost management programs.	Non-Empirical: Theoretical	None
Carr & Ng (1995) *MAR*	Target costing	Automotive industry	The paper offers a description of how Nissan uses target costing in the UK, in particular how it is being extended to encompass local suppliers.	Empirical: qualitative	Case-Study

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Chenhall & Langfield-Smith (1998) *MAR*	Target costing	Manufacturing firms	This article uses a survey to identify the extent to which Australian manufacturing firms have adopted certain traditional and recently developed management accounting practices, such as target costing. The findings indicate that, overall, the rates of adoption of traditional management accounting practices were higher than recently developed techniques. However, newer techniques were more widely adopted than found in prior surveys. Also, the benefits obtained from traditional management accounting techniques were higher than those of newer techniques.	Empirical: survey	None
Chenhall (2008) *AOS*	Target costing	Not given	This paper is a review essay. The horizontal organisation is essentially about structural forms and organisational arrangements that enable a lateral integration of strategies, processes, structures and people to deliver value to customers. Complementary developments in management accounting include activity-based costing, and target costing. Target costing could enable the management accountant to be part of product development teams.	Non-Empirical: Theoretical	None
Cooper & Slagmulder (2004) *AOS*	Target costing Value engineering	Japanese manufacturing firms	The paper focusses on hybrid forms of collaboration between suppliers and buyers, and the make-or-buy decision in such contexts. In case studies of three large Japanese manufacturing firms, interorganisational uses of target costing and value engineering is observed. This crossed the organisational boundaries between buyers and suppliers and it was used to overcome the information asymmetry that existed between buyers and suppliers, which enabled their design teams to coordinate and cooperate effectively in order to identify low-cost solutions by changing the specifications of the outsourced items and sometimes the end product itself.	Empirical: qualitative	Case-Study
Dekker et al. (2013) *MAR*	Target costing	Japanese manufacturing firms	The paper examines firms' use of control practices to manage risks associated with intensified collaboration with supply chain partners. These supply chain management control practices included the target-setting activity of target costing. Results indicated that transaction characteristics (such as unpredictability of technology development, and asset specificity) affect the use of these control practices. Furthermore, trust in supplier competencies facilitates the use of these control practices.	Empirical: survey	None
Duh et al. (2008) *JMAR*	Target costing	Not given	The paper presents an overview of 283 management accounting articles published in 18 major Chinese academic journals from 1997 to 2005. There is a relatively high level of attention to target costing within Chinese journals, especially in the period 1997–2001.	Non-Empirical: Theoretical	None

Appendix A, Table 1a: Target Costing: Setting the Cost Target

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Ewert & Ernst (1999) *EAR*	Target costing	Not given	The paper presents a theoretical analysis of target costing. The analysis addresses three distinct characteristics of target costing: market orientation, its use as co-ordination instrument, and its interaction with other factors affecting long-term cost structure.	Non-Empirical: Analytical	None
Fayard et al. (2012) *AOS*	Kaizen costing Target costing	Multiple industries	The study investigates antecedents of a firm's interorganisational cost management practices, which refers to activities that allow organisations to manage costs that extend beyond their boundaries. One of the hypothesized and supported antecedents was internal cost management, because firms with a strong ability to manage internal costs may leverage this to develop similar interorganisational abilities. Target costing and Kaizen costing are examples of cost management practices that can be extended to an interorganisational context.	Empirical: survey	None
Guilding et al. (2000) *MAR*	Target costing Life-cycle costing	Large companies in multiple industries	The study investigates the use and perceived merit of 12 management accounting practices, among which target costing and life cycle costing, in three different countries (New Zealand, U.K. and U.S.). The perceived merit of target costing scored above the mid-point of the perceived merit scale in the U.S. For all practices appraised, the perceived merit scores are significantly greater than the usage rate score.	Empirical: survey	None
Hopper et al. (1999) *ABR*	Target costing Value engineering Life-cycle costing	Japanese SMEs	The paper provides impressions of cost management practices of small and medium sized Japanese companies. Costing systems proved to be similar to those of larger Japanese firms.	Empirical: qualitative	Case-Study
Hyvönen (2003) *EAR*	Target costing Life-cycle costing	High-tech industry	The study presents survey results from Finland on management accounting information systems. This included questions on the adoption of advanced management accounting techniques, such as target costing and life cycle costing. The low adoptions were 8% and 5%, respectively. Those firms who had adopted these and other modern management accounting techniques did not use significantly more ERP systems than other kinds of information systems.	Empirical: survey	None
Lee & Monden (1996) *IJA*	Target costing Kaizen costing Value engineering	Automotive industry	This paper provides a study of the use of cost management systems, which have been claimed as manufacturing-friendly, at a Japanese car manufacturing company. Specifically, activity-based costing is compared to target costing and Kaizen costing. Value engineering is an important element of target costing, and it relies on employees devising new way of improving products and operations to achieve the cost targets. Cost tables are used to estimate costs.	Empirical: qualitative	Case-Study
Lin & Yu (2002) *MAR*	Target costing	Manufacturing firm	The paper presents a case study of the cost control system in a Chinese steel company, and this system includes target costing. Cost targets are decomposed to	Empirical: mix (QQ)	Case-Study

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			production factories, and further broken down to departments and teams.		
Mouritsen et al. (2001) *MAR*	Target costing Functional cost analysis	High-tech industry	The paper investigates effects of target costing and functional analysis while establishing processes of developing inter-organisational controls. In two innovative, high-tech firms, inter-organisational management controls (such as target costing and functional analysis) became important, because they had outsourced many product development and production processes. However, these had not only inter- but also intra-organisational effects. Functional analysis and target costing affected how these companies looked at their own strategy, technology, and organisation.	Empirical: mix (QQ)	Case-Study
Roslender & Hart (2003) *MAR*	Target costing	Manufacturing firms	The paper presents an exploratory field study of strategic management accounting practices in the UK, which played a role at the interface between management accounting and marketing management. Target costing is seen as a key example of strategic management accounting. However, there was little evidence that the companies in the field study where implementing strategic management accounting practices, such as target costing.	Empirical: mix (QQ)	Case-Study
Scarbrough et al. (1991) *MAR*	Target costing	Four different manufacturing industries	The paper seeks to identify several important management accounting practices in Japan. A striking result was the widespread use of target costing, especially in the two assembly-oriented industries of electronic equipment and transportation equipment.	Empirical: survey	None
Seal et al. (2004) *AOS*	Target costing	Manufacturing firms	This is a study of a supply chain initiative in UK electronics manufacturing. The case company set up the cost management group, which evolved into a semi-autonomous team dominated by accountants. These supply chain actors and practices not only represented the supply chain costs, but it also became a source of change. While techniques of interorganisational accounting such as target costing are portrayed in the literature as enabling firms to maintain control over outsourced activities, but this study suggests that accounting can be influential in other ways.	Empirical: qualitative	Case-Study
Wagenhofer (2006) *JMAR*	Target costing	Not given	This paper reviews current research and practice in management accounting in Germany, Austria, and (part of) Switzerland based on 240 management accounting articles by authors affiliated to a German institution, published in the leading German-language journals and in international management accounting journals from 1998 to 2004. Target costing technique was one of the topics in the articles on cost management.	Non-Empirical: Theoretical	None

Appendix A, Table 1a: Target Costing: Setting the Cost Target

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Wijewardena & De Zoysa (1999) *IJA*	Target costing	Manufacturing firms	The paper presents a comparative analysis of management accounting practices in Australia and Japan. Management accounting practices in Australia placed emphasis on cost control tools at the manufacturing stage, mainly budgets, historical accounting statements and standard costing. Management accounting practices in Japan devoted greater attention to cost planning and cost reduction tools at the product design stage. Target costing was found to be the most important management accounting tool, used for cost reduction at the pre-production stage.	Empirical: survey	None
Wu et al. (2007) *IJA*	Target costing	Joint ventures (JV) & state owned enterprises (SOE)	This study investigates the adoption and perceived benefits of management accounting practices in the Chinese emerging market economy. Findings suggests that the practices relating to budgeting for cost control, profit budgeting, sales budgeting and target costing are perceived to be the more beneficial by the senior financial officers of state owned enterprises compared to joint ventures.	Empirical: survey	None

Appendix A, Table 1b: Target Costing: Early Costs Estimation

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Al Chen et al. (1997) *IJA*	Target costing: cost estimation Value engineering	Manufacturing firms	This is a study about the current direction of accounting practices that are being transferred from Japan to the U.S. work environment. Most of the U.S.-based Japanese firms in the sample were similar to what is known in the literature about Japanese domestic firms in their use of management accounting methods such as target costing and value engineering.	Empirical: survey	None
Anderson & Sedatole (1998) *AH*	Target costing: cost estimation	Not given	Quality costing information reflects costs of conformance quality in manufacturing operations, taking as given the product design. The paper presents a framework for accounting information that focuses on achieving design quality during product development. Target costing provides opportunities to develop accounting data that promotes quality being designed into, rather than inspected into, products.	Non-Empirical: Theoretical	None
Bhimani (2003) *AOS*	Target costing: cost estimation	Electronics and electrical component industry	The paper presents a case study of the design of an innovative management accounting system in Germany. It included interviews, documents, and a survey in the company. The process based target costing (PBTC) reports were intended to enable the costs of functions to be compared to the perceived customer value for those functions. PBTC was to delineate production flows visually at the design stage by producing graphic images of time, cost and quality resource consumption across processes.	Empirical: survey	None
Cooper & Slagmulder (2003) *CM*	Target costing: cost estimation Kaizen costing	Not given	The article proposes three steps to implement strategic cost management: audit cost management initiatives, extend the scope of cost management beyond the walls of the factory, and extend cost management beyond the boundaries of the firm. Target costing and Kaizen costing are proposed as key techniques for reducing costs. Both help to reduce costs, internally and together with suppliers. However, these require a high level of cooperation and information sharing (e.g., data disclosure).	Non-Empirical: Theoretical	None
Cooper (1996) *MAR*	Target costing: cost estimation Kaizen costing Value engineering	Japanese manufacturing firms	The paper describes costing techniques to support corporate strategy in Japanese firms. These firms adopted a confrontation strategy, and effective cost management became crucial. To reduce costs, several techniques are used, such as target costing and value engineering for future products, and Kaizen costing for existing products.	Empirical: qualitative	Case-Study

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Davila & Wouters (2004) *AH*	Target costing: cost estimation Product platform Modular design Component com.	High-technology industry	Target costing was not frequently used in the companies (for medical devices and computer hardware) studied in Europe and the U.S., when other considerations than costs where crucial and resources where shared by many different products. Alternative practices for managing costs during product development included modular design, parts & process commonality, and product platforms.	Empirical: qualitative	Case-Study
Kato (1993) *MAR*	Target costing: cost estimation	Japanese manufacturing firms	The paper investigates what is the contribution of target costing for cost reduction activities in Japanese companies. Target costing is an activity aimed at reducing the life-cycle cost of new products while ensuring quality, reliability and other customer requirements, by examining all possible ideas for cost reduction at the product planning, research and development, and the prototyping phases of a product. Target costing is a subtle combination of the use of human intelligence for creativity and technologies of target costing support systems, such as databases with detailed cost tables to enable cost estimation of designs and identification of cost reduction opportunities.	Non-Empirical: Theoretical	None
Mihm (2010) *MS*	Target costing: cost estimation	Not given	When engineers introduce late design changes and exhibit weak cost compliance, this reduces the product's profit or competitiveness. Providing specifically designed incentives for individuals can eliminate such behavior, and thus improve cost compliance and project timeliness. This paper discusses several practical incentive schemes, including component-level target costing. This transforms the task of the engineer from an incentive viewpoint. Instead of "design a good component" the task becomes "design the best component for a given amount of money". Target costing is an attractive method of incentivizing engineers working on routine projects for which comparable products already exist.	Non-Empirical: Analytical	None
Monden & Hamada (1991) *JMAR*	Target costing: cost estimation Kaizen costing	Automotive industry	The paper describes features of the system of total cost management in Japanese automobile companies. Target costing and Kaizen costing are of paramount importance for the total cost management system in all phases of the product life cycle of an automobile.	Non-Empirical: Theoretical	None
Nixon (1998) *MAR*	Target costing: cost estimation	Production equipment (continuous casting machines)	How can management accounting techniques be useful when cost is a critical design parameter? In a case study in the U.K., cost accounting (especially target costing) was useful to integrate customer requirements into the product development activity. Target costing was important for the evaluation of the impact of different design proposals on operating, construction and development costs. Target costing, and related techniques like value engineering were the tools that structured and articulated the dialogue among all members of the product development project team in a bid to meet the many technical and financial goals.	Empirical: mix (QQ)	Case-Study

Author, date, journal	**Cost management method(s)**	**Industry**	**Summary (regarding the focal cost management method)**	**Type of data**	**Field work**
Woods et al. (2012) *MAR*	Target costing: cost estimation Kaizen costing Value engineering Life-cycle costing	Electronic component industry	This is a case study how one major European based multinational corporation introduced economic value added (EVA) into its target costing system. The target costing system also included value engineering, life cycle costing, and Kaizen costing. The study showed that there were many technical accounting difficulties for cascading EVA down to the product level, which led to simplification of the EVA measurement. The study suggest that target costing was a more direct approach to serve the interests of shareholders through value based management, as well as to product value for customers.	Empirical: mix (QQ)	Case-Study

Appendix A, Table 2: Value Engineering

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Agndal & Nilsson (2009) *MAR*	Target costing Value engineering Kaizen costing	Automotive industry	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: qualitative	Case-Study
Agndal & Nilsson (2010) *MAR*	Target costing Value engineering Kaizen costing	Automotive, retailer and telecom	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: qualitative	Case-Study
Al Chen et al. (1997) *IJA*	Target costing: cost estimation Value engineering	Manufacturing firms	See Appendix A, Table 1b: Target Costing: Early Costs Estimation.	Empirical: survey	None
Anderson & Dekker (2009) *AH*	Target costing Value engineering Kaizen costing	Not given	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Non-Empirical: Theoretical	None
Cooper & Slag-mulder (2004) *AOS*	Target costing Value engineering	Japanese manufacturing firms	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: qualitative	Case-Study
Cooper (1996) *MAR*	Target costing: cost estimation Kaizen costing Value engineering	Japanese manufacturing firms	See Appendix A, Table 1b: Target Costing: Early Costs Estimation: Target Costing: Early Costs Estimation.	Empirical: qualitative	Case-Study
Hopper et al. (1999) *ABR*	Target costing Value engineering Life-cycle costing	Japanese SMEs	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: qualitative	Case-Study
Lee & Monden (1996) *IJA*	Target costing Kaizen costing Value engineering	Automotive industry	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: qualitative	Case-Study
Tani et al. (1994) *MAR*	Value engineering	Manufacturing firms	The paper explores total cost management practices in Japanese firms. Cost reduction was the main purpose of these practices. Setting cost targets, value engineering, and cost tables for cost estimation are explicitly mentioned in the paper.	Empirical: survey	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Woods et al. (2012) *MAR*	Target costing: cost estimation Kaizen costing Value engineering Life-cycle costing	Electronic component industry	See Appendix A, Table 1b: Target Costing: Early Costs Estimation.	Empirical: mix (QQ)	Case-Study

Appendix A, Table 3: Quality Function Deployment

Author, date, journal	**Cost management method(s)**	**Industry**	**Summary (regarding the focal cost management method)**	**Type of data**	**Field work**
Burchill & Fine (1997) *MS*	QFD	Not given	The paper introduces a very detailed, structured decision process for product concept development, called “concept engineering”. It enhances the use of Quality Function Deployment (QFD). It has been tried out by a number of product development teams in different companies. This showed those teams placed more emphasis on time or market considerations compared to teams not applying the concept engineering method.	Empirical: mix (QQ)	Engineering, "how to"
Easton & Pullman (2001) *DS*	QFD	Not given	The number of different possible product and service configurations easily become far too many to evaluate during product development. The paper proposes a model to solve the NP-hard service design problem that integrates realistic service delivery cost models with conjoint analysis. The numerical simulation results suggest that the proposed method quickly and reliably identifies optimal or near-optimal service configurations, and significantly outperforms competing approaches. Following this model, managers can evaluate costs of just a few full configurations and find a near-optimal solution using nothing more than an electronic spreadsheet. This goes beyond the QFD technique that is used to capture the voice of the customer in product and process design decisions, but that does not specifically address costs or profitability.	Non-Empirical: Simulation	None
Griffin & Hauser (1992) *MS*	QFD	Automotive industry	The starting point for this study is that new product development can be more successful if there is greater communication among marketing, engineering, and manufacturing. QFD may facilitate this. The study was conducted in the automobile industry, comparing two teams that were similar in many ways, but only one team applied QFD. The data suggest that QFD enhanced communication within the core team (marketing, engineering, and manufacturing). Furthermore, the QFD team communicated less with external information sources and with management, but more on external topics, such as customer needs and market information.	Empirical: experimental	Case-Study
Karmarkar & Pitbladdo (1997) *MS*	QFD	Not given	This presents a formal economic framework for quality management that brings together quality concepts from marketing and manufacturing. Quality in manufacturing terms means conformance to specifications, while quality in marketing means meeting customer preferences. A product is characterised as a bundle of attributes. The firms manufacture and market several products that have a probability distribution on product attributes. The model is able to provide an integrated framework for many concepts from quality management, such as competition, process improvement, and QFD.	Non-Empirical: Analytical	None

Appendix A, Table 4: Functional Cost Analysis

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Mouritsen et al. (2001) *MAR*	Target costing Functional cost analysis	High-tech industry	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: mix (QQ)	Case-Study
Yoshikawa et al. (1995) *MAR*	Functional cost analysis	Manufacturing firm	The paper presents a case study of how a Japanese manufacturing company had adopted and modified FCA for their cost management. The results suggest that using FCA had provided several important benefits, such as higher cost consciousness and customer awareness, and reductions in the costs of products and overhead processes. However, FCA also limited innovation that would lead to greater functionality, increased costs, but also increased profits.	Empirical: mix (QQ)	Case-Study

Appendix A, Table 5: Kaizen Costing

Author, date, journal	Cost Management Method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Agndal & Nilsson (2009) *MAR*	Target costing Value engineering Kaizen costing	Automotive industry	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: qualitative	Case-Study
Agndal & Nilsson (2010) *MAR*	Target costing Value engineering Kaizen costing	Automotive, retailer and telecom	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: qualitative	Case-Study
Anderson & Dekker (2009) *AH*	Target costing Value engineering Kaizen costing	Not given	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Non-Empirical: Theoretical	None
Cooper & Slag-mulder (2003) *CM*	Target costing: cost estimation Kaizen costing	Not given	See Appendix A, Table 1b: Target Costing: Early Costs Estimation.	Non-Empirical: Theoretical	None
Cooper (1996) *MAR*	Target costing: cost estimation Kaizen costing Value engineering	Japanese manufacturing firms	See Appendix A, Table 1b: Target Costing: Early Costs Estimation.	Empirical: qualitative	Case-Study
Ezafe et al. (2004) *AOS*	Kaizen costing	Manufacturing	Kaizen was interpreted by workers in a manufacturing plan of a large multina-tional company as an initiative for intensifying labor and reducing head count.	Empirical: qualitative	Case-Study
Fayard et al. (2012) *AOS*	Kaizen costing Target costing	Multiple industries	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: survey	None
Lee & Monden (1996) *IJA*	Target costing Kaizen costing Value engineering	Automotive industry	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: qualitative	Case-Study
Monden & Hamada (1991) *JMAR*	Target costing: cost estimation Kaizen costing	Automotive industry	See Appendix A, Table 1b: Target Costing: Early Costs Estimation.	Non-Empirical: Theoretical	None

Author, date, journal	Cost Management Method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Shih (1998) *TAR*	Kaizen costing	Not given	The paper presents a general model about hierarchical goals. If it is difficult (easy) for subunits to achieve their goals, it is almost always more difficult (easier) for the unit to achieve the consolidated goal. This is applied to Kaizen costing: if each subunit's Kaizen goal is lower than the mean of its cost, the unit's chance of meeting its goal will be even lower than the subunit's chances of meeting their respective goals.	Non-Empirical: Analytical	None
Woods et al. (2012) *MAR*	Target costing: cost estimation Kaizen costing Value engineering Life-cycle costing	Electronic component industry	See Appendix A, Table 1b: Target Costing: Early Costs Estimation.	Empirical: mix (QQ)	Case-Study

Appendix A, Table 6: Life Cycle Costing

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Basu et al. (1997) *MS*	Life-cycle costing	Not given	The study investigates how representation of models using a graph theoretic structure, called a metagraph, can facilitate the construction and maintenance of model base views. The model is illustrated using an example from life cycle costing for passenger automobiles as an example. It does not address the use of LCC for cost-management purposes.	Non-Empirical: Analytical	None
Bjørnenak & Olson (1999) *MAR*	Life-cycle costing Target costing	Not given	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Non-Empirical: Theoretical	None
Cadez & Guilding (2008) *AOS*	Target costing Life-cycle costing	Multiple industries	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: mix (QQ)	None
Deegan (2008) *AAR*	Life-cycle costing	Electricity distribution industry.	The study highlights the many factors to be considered in a life-cycle costing exercise for environmental costing. Life-cycle costing of a product can help an organisation to discern future opportunities and threats associated with current purchase alternatives. The 'traditional' LCC approach fails to take account of future social and environmental implications, many of which are not quantified in monetary terms. The challenge for LCC is include a number of costs that are difficult to quantify in financial terms (such as cost associated with climate-change mitigation efforts).	Empirical: mix (QQ)	Case-Study
Dunk (2004) *MAR*	Life-cycle costing	Manufacturing firms	The study investigates which factors affect the use of life cycle cost analysis within firms. It is found that Customer profiling, Competitive advantage, and Quality of information system information are antecedents of the use of product life cycle costing in organisations. These results suggest that organisations find life cycle analysis important in responding to specific customer requirements as well as in seeking competitive advantage, and facilitated by improved information-system quality.	Empirical: survey	None
Guilding et al. (2000) *MAR*	Target costing Life-cycle costing	Large companies in multiple industries	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: survey	None
Gutschelhofer & Roberts (1997) *IJA*	Life-cycle costing	Not given	The paper compares Anglo-Saxon and German approaches to life-cycle costing. The German method of multiple-step fixed cost accounting is considered the closest equivalent to life-cycle costing. German cost accounting provides a new design for life-cycle cost accounting with practical relevance in the area of	Non-Empirical: Theoretical	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			marketing cost management.		
Hopper et al. (1999) *ABR*	Target costing Value engineering Life-cycle costing	Japanese SMEs	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: qualitative	Case-Study
Hyvönen (2003) *EAR*	Target costing Life-cycle costing	High-tech industry	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Empirical: survey	None
Jackson et al. (1999) *DS*	Life-cycle costing	Waste site remediation	The paper presents a decision support tool which assists the decision maker to find an optimal portfolio of technologies for a waste site remediation project. Life cycle costs of the entire remediation project are one of the criteria in the model.	Non-Empirical: Theoretical	None
Krishnan et al. (2000) *MS*	Life-cycle costing	Software development	This study focusses on life cycle costs of software, which include both development costs and support costs. Life-cycle productivity of a product was defined as the ratio of product size (i.e., lines of code of the software) and total life-cycle costs. The study investigated the relationship between this life-cycle productivity and conformance quality in software products. Results provide evidence for significant increases in life-cycle productivity from improved quality in software products shipped to the customers. Higher quality is associated with deployment of resources in initial stages of product development and improvements in software development processes.	Empirical: archival	None
Parker (2000) *AAR*	Life-cycle costing	Corporate sector	This paper focusses on environmental strategies and their related costs. Published corporate examples are reviewed, and life cycle costing is recommended for the initial development of environmental costing practices at the corporate level. Hence, for the identification, measurement, analysis and reporting of environmental cost. Life-cycle costing, this may facilitate the development of more efficient and environmentally friendly product designs.	Non-Empirical: Theoretical	None
Ramdas & Sawhney (2001) *MS*	Life-cycle costing	Manufacturing (wristwatches)	The introduction of new product variants has cost and revenue implications. This study presents an optimisation model, an actual application of the model, and further results from a simulation study.	Empirical: mix (QQ)	Engineering, "how to"
Woods et al. (2012) *MAR*	Target costing: cost estimation Kaizen costing Value engineering Life-cycle costing	Electronic component industry	See Appendix A, Table 1b: Target Costing: Early Costs Estimation.	Empirical: mix (QQ)	Case-Study

Appendix A, Table 6: Life Cycle Costing

Appendix A, Table 7: Total Cost of Ownership

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Arping & Lóránth (2006) *JB*	TCO	Not given	Total cost of ownership in this study concerns the costs of customers who buy assets (e.g., equipment, software) that require ongoing services, supplies, maintenance, upgrades, etc., and whose costs drastically increase if the supplier would go out of business. The supplier firm can address this concern for total cost of ownership by reducing financial leverage (which reduces the risk of going out of business) or by reducing product differentiation (so the customer could more easily get the services, suppliers, etc., from another supplier). The paper presents a model about this interplay between leverage and product differentiation, and it offers an alternative explanation for the often observed negative correlation between financial leverage and product uniqueness.	Non-Empirical: Analytical	None
Caglio & Ditillo (2008) *AOS*	TCO Target costing	Not given	See Appendix A, Table 1a: Target Costing: Setting the Cost Target.	Non-Empirical: Theoretical	None
Degraeve & Roodhooft (2000) *JBFA*	TCO	Printing company	The paper proposes a mathematical-programming model that uses activity-based costing information to select suppliers for several orders over a specific time horizon. TCO is seen as the application of activity-based costing to purchasing decisions, such as about suppliers. The objective function in mathematical-programming model is the total cost of ownership associated with de purchasing decision. The application of the model is demonstrated in a case study of a printing company.	Empirical: archival	Engineering, "how to"
Degraeve et al. (2005) *ABR*	TCO	Telecom-munications firm	Building on Degraeve and Roodhooft (2000), the paper presents a TCO-based supplier selection methodology based on activity-based costing data and mathematical programming. This applied to a case of a telecommunications company buying electronic components. The results for three cases indicate possible savings of between 6% and 14% of the total cost of ownership of the current purchasing policy.	Empirical: archival	Engineering, "how to"
Van den Abbeele et al. (2009) *AOS*	TCO	Not given	The study investigates the influence of total cost of ownership (TCO) information on buyer–supplier negotiations in different power settings. TCO provide decision-makers with an objective and easily understood argument to support purchasing decisions. In an experiment, less powerful buyers that had TCO information used problem solving techniques (to quantify all relevant costs) more frequently than powerful buyers, and powerful buyers tended to rely on negotiation techniques. TCO information reduced the performance disadvantage of less powerful buyers.	Empirical: experimental	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Wouters et al. (2005) *AOS*	TCO	Multiple industries	This study investigated which factors explain the successful adoption of TCO for sourcing decisions, such as reflected in the adequacy of TCO information, the success of TCO initiatives, and the use of TCO as the basis for performance review and reward. Antecedents of these were value analysis experience, top management support and functional (non-accounting) commitment to improved cost information, and a strategic purchasing orientation.	Empirical: survey	None

Appendix A, Table 8: Stage-Gate Reviews, and Funnels

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Davila et al. (2009) *EAR*	Stage-gate reviews	Not given	Literature review of management control systems in innovative settings (R&D, entrepreneurship). Gates are management meetings at the end of each stage in the product development process where progress is compared to the plan and the plan is adjusted in light of new information, citing Cooper (1990).	Non-Empirical: Theoretical	None
Ding & Eliash-berg (2002) *MS*	Funnels	Pharmaceutical Industry	The study focusses on R&D budgets, in a setting when multiple approaches may be taken to develop a product and there is uncertainty which approach will be successful. The goal is to develop one successful product. The question is how many development approaches to invest in (called "the pipeline"). The model is based on option trees, and optimal structure of the pipeline is driven by the cost per development approach, its probability of survival, and the expected profitability. Examples from the pharmaceutical industry are used to demonstrate the implementability of the model.	Empirical: observations	Engineering, "how to"
Hertenstein & Platt (2000) *AH*	Stage-gate reviews	Manufacturing	Descriptive findings from interviews, an expert panel workshop, and a survey highlight the key roles of stage-gate processes and performance measures for managing product development.	Empirical: mix (QQ)	Case-Study
Jørgensen & Messner (2009) *JMAR*	Stage-gate reviews Modular design	Manufacturing	Enabling formalisation in product development was achieved through the stage-gate model, which allowed for a separation in time between activities that needed more flexibility and those that were in need of more efficiency. Thus, the stage-gate process structured the relationship between tasks and provided the basis for more specific definitions of what is expected in the different stages. Engineers and managers used the same tools (budgets, profitability calculation tools) to achieve internal transparency regarding their local practice. Modularity was more problematic, because the calculation models could not capture the costs and benefits of modularity.	Empirical: qualitative	Case-Study
Jørgensen & Messner (2010) *AOS*	Stage-gate reviews Modular design	Manufacturing	Building on Jørgensen & Messner (2009), however, the limitations of the calculation models were not too problematic, because managers could intuitively combine financial and nonfinancial considerations, they could refine their understanding about the consequences of modularity over time, and the limitations of the model left room in the discussions for managers to express different ideas.	Empirical: qualitative	Case-Study

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Nagji & Tuff (2012) *HBR*	Stage-gate reviews	Not given	The paper addresses the question of how to manage an innovation portfolio. It identifies five areas to organise and manage the total innovation system: 1. talent, 2. integration, 3. funding, 4. pipeline management (stage-gates), and 5. metrics (stage-gates). Stage-gate processes evaluate projects periodically, recalculate their projected ROI according to any changed conditions, and decide whether they should get a green light. The study suggests that stage-gate processes are lethal to transformational innovation, because it rejects promising options before they are properly explored.	Non-Empirical: Theoretical	None
Song et al. (2009) *DS*	Stage-gate reviews	Service sector	The paper investigates a model for the innovation process of services. The model draws on the stage-gate processes that is underlie many new product development processes, but it also includes modifications for service innovation. The empirical results support the model.	Empirical: survey	None

Appendix A, Table 9: Design for…

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Bajaj et al. (2004) *MS*	DFM/A	Avionics guidance systems manufacturer	The study focus on three aspects of management of product development: (i) degree of specialisation input in design, (ii) the degree of oversight by the project management in the design phase and (iii) the intensity of customer interaction during design, and their effect on lead time and costs during the design phase and the manufacturing phase of projects. The hypotheses are based on the notion of DFM that up-front investment in design pays of in the subsequent manufacturing phase, both in terms of time and money. The findings provide partial empirical support for the hypotheses.	Empirical: archival	Case-Study
Datar et al. (1997) *MS*	DFM/A	Electronic component manufacturers	The study investigates which product development structure (concentrated or distributed) provides shorter time to prototype and shorter time to volume production. One of the hypotheses concerned the relationship between prototyping time and the "time to volume production", which was supported. This is based on the DFM idea that careful prototype development reduces potential difficulties at the manufacturing stage.	Empirical: archival	None
Ettlie (1995) *MS*	DFM/A	U.S. firms (mostly machinery)	The study investigates the relationship between integrated product-process development approaches and organisational success. DFM training was one of the three practices to measure the use of such integrated approaches.	Empirical: survey	None
Fuchs & Kirchain (2010) *MS*	Design for X DFM/A	Optoelectronic component manufacturers	The paper uses a combination of simulation modeling and empirical data to quantify the tradeoffs for optoelectronic manufacturers in deciding whether to move manufacturing offshore. It is related to the literature on DFX and DFM in the sense that the “X” can represent a variety of matters that can be considered during development to manage costs of products—here: manufacturing location.	Empirical: mix (QQ)	Case-Study
Hansen (2010) *MAR*	DFM/A	High-Technology industry	This research focusses on externalities caused by nonfinancial performance measures. Externalities means that improved performance of one task negatively or positively affects the performance of other tasks. The introduction of performance measures may create externalities. Some of the newly introduced performance measures in the two cases concerned the progress of DFM initiatives, measured as the reduction of components on printed circuit boards and the reduction of products parts. These DFM measures involved several negative externalities in both companies.	Empirical: mix (QQ)	Case-Study

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Jayaram & Malhotra (2010) *DS*	DFM/A	Multiple industries	The study investigates effects of concurrency on product development project performance. Concurrency is a systematic approach to new product development projects, involving integrated design of products and their related manufacturing and support processes. DFM as an integrated design tool was used in the survey as one of the practices measuring the implementation of product concurrency.	Empirical: survey	None
Ulrich & Pearson (1998) *MS*	DFM/A	Manufacturing, coffee makers	Based on in-depth analysis of a specific product category (coffee makers), this study assesses the impact of design on determining product costs.	Empirical: observations	None
Ulrich et al. (1993) *MS*	DFM/A	Manufacturing (application to Polaroid cameras)	The study extends the notion of DFM to also incorporate the trade-off between lower unit costs and longer product development lead time. An application of the method to Polaroid cameras supported the conventional rational for DFM methodologies: extra effort in product development to achieve parts integration reduced unit costs. However, when this would also lead to a longer development lead time the revenue implications made this, on balance, a negative scenario.	Empirical: mix (QQ)	Engineering, "how to"

Appendix A, Table 10: Component Commonality

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Akçay & Xu (2004) *MS*	Component com.	Not given	To fully utilize the benefits of component commonality for lower inventory, replenishment and allocation decisions need to be considered simultaneously	Non-Empirical: Simulation	None
Benton & Krajewski (1990) *DS*	Component com.	Not given	The effects of poor vendor quality and vendor lead time uncertainty on inventories and backlogs (late deliveries to customers) depends on the degree of component commonality. The study does not directly address the use of component commonality for cost management during product development.	Non-Empirical: Simulation	None
Bernstein et al. (2011) *MS*	Component com.	Not given	Common components enable the allocation of limited availability to the most profitable products and customers (in an assembly to order context).	Non-Empirical: Simulation	None
Davila & Wouters (2004) *AH*	*	Medical devices and computer hardware	See Appendix A, Table 1b: Target Costing: Early Costs Estimation. *Cost management methods: Product platform Modular design Component commonality Target costing: cost estimation	Empirical: qualitative	Case-Study
Desai et al. (2001) *MS*	Component com.	Not given	Commonality involves a marketing-manufacturing trade-off: it may lower manufacturing costs but limit premium pricing through product differentiation. The importance and cost of a component determine the suitability of making the component common.	Non-Empirical: Analytical	None
Fisher et al. (1999) *MS*	Product platform Component com.	Automotive industry	Commonality of components that are not contributing to product differentiation from the customer's perspective can be determined based on cost tradeoffs (design, production, and logistics). A model of such tradeoffs was able to explain variety in product commonality for automotive braking systems.	Empirical: observations	None
Hu et al. (2013) *MS*	Component com.	Not given	When several buyers use a common critical component, they can have benefits when they buy this jointly.	Non-Empirical: Analytical	None
Krishnan & Gupta (2001) *MS*	Product platform Component com.	Manufacturing (application to computer manufacturing)	Commonality of components may save development costs but also increase the variable cost per unit due to overdesign, or lead to loss of quality due to underdesign. Platforms are not appropriate for extreme levels of market diversity or high levels of non-platform scale economies.	Non-Empirical: Simulation	None
Song (2002) *MS*	Component com.	Not given	What is the impact of introducing common components on inventory and service trade-offs? The paper contributes to the mathematical modeling of this question. The study does not directly address the use of commonality for cost management.	Non-Empirical: Analytical	None

Author, date, journal	**Cost management method(s)**	**Industry**	**Summary (regarding the focal cost management method)**	**Type of data**	**Field work**
Steele et al. (1995) *DS*	Component com.	Not given	This research compares material requirements planning (MRP), Kanban, and period batch control (PBC) as alternative approaches to the planning and control of multi-cell manufacturing. Component commonality does not appear to be critical for this comparison. The paper does not address cost management.	Non-Empirical: Simulation	None
Swaminathan & Tayur (1998) *MS*	Component com.	Manufacturing (application to computer manufacturing)	Common components reduce inventory, because they allow building semi-finished products that can be completed to fulfill demand for multiple end products.	Non-Empirical: Simulation	None
Van Mieghem (2004) *MS*	Component com.	Not given	The paper contributes to the mathematical modeling of conditions under when component commonality is appropriate. Cost tradeoffs are modeled at an abstract level.	Non-Empirical: Analytical	None
Xiao et al. (2007) *DS*	Component com.	Not given	Manufacturers that produce partially substitutable products and make production and outsourcing decisions can play a strategic game with quantity competition. The study does not directly address the use of component commonality for cost management.	Non-Empirical: Simulation	None
Xu & Li (2007) *MS*	Component com.	Manufacturing	Common components reduce inventory and may reduce obsolescence costs when technology changes.	Non-Empirical: Simulation	None

Appendix A, Table 11: Modular Design

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Baldwin & Clark (1997) *HBR*	Modular design	Multiple industries	Practical examples of modularity application are presented, that demonstrate that modularity enhances flexibility and manufacturing performance.	Empirical: qualitative	Management practice
Davila & Wouters (2004) *AH*	*	Medical devices and computer hardware	See Appendix A, Table 1b: Target Costing: Early Costs Estimation. *Cost management methods: Product platform Modular design Component commonality Target costing: cost estimation	Empirical: qualitative	Case-Study
Ethiraj & Levin-thal (2004) *MS*	Modular design	Not specified	Model to determine the optimal extent of modularisation. Modularisation involves a tradeoff: more modularisation increases technological innovation per module, but it becomes more problematic that implications outside a module are neglected. The analysis highlights an asymmetry in this tradeoff. Costs are not explicitly modelled, but a more abstract "performance" outcome is included in the model. Does not directly address cost management issues in modularity.	Non-Empirical: Simulation	None
Ethiraj & Levin-thal (2004) *ASQ*	Modular design	Not specified	Extends the idea of Ethiraj and Levinthal (2004) to organisational adaptation.	Non-Empirical: Simulation	None
Ethiraj et al. (2008) *MS*	Modular design	Not specified	Extends the idea of Ethiraj and Levinthal (2004) to also consider the effects of modularity on imitation. Does not directly address cost management issues in modularity.	Non-Empirical: Simulation	None
Feitzinger Lee (1997) *HBR*	Modular design	Computers (Hewlett-Packard)	Modularity of product design and of process design enabled HP to efficiently offer mass-customised products. Cost savings were, for example, related to inventory and to transportation.	Empirical: qualitative	Management practice
Gamba & Fusari (2009) *MS*	Modular design	Not specified	The paper presents a valuation of the six aspects of product modularity as proposed by Baldwin & Clark, using a real options valuation model and Monte Carlo simulation. The model is proposed for valuation of alternative designs that use modularity.	Non-Empirical: Simulation	None
Granlund & Taipaleenmäki (2005) *MAR*	Modular design	New economy firms (information & comunication technology, life sciences)	Exploratory study to analyze and explain the current status of management control developments in these firms. Modularity was one of the aspects in the study. The need for short time-to-market caused a shift to technology platforms and modularity orientation, which led to problems also in management accounting. Cost and profitability per unit became less important, shifting to technology or solution based product lines and to business units.	Empirical: mix (QQ)	Case-Study

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Hoetker et al. (2007) *MS*	Modular design	Automotive industry	The relationship between of three aspects of buyer-supplier relationships (namely relationship duration, autonomy, and customer status) and supplier survival is different for low- and high-modularity components. The study does not address the use of modularity for cost-management purposes.	Empirical: archival	None
Jørgensen & Messner (2009) *JMAR*	Stage-gate reviews Modular design	Manufacturing	See Appendix A, Table 8: Stage-Gate Reviews, and Funnels.	Empirical: qualitative	Case-Study
Jørgensen & Messner (2010) *AOS*	Stage-gate reviews Modular design	Manufacturing	See Appendix A, Table 8: Stage-Gate Reviews, and Funnels.	Empirical: qualitative	Case-Study
Krishnan & Ramachandran (2011) *MS*	Modular design	Not given	A model to identify and formulate the notion of design consistency. Does not address modularity for cost-management during product development.	Non-Empirical: Analytical	None
Lee & Tang (1997) *MS*	Modular design	Not given	A model that captures the costs and benefits associated with delaying the point of product differentiation through standardisation, modular design, and process restructuring.	Non-Empirical: Analytical	None
Ramdas & Randall (2008) *MS*	Product platform Modular design	Automotive industry	Empirical study on the impact of component sharing, modularity, and product platforms on product reliability. Study does not address cost management during product development.	Empirical: archival	None
Sosa et al. (2004) *MS*	Modular design	Manufacturing	Modularity increases the need for teams to interact to address the interfaces between modules. This paper looks at the alignment between interfaces and interactions. Does not directly address cost management issues in modularity.	Empirical: mix (QQ)	Case-Study
Tan (2001) *DS*	Modular design	Manufacturing, wholesalers, retailers, services	Empirical study on the effects of supplier assessment, just-in-time, and quality management on new product design and development. One result is that shorter development lead-times lead to the adoption of modularity. Does not address the use of modularity for cost management in product development.	Empirical: survey	None
Terjesen et al. (2012) *DS*	Modular design	Manufacturing firms	Empirical investigation of the relationship between firms' supply chain integration (SCI) with suppliers, buyers, and customers and their operational performance, and the role of modularity in this relationship. Study does not address the use of modularity for cost management in product development.	Empirical: survey	None
Tu et al. (2004) *DS*	Modular design	Manufacturing firms	Empirical study of the relationship between modularity-based manufacturing practices (MBMP) and firms' mass customisation capability. Study does not	Empirical: survey	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			address the use of modularity for cost management in product development.		
Ülku et al. (2012) *MS*	Modular design	Technological products	Empirical study of how consumers respond to modular products. Purchasing decisions involved, first, a choice between a modularly upgradeable product and an integral one, and second upgrade decision (replacement of a module versus full product replacement).	Empirical: experimental	None
Voss & Hsuan (2009) *DS*	Product platform Modular design	Services	Discussion of similarities between product systems and service systems. Offers the concept of a service platform and the service modularity function (SMF).	Non-Empirical: Theoretical	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Davila & Wouters (2004) *AH*	*	Medical devices and computer hardware	See Appendix A, Table 1b: Target Costing: Early Costs Estimation. *Cost management methods: Product platform Modular design Component commonality Target costing: cost estimation	Empirical: qualitative	Case-Study
Davis & Eisen-hardt (2011) *ASQ*	Product platform	Global compu-ting and communications industry	The study examines why some interorganisational collaborations product techno-logical innovations and others not. Product platforms were used to measure the collaborative innovation performance. This study does not address platforms for cost management in product development.	Empirical: qualitative	Case-Study
Fisher et al. (1999) *MS*	Product platform Component com.	Automotive industry	See Appendix A, Table 10: Component Commonality.	Empirical: observations	None
Kim & Mauborg-ne (1997) *HBR*	Product platform	Multiple industries	Value innovation means that a company creates products or services for which there are not direct competitors. Companies most successfully doing this took advantage of three platforms on which innovation can take place: product, service, and delivery.	Empirical: qualitative	Management practice
Krishnan & Gupta (2001) *MS*	Product platform Component com.	Manufacturing (application to computer manufacturing)	See Appendix A, Table 10: Component Commonality.	Non-Empirical: Simulation	None
Krishnan & Ulrich (2001) *MS*	Product platform	Not given	A literature review on product development decisions. Platforms are considered under "product strategy and planning".	Non-Empirical: Theoretical	None
Meyer et al. (1997) *MS*	Product platform	Manufacturing (application to measurement systems manu-facturer)	The study proposes metrics for measuring R&D performance focused on plat-forms and their follow-on products within a product family.	Empirical: archival	Engineering, "how to"
Ramdas & Randall (2008) *MS*	Product platform Modular design	Automotive industry	See Appendix A, Table 11: Modular Design.	Empirical: archival	None
Voss & Hsuan (2009) *DS*	Product platform Modular design	Services	See Appendix A, Table 11: Modular Design.	Non-Empirical: Theoretical	None

Appendix A, Table 13: Technology Roadmaps

Author, date, journal	**Cost management method(s)**	**Industry**	**Summary (regarding the focal cost management method)**	**Type of data**	**Field work**
Alkaraan & Northcott (2006) *BAR*	Technology road-maps	Manufacturing	The study investigated the use of technology roadmapping and four other analysis tools by UK manufacturing firms to support capital investment decision-making, based on a survey and follow-up interviews. Roadmapping was not used widely by the firms in the sample.	Empirical: mix (QQ)	None
Erat & Kavadias (2006) *MS*	Technology road-maps	Not given	The study considers the setting in which technology providers sequentially introduce technology to industrial customers. The study develops a game-theoretic model that explores the determinants of the technology provider's introduction decisions. The presence of a roadmap benefits the technology provider because it increase control over the diffusion process.	Non-Empirical: Analytical	None
Jordan et al. (2013) *MAR*	Technology road-maps	Oil and gas industry	The paper describes the application of "risk maps" as a variation of technology road maps in building project in the Norwegian oil and gas industry. Many different parties with different interests were involved in the project. Risk maps enabled different actors to represent and negotiate their interests and concerns.	Empirical: mix (QQ)	Case-Study
Miller & O'Leary (2007) *AOS*	Technology road-maps	Semiconductor industry	The study investigates the semiconductor industry, as a prime example of an economic context of very large R&D investments that are by many different parties under great uncertainty, which creates the need for coordination. Technology roadmaps are used as a "mediating instrument" that supports these investment decisions. Specifically, technology roadmaps have been used to translate Moore's Law into targets and timelines that guide firms' R&D planning and investment processes.	Empirical: mix (QQ)	Case-Study
Miller et al. (2008) *AOS*	Technology road-maps	Semiconductor industry, and healthcare	The paper studies accounting in the context of hybrid organisations, such as joint ventures, license agreements, and supplier arrangements. The study does not only study organisational forms, but also looks at hybrid practices, processes and expertise. These enable the flow of lateral information and cooperation across the boundaries of organisations, firms and groups of experts or professionals. Accounting also plays a role in this. Building on Miller and O'Leary (2007) the paper compares the semiconductor industry with healthcare to develop a further understanding of accounting and hybrid organisations.	Empirical: mix (QQ)	Case-Study

Appendix B

Appendix B, Table 1: Results for Target Costing

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Afonso et al., 2008) IJPE	Target costing	Manufacturing	This paper investigated the influence of TC and Time-to-Market (TtM) on NPD success. It is based on 82 responses to a survey among Portuguese manufacturing SMEs. TC was not always related to NPD success. Only firms which applied TC on a product level seemed to have a significant advantage, unlike the firms which used TC on a component level. Another finding was even when TC and TtM both had a positive impact on NPD success, they did not significantly correlate with each other.	Empirical: Survey	None
(Albright & Kappel, 2003) RTM	Target costing Technology roadmaps	Telecommunication industry (Lucent Technologies)	See Appendix B, Table 15: Results for Technology Roadmap.	Empirical: mix	Management practice
(Onofrei, Hunt, Siemienczuk, Touchette, & Middleton, 2004) MIT SMR	Target costing	Diverse	The intention of the paper is to give managers a road map for implementing TC systems. An in-depth case study among seven big Japanese companies was conducted.	Empirical: Qualitative	Management practice
(R. Cooper & Slagmulder, 2004) MIT SMR	Target costing Kaizen Costing	Technology & Telecommunication	The paper focused on how Olympus Optical Co. Ltd achieves sustainable cost reductions through the complete life cycle of their products. Therefore the authors made in-depth observations at the consumer-products division of Olympus Optical focusing on the new Stylus Zoom camera. TC and Kaizen Costing (general and product specific) were three of five methods observed. One conclusion is that considering multiple costing methods will be more beneficial in most cases than focusing on just one.	Empirical: Qualitative	Management practice
(R. Cooper & Yoshikawab, 1994) IJPE	Target costing Value engineering	Automotive	Interviews with managers and engineers ware conducted to investigate the inter-organisational cost management system of three companies in one supply chain in the automotive industry. Results show that TC in combination with value engineering can be used to spread the competitive pressure and pass on consumers' demands along the value chain.	Empirical: Qualitative	Case study

Appendix B, Table 1: Results for Target Costing

Author, date, journal	**Cost management method(s)**	**Industry**	**Summary (regarding the focal cost management method)**	**Type of data**	**Field work**
(Everaert & Bruggeman, 2002) IJOPM	Target costing	Consumer Goods	Considering cost targets and time pressure, this paper examines their impact on NPD. Experiments are used to simulate a real design process. The interaction of cost targets and time pressure indicates that the use of cost targets is not always beneficial. Cost targets are helpful when no time pressure is given, so they can direct to cost improvements without adverse impact on design quality. On the other hand, if time pressure exists, cost targets may even lead to an increase in development time without achieving a reduction in costs.	Empirical: Experimental	None
(Filomena et al., 2009) IJPE	Target costing	Automotive	The paper describes an experience with developing early-stage cost parameters for a specific product development process effort at a mid-sized Brazilian manufacturing company. A model for the application of TC is proposed and applied, which should help operationalizing the method during NPD. TC is split in four stages. In stage 1 the product is divided into parts, features and common elements. Stage 2 focuses on the unitary target PD costs, which are the target cost per unit product related to the costs incurred to develop a product. The objective of stage 3 is the actual product target cost. Stage 4 defines "Insertion Target Costs," "Insertion Target Cost Breakdown into Parts," and "Insertion Target Cost Breakdown into Features,"	Empirical: Observations	Engineering, "how to"
(M. Hoque et al., 2005) IJPR	Target costing QFD	Technology & Telecommunication	To encourage concurrent engineering, this paper presents a model that represents a simple solution for the integration of different functions and departments within an organisation. It is applied in a fictional case of a cellular phone development. The authors integrate the methods QFD and TC in their approach in order to consider customer needs (QFD) and develop an economically feasible product (TC).	Non-empirical: Analytical	None
(Ibusuki & Kaminski, 2007) IJPE	Target costing Value engineering QFD	Automotive	This research proposes a method for the product development process in an automotive company. It is tried out in a case study: the development of a pneumatic engine-starter. VE is split in three steps: "Concept VE," "Project VE" and "Validation VE." Within this framework, QFD and TC are applied to integrate customer desires and financial aspects in the design process. For the purpose of reducing costs, other methods like DFM or modular design are briefly discussed.	Empirical: Observations	Engineering, "how to"

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Kee, 2010) IJPE	Target costing	Not specified	The paper argues that the lack of cost of capital in most TC approaches can lead to wrong decisions during the design stage of a product. A numerical example demonstrates that a traditional TC model can lead to accepting products that have a negative net present value, while rejecting products that have a positive net present value.	Non-empirical: Simulation	None
(Li et al., 2012) IJPE	Target costing	Not specified	Two different approaches of target pricing (demand-side and supply-side) are analysed in the paper. Using a general oligopoly and Cournot duopoly model, the authors characterize the equilibrium and optimal policy for each approach under various conditions. They find that sharing cost-reduction expenses allows the manufacturer using the supply-side approach to attain competitive advantage in the form of increased market share and higher profit, particularly in industrial conditions where margins are thin and price sensitivities are high.	Non-empirical: Simulation	None
(Liker et al., 1996) ResPol	Target costing Value engineering	Automotive component suppliers (Japan, U.S.)	Based on a survey, this paper investigates the differences in supplier design involvement between Japanese and U.S. component suppliers and their largest customers. Value engineering was used much by subsystem suppliers in both countries, yet even more in Japan (92% and 70% of U.S. subsystem suppliers). In both countries, value engineering was more widespread among subsystem suppliers than among lower-tier suppliers. Value engineering resulted in financial advantages, as subsystem suppliers reported an average of 17% cost savings in Japan and 15% in the United States. Target pricing was common for almost all Japanese subsystem suppliers and also substantial for their U.S. counterparts.	Empirical: Survey	None
(Petersen et al., 2003) JPIM	Target costing	Multiple industries	This paper develops a model to assess supplier integration into NPD to identify critical activities for successful integration. Sharing information on technology and costs was positively associated with supplier involvement in decision-making and with project outcomes. Even though not particularly in focus, TC objectives motivated buyers and suppliers to jointly work on alternative technical solutions.	Empirical: Survey	None
(Plank & Ferrin, 2002) IMM	Target costing TCO	Mainly manufacturing industries	By conducting an exploratory survey among purchasing agents, this paper discusses the use and application of different methods and ways in which industrial companies value purchase offerings. Total cost of ownership was frequently used, especially among manufactured parts, yet respondents saw	Empirical: Survey	None

Appendix B, Table 1: Results for Target Costing

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			potential for further development. They viewed their firms' capability to effectively identify cost drivers for total cost of ownership purchase offering valuation only to be mediocre on average. The use of varying cost drivers for different kinds of offerings was medium. Target pricing was used in half the purchases reported.		
(Rabino, 2001) JETM	Target costing Value engineering Kaizen costing	Multiple industries	Based on a survey among managers affiliated with NPD teams, this paper examines if NPD teams wanted to employ American and Japanese accounting information and if accountants were increasingly considered in cross-functional NPD teams. Japanese accounting practices employed methods such as kaizen costing, TC and value engineering. Activity-based costing (ABC) is presented as a typical American accounting method. The outcome suggests that both Japanese and American methods were increasingly asked for. Remarkably, accounting was consistently ranked as the least important functional team member and accountants were part of only 34% of the respondents' teams.	Empirical: Survey	None
(Ro et al., 2007) IEEE-EM	Target costing Modular design	Automotive original equipment manufacturers (OEMs) and suppliers (U.S.)	The purpose of this paper is to better understand the process and consequences of moving towards modularity as part of a mass customisation strategy, using automotive as a case example. Modularity had considerable effects on product development, outsourcing, and supply chain coordination. The ineffective implementation of target pricing was seen as an impediment towards modularity among U.S. suppliers, and more generally, suppliers felt that their additional cost incurred through modularity were not sufficiently reflected in the OEMs' cost assessments. U.S. automotive companies seemed to outsource modules to suppliers for cost reduction purposes, rather than to satisfy customers.	Empirical: Qualitative	Management practice
(Yazdifar & Askarany, 2012) IJPE	Target costing	Manufacturing	This paper researches the adoption and implementation of TC. A survey among selected members of the Chartered Institute of Management Accountants (CIMA) was conducted. The 584 responses identify the "ability to get the job/service done quicker"(p. 390) and "being able to try the technique before deciding to implement it (or not)"(p. 390) as the main attributes for implementing TC.	Empirical: Survey	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Zengin & Ada, 2010) IJPR	Target costing Value engineering QFD Kaizen costing	Manufacturing	The study investigates an implementation of TC combined with QFD analysis and value engineering in a small manufacturing company, and it develops a TC module that will encourage its use in SMEs. Additionally, Kaizen costing is introduced as a tool for continuous improvement after the actual NPD process. The company was able to significantly reduce its cost without sacrificing quality and functionality. Other results are that the introduced QFD-TC process is very reliant on cross functional integration and that QFD-TC can be a suitable solution for SMEs to manage their NPD process.	Empirical: Observations	Case study

Appendix B, Table 2: Results for value engineering

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Chung, Syachrani, Jeong, & Kwak, 2009) IEEE-EM	Value engineering	Construction industry	This paper presents a process simulation VE model. It attemptes to quantify experts' estimations on cost and time savings of different alternatives while at the same time aiming at minimising the level of subjectivity involved. The monetary value of different functions is compared to the estimated actual cost. This enables the engineers to make effective decisions for different design alternatives. In an empirical case study on one specific construction activity of a hospital building project, the different phases of the model are explained and demonstrated in detail. Also when considering the implementation cost, the execution of the model achieved cost savings. The authors estimate that applying the model generates a return on investment between 1200-2200%.	Empirical: Archival	Engineering, "how to"
(R. Cooper & Yoshikawab, 1994) IJPE	Target costing Value engineering	Automotive	See Appendix B, Table 1: Results for Target Costing.	Empirical: Qualitative	Case study
(Ibusuki & Kaminski, 2007) IJPE	Target costing Value engineering QFD	Automotive	See Appendix B, Table 1: Results for Target Costing.	Empirical: Observations	Engineering, "how to"
(Liker et al., 1996) ResPol	Target costing Value engineering	Automotive component suppli-ers (Japan, U.S.)	See Appendix B, Table 1: Results for Target Costing.	Empirical: Survey	None
(Loch, Stein, & Terwiesch, 1996) JPIM	Value engineering DFM/A Design for X	Electronics indus-try	This paper presents a model to measure NPD output performance as the driver of business success and applies it to a sample of 95 companies within the electronics industry. Various antecedent and consequential relationships between variables describing the development process (e.g., DFM, VE), their outputs (e.g., design-to-cost) and business success are established, often with reference to specific branches within the electronics industry. On this basis, particularities of the different electronics branches are determined, and mana-gerial implications are derived.	Empirical: Survey	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Martínez Sánchez & Pérez, 2003) JPIM	Value engineering DFM/A	Automotive suppliers (Spain)	This article shows the results of a survey of 63 Spanish automotive suppliers to test the moderation effect of cooperation in the relationship between the use of NPD firm practices and the company's NPD time and cost minimisation abilities. The application of NPD practices was found to be more widespread among high-cooperation companies, allowing them to be better able to reduce NPD time and cost. The results suggest that cross-functional design (including value analysis) and the design-manufacturing interface (including DFM) are explanatory factors for this perceived time and cost minimisation ability. The posited moderation effect of cooperation was supported.	Empirical: Survey	None
(Rabino, 2001) JETM	Target costing Value engineering Kaizen costing	Multiple industries	See Appendix B, Table 1: Results for Target Costing.	Empirical: Survey	None
(Romano, Formentini, Bandera, & Tomasella, 2010) IJPR	Value engineering	Cruise ship build-ing	The authors developed and implemented in an Italian company an original decision support tool, based on value analysis, which designers can use to document and formalize their choices. This tool helped to cuts costs and supported the selection of the most valuable solution by means of objective parameters.	Empirical: mix	Engineering, "how to"
(H. S. Wang & Che, 2008) IJPR	Value engineering	Technology & Telecommunication	This paper focusses on the problems that come along with changing parts of a product. To overcome these problems during the redesign of a product, a theoretical model is proposed and supported by an illustrative example. VE is part of the second step in the model (out of three). It is shown how the method can be used for the evaluation of suppliers.	Non-empirical: Simulation	None
(Takeo Yoshikawa, Innes, & Mitchell, 1994) IJPE	Functional cost analysis Value engineering	Manufacturing	This paper explores the nature and impact of functional cost analysis as it is used in VE. Based on numerical examples, a guideline for the application of FCA in different manufacturing areas is given. It is concluded that FCA is not just limited to physical products but it is also applicable to overhead services and business processes.	Non-empirical: Simulation	None
(Zengin & Ada, 2010) IJPR	Target costing Value engineering QFD Kaizen costing	Manufacturing	See Appendix B, Table 1: Results for Target Costing.	Empirical: Observations	Case study

Appendix B, Table 3: Results for Quality Function Deployment

Appendix B, Table 3: Results for Quality Function Deployment

Author, date, journal	**Cost management method(s)**	**Industry**	**Summary (regarding the focal cost management method)**	**Type of data**	**Field work**
(Bai & Kwong, 2003) IJPR	QFD	Automotive	Typicall, in the early design stage of a product no precise information about final specifications can be given. The paper introduces a fuzzy optimisation approach to support decision-making within QFD in this early stage. The proposed model is able to generate a set of solutions depending on different design scenarios and engineering requirements. Costs are seen as one possible design requirement. The model is demonstrated with a numerical example.	Non-empirical: Simulation	None
(Bovea & Wang, 2007) IJPR	Life-cycle costing QFD	Consumer Goods	This paper presents a redesign approach that allows integrating environmental requirements in product development, taking into account cost and customer preferences. The proposed method allows the identification of environmental improvement options and assessment of the effect of incorporating these. Through QFD combined with LCC and some other methods, it was found that for the case of office furniture products, 50% of the customers are willing to pay 14% more for an environmental friendlier product.	Empirical: mix	Case study
(Brad, 2009) IJPR	QFD Design for X	Consumer Goods	QFD is a major part of the concurrent multifunction deployment (CMFD) method presented in the paper. The model can be seen as an advanced form of QFD that integrates concepts of concurrent engineering for planning product development with multi-objective functions.	Non-empirical: Simulation	None
(Chaudhuri & Bhattacharyya, 2009) IJPR	QFD	Automotive	Starting point of this research is the idea that QFD and Conjoint Analysis (CA) both cannot be used sole to guaranty successful NPD, but connected they can. So in the suggested model QFD is used to determine the required product profiles including the needed technical characteristics, and CA is afterwards applied to maximise customer utility. To promote this model an illustrative numerical example with hypothetical data is presented.	Non-empirical: Simulation	None
(Y. Z. Chen & Ngai, 2008) IJPR	QFD	Automotive	The paper argues that today's QFD approaches cannot handle complex product planning (CPP), multiple engineering requirements, and uncertainty simultaneously. Therefore, fuzzy set theory is embedded in a QFD framework and a novel fuzzy QFD program modelling approach to CPP is proposed to optimize the values of engineering characteristics by taking into account design uncertainty and financial considerations.	Non-empirical: Simulation	None
(Y. Chen, Fung,	QFD	Automotive	A novel fuzzy expected value operator approach is proposed to model the QFD	Non-	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
& Tang, 2005) IJPR			process in a fuzzy environment, and two fuzzy expected value models are used to determine the target values of engineering characteristics in handling different practical design scenarios. The illustrated example of a quality improvement problem of a motor car shows that the proposed approach can model the QFD process effectively in a fuzzy environment by taking into account competition requirements, technical feasibility and financial factors.	empirical: Simulation	
(J. J. Cristiano et al., 2000) JPIM	QFD	Multiple industries	This paper provides a study on QFD, in particular by comparing its adoption and several other aspects between Japan and the U.S. Cost deployment is found to be scarcely used both in Japan and the U.S. Notably decreased manufacturing costs as an impact of QFD are reported by 14.3% of the Japanese and 23.8% of the U.S. companies.	Empirical: Survey	None
(Delice & Güngör, 2011) IJPR	QFD	Consumer Goods	This paper uses a mixed integer linear programming strategy and a mixed integer goal programming model to manage discrete values of design requirements. The results should deliver the best solution for the product design, by incorporating customer satisfaction, cost and technical issues. The model is tested in the case of a washing machine development.	Non-empirical: Simulation	None
(Delice & Güngör, 2013) IJPR	QFD	Consumer Goods	This paper refines the model mentioned in the row above by implementing a fuzzy mixed integer goal programming procedure. The change is made to take into account imprecise information and uncertainty about the future environment during product development. The proposed model was tried out for the Turkish white goods industry.	Empirical: Observations	Engineering, "how to"
(Fargnoli, De Minicis, & Tronci, 2013) JETM	QFD Design for X	Gardening equipment firm (Italy)	Conducting a case study, this paper investigates how to integrate environmental aspects in NPD considering other aspects, such as the user-product relationship and cost (called: Design Management for Sustainability). Relying on Bovea & Wang (Bovea & Wang, 2007), a Green-QFD approach is employed to address different aspects of the products in various QFD-houses. Costs are considered in the cost house, distinguishing between internal costs (such as materials, manufacturing, and waste management) and external costs (social consequences during the product's life cycle). This reduced that the cost index applied.	Empirical: mix	Case study
(Fung, Tang, Tu,	QFD	Consumer Goods	The proposed model tries to maximise the benefit from used resources for	Non-	None

Appendix B, Table 3: Results for Quality Function Deployment

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
& Wang, 2002) IJPR			future products. This research focuses on the correlation between individual technical attributes and how they can influence each other. A non-linear fuzzy model connected to either a parametric optimisation method or a hybrid genetic algorithm is applied to receive an optimal solution. The model is demonstrated using the hypothetical development of a pencil as an example.	empirical: Simulation	
(Griffin, 1992) JPIM	QFD	Multiple industries	A field-based, scientific study of U.S. firms' efforts to implement QFD methods. Based on a study of 35 projects, the author found that QFD provided only minor, short-term, measurable impacts on product development performance. For two physical goods projects and five service projects out of 35 projects observed, QFD resulted in increased performance at the same product cost. Time or cost to commercialisation was reduced for these two physical goods projects.	Empirical: Observations	Case study
(Heim, Mallick, & Peng, 2012) IEEE-EM	QFD DFM/A	Manufacturing industries	This paper investigates the use and impact of NPD practices (DFM, QFD and rapid prototyping) and software tools (e.g., computer-aided design, product data management) among manufacturing industries through an international survey. The results suggest that the NPD practices have a positive, significant effect on 1) cost control 2) responsiveness 3) product conformance quality 4) product performance quality 5) time to market. Of these performance metrics, cost control, time to market, and performance quality showed evidence to drive market success.	Empirical: Survey	None
(M. Hoque et al., 2005) IJPR	Target costing QFD	Technology & Telecommunication	See Appendix B, Table 1: Results for Target Costing.	Non-empirical: Analytical	None
(Hoyle & Chen, 2009) IEEE-EM	QFD	Not specified	Addressing the notion that QFD is biased toward fulfilling customer requirements and lacks consideration of costs, this paper presents a new design tool as a replacement of QFD. The method is used to select the preferred design concept, set target levels of engineering performance, and set engineering priorities and thereby aims to maximise enterprise utility. It incorporates estimates on costs, such as manufacturing and material costs. In an example, the suggested tool yielded significantly higher profits and lower unit costs than the QFD method.	Non-empirical: Simulation	None
(Ibusuki & Kaminski, 2007)	Target costing Value engineering	Automotive	See Appendix B, Table 1: Results for Target Costing.	Empirical: Observations	Engineering, "how to"

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
IJPE	QFD				
(Iranmanesh & Thomson, 2008) IJPE	QFD	Technology & Telecommunication	A cost-design parameter method that optimizes cost and design characteristics simultaneously during product development is presented. The method is based on QFD, which relates desired product attributes to design characteristics. The method works at three levels: strategic, tactical and operational. This model is validated through use in an example, where customer satisfaction versus new expenditure on the product is calculated.	Non-empirical: Simulation	None
(Ittner & Larcker, 1997) JMR	QFD	Automotive and computer industry (Canada, Germany, Japan, U.S.)	The authors develop and test a simple conceptual model linking product development cycle time to organisational performance. They find faster cycle time alone is not associated with higher accounting returns, sales growth, or perceived overall performance. Tools like QFD, failure mode and effects analysis and design of experiments moderate the relationship between cycle time and organisational performance and increase return on assets and return on sales in the computer industry.	Empirical: Survey	None
(Ji, Jin, Wang, & Chen, 2014) IJPR	QFD	Technology & Telecommunication	This paper integrates an existing model on customer requirements with QFD. A mixed non-linear integer programming model is formulated to maximise customer satisfaction under cost and technical constraints. An illustrative example regarding the design of notebook computers is presented to demon-strate the availability of the proposed approach.	Non-empirical: Simulation	None
(Karsak, 2004) IJPR	QFD	Consumer Goods	This paper presents a fuzzy multiple objective programming approach that incorporates imprecise and subjective information in the QFD planning process to determine the level of fulfilment of design requirements. Linguistic variables are used to represent the imprecise design information and the importance of each design objective. The fuzzy Delphi method is utilised to achieve consensus of customers in determining the importance of customer needs. A pencil design example illustrates the application of the multiple objective decision analysis.	Non-empirical: Simulation	None
(Lager, 2005) RADMA	QFD	Not specified (multiple empirical studies)	This paper provides a literature review and analysis on QFD, assessing its industrial usability and, in particular, identifying best practices and success factors in its introduction and use. Evidence of QFD lowering manufacturing costs was scarce (only two out of nine studies reviewed showed weak support),	Non-empirical: Theoretical	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			lower design costs were not reported at all.		
(A. H. I. Lee, Kang, Yang, & Lin, 2010) IJPR	QFD	Metals & Electronics	The paper presents a framework for the selection of engineering characteristics (ECs) for product design. In the first phase, QFD is incorporated with the supermatrix approach of analytic network process (ANP) and the fuzzy set theory to calculate the priorities of ECs. In the second phase, a multi-choice goal programming model is constructed based on the outcome of the first phase and other goals, such as NPD cost and manufacturability, in order to select the most suitable ECs. A case study of the product design process of backlight unit in thin film transistor liquid crystal display industry in Taiwan is carried out to verify the practicality of the proposed framework.	Empirical: mix	Engineering, "how to"
(Olhager & West, 2002) IJOPM	QFD	Technology & Telecommunication	The paper is to apply the QFD approach to manufacturing flexibility. It proposes an approach to deploy flexibility-related customer needs into manufacturing system features regarding costs, quality, innovativeness and more. The suggested method is successfully applied in the case of a mobile phone manufacturer.	Empirical: Qualitative	Case study
(Romli, Prickett, Setchi, & Soe, 2014) IJPR	QFD	Health and pharmaceuticals	This paper presents an integrated eco-design decision-making method using three stages: life cycle assessment, an eco-design process model and an enhanced eco-design QFD process. An application of the approach is presented in a case study of the redesign of a single-use medical forceps.	Empirical: Observations	Engineering, "how to"
(Trygg, 1993) JPIM	QFD DFM/A	Manufacturing industry (Sweden)	Based on a survey among Swedish manufacturing companies, this paper investigates how these companies employ concurrent engineering methods to improve their speed to market. Design for manufacturing and assembly (DFMA) was found to be significantly more applied among the successful companies, which have achieved shorter lead times in their product development. This also applies to the use of QFD, yet less distinctly. For QFD, there was only a marginal effect on development lead time (56% yes, 44% no) and on development cost (52% yes, 48% no).	Empirical: Survey	None
(Vanegas & Labib, 2001) IJPR	QFD	Automotive	This paper proposes a novel method for determining optimum targets in QFD. Fuzzy numbers are used to represent the imprecise nature of the relationships between engineering characteristics and customer attributes. Constraints such as cost, technical difficulty and market position are considered. An example of a car door is presented to show the application of the method.	Non-empirical: Simulation	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Wasserman, 1993) IIE	QFD	Not specified	This paper presents a mathematical decision framework to prioritize design requirements during QFD. In an example, it is shown that cost considerations can influence the designers' decisions considerably, if the importance of certain design requirements is set in relation to cost instead of employing it as sole decision criterion. Ranking the design requirements based on the importance/cost ratio is recommended to assign resources.	Non-empirical: Analytical	None
(Zengin & Ada, 2010) IJPR	Target costing Value engineering QFD Kaizen costing	Manufacturing	See Appendix B, Table 1: Results for Target Costing.	Empirical: Observations	Case study
(Y. Zhang, 1999) IJPR	QFD Life-cycle costing	Automotive	Green Quality Function Deployment-II (GQFD-II) is introduced in this paper. By integrating Life Cycle Costing (LCC) into QFD matrices and deploying quality, environmental and cost requirements throughout the entire product development process it is possible to design products with focus on quality and cost as well as environmental issues. An illustrative example (engine filters) is used to demonstrate the concept of GQFD-II.	Non-empirical: Simulation	None

Appendix B, Table 4: Results for Functional Cost Analysis

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Roy, Souchoroukov, & Griggs, 2008) IJPR	Functional cost analysis	Diverse	This paper presents a function-based cost estimating (FUCE) framework to link the commercial and engineering departments in the conceptual design stage. The objective of FUCE is to translate the un-quantified terminology and requests regarding product specifications that are used by cost estimators with a commercial background into a medium that cost estimators with an engineering background can process. FUCE is developed using a detailed case study on an automotive exhaust system. The method is then validated using two case studies from the automotive and aerospace industries.	Empirical: mix	Case study
(Takeo Yoshikawa et al., 1994) IJPE	Functional cost analysis Value engineering	Manufacturing	See Appendix B, Table 2: Results for value engineering.	Non-empirical: Simulation	None

Appendix B, Table 5: Results for Kaizen Costing

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(R. Cooper & Slagmulder, 2004) MIT SMR	Target costing Kaizen costing	Technology & Telecommunication	See Appendix B, Table 1: Results for Target Costing.	Empirical: Qualitative	Management practice
(Rabino, 2001) JETM	Target costing Value engineering Kaizen costing	Multiple industries	See Appendix B, Table 1: Results for Target Costing.	Empirical: Survey	None
(Zengin & Ada, 2010) IJPR	Target costing Value engineering QFD Kaizen costing	Manufacturing	See Appendix B, Table 1: Results for Target Costing.	Empirical: Observations	Case study

Appendix B, Table 6: Results for Life-Cycle Costing

Author, date, journal	**Cost management method(s)**	**Industry**	**Summary (regarding the focal cost management method)**	**Type of data**	**Field work**
(Bard, 1992) IIE	Life-cycle costing	U.S. Army	Extending Bard & Sousk (Bard & Sousk, 1990), this paper reports a case study dealing with two different methods to assess technological alternatives of rough terrain cargo handlers for the U.S. Army. Life-cycle costs were used as scaling constant for both methods. The case study group believed that a full assessment of life-cycle costs would provide more supportive data, yet the effort required was considered to be considerable.	Empirical: mix	Case study
(Bovea & Wang, 2007) IJPR	Life-cycle costing QFD	Consumer Goods	See Appendix B, Table 3: Results for Quality Function Deployment.	Empirical: mix	Case study
(Dutta & Lawson, 2008) IJTM	Life-cycle costing	High-technology industries	This paper investigates how accounting standards and their financial effects influence firms' decisions to invest internally in "sustaining technology" and through joint ventures or research partnerships in "disruptive technologies." Even though the method of LCC is not particularly in focus, the paper depicts the distribution of costs and profits over the products' lifetime for comparing sustainable and disruptive technologies.	Empirical: Archival	Case study
(Elimam & Dodin, 1994) IIE	Life-cycle costing	Wastewater treatment plants	This paper examines the selection of sludge dewatering processes and operation modes for wastewater treatment. It applies an infinite-horizon LCC model and a mathematical programming model. The model considers operations, maintenance, cost of capital, transportation, and use of polymers (for sludge treatment). The models were applied in two wastewater treatment plants in Kuwait.	Empirical: Archival	Engineering, "how to"
(Folgado, Peças, & Henriques, 2010) IJPE	Life-cycle costing	Manufacturing	The topic of this paper is the selection of the best technology alternative for the manufacturing of injection moulds in the product development stage through LCC. The proposed model is verified by a case study with archival data. For the life-cycle costs, in this example the critical variable was the targeted production volume.	Empirical: Archival	None
(Goffin, 2000) RTM	Life-cycle costing TCO Design for X	Multiple industries	By giving many practical examples, the author suggests that supportability concerns are not sufficiently considered by many companies, yet inspiring cases exist. It is proposed to incorporate aspects of product support early in the design stage to achieve cost savings (which may be measured with total cost of ownership or LCC approaches). The author also presents a simple way to	Empirical: Qualitative	Management practice

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			classify companies' design for support activities.		
(Goh, Newnes, Mileham, McMahon, & Saravi, 2010) IEEE-EM	Life-cycle costing	Not specified	This paper presents a review of the uncertainty classification in the engineering literature and the nature of uncertainty in life-cycle cost estimation. Based on the review, the paper presents a critique of the current uncertainty modeling approaches in cost estimation and suggests requirements for a different approach to handling uncertainty in life-cycle cost estimation.	Non-empirical: Theoretical	None
(Grote, Jones, Blount, Goodyer, & Shayler, 2007) IJPR	Design for X Life-cycle costing	Consumer Goods	In this paper a model for the development of "energy using products" is presented. The model comprises DFX and LCC elements. It pays attention to economic as well as ecological design requirements. A fictitious case study for a small household item is conducted. The results indicate a reduction of CO2 emissions and energy costs.	Non-empirical: Simulation	None
(Hatch & Badinelli, 1999) IEEE-EM	Life-cycle costing TCO	Not specified (tests with typical data from military logistics support)	This paper presents a model-based approach to coordinate concurrent engineering and to support decision-making among cross-functional design-team members. The model uses dynamic programming to minimize life-cycle costs/total costs of ownership while attempting to achieve a good level of product availability. The model includes an algorithm that selects the best combination of options and computes the resulting product availability and LCC. The model is tested with several samples of realistic input parameters regarding military logistics support.	Non-empirical: Analytical	None
(Hegde, 1994) IIE	Life-cycle costing	Durable goods industry	This paper presents a model to estimate LCC for a durable product (e.g., a computer) by considering failure cost data, which engineers may obtain from field support. The model is illustrated with a numerical example, which suggests that considering failure cost may be critical for selecting design alternatives. The authors further stress the need for improved cost information sharing between engineering and the field support function.	Non-empirical: Analytical	None
(M. R. Johnson & Wang, 1995) IJPR	Design for X Life-cycle costing	Technology & Telecommunication	The disassembly of products is the prime issue in this research. A model is developed to support and improve material recovery. Besides the opportunity to reuse some materials at the end of a product's life, LCC of a product were also considered. This was accomplished through a DFX approach, supported by LCC. An example is provided that demonstrates the approach.	Non-empirical: Simulation	None
(Kleyner &	Life-cycle costing	Automotive	This paper investigates the relationship between the reliability of a product and	Non-	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Sandborn, 2008) IJPE			its life-cycle costs. The model creates different scenarios through a Monte Carlo simulation to estimate the trade-off. To testify its applicability, the model is illustrated in an example in the automotive industry. Findings indicate that the regularly requested +99% in reliability may be not the optimum when considering the life-cycle cost.	empirical: Simulation	
(Mangun & Thurston, 2002) IEEE-EM	Life-cycle costing Design for X	Not specified (example from personal computer industry)	This paper develops a model for incorporating long-range planning for component reuse in product design. The model employs a product portfolio approach based on market segmentation, rather than a single product. The model is embedded in a decision tool for when a product should be taken back, and which components should be reused, recycled, or disposed. A case study of a line of personal computers (PCs) demonstrates an implementation of the model. It uses cost information on product take-back and disassembly and therefore represents a form of LCC, even though LCC is not literally mentioned in the paper. One important finding is that allowing the possibility of reuse, remanufacture, or recycling actually improved cost, environmental impact and customer satisfaction when a company was exposed to product take-back legislation.	Empirical: Archival	Engineering, "how to"
(Mildenberger & Khare, 2000) Techn	Life-cycle costing	Automotive	The paper focusses on the environmental issues in the automobile industry and the environmental impact presently associated with the automobile's life cycle. The paper reviews existing tools and opportunities for reducing these burdens in the future through decision-making by the industry and other stakeholders. LCC tools are briefly introduced and related to the automotive industry.	Non-empirical: Theoretical	None
(Quariguasi Frota Neto, Walther, Bloemhof, van Nunen, & Spengler, 2010) IJPR	Life-cycle costing	Metals & Electronics	This paper researches the sustainability of closed loop supply chains (CLSCs). A fictional case study is presented. In this model for CLSCs, LCC is addressed as a method to manage costs, and life-cycle assessment is seen as a method to get an overview of the environmental impacts. The model can be used for the development of sustainable products.	Non-empirical: Simulation	None
(Riggs & Jones, 1990) IEEE-EM	Life-cycle costing	Not specified	Using a hypothetical example of a radar system, this paper presents a graphical representation technique, called a flow graph, illustrating the interrelationships between the variables and functions to conduct LCC analyses. Advantages include computational solvability, the graphical representation, which makes logical errors more evident, as well as reduced time necessary for someone to	Non-empirical: Analytical	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			comprehend the cost system.		
(Tubig & Abetti, 1990) IEEE-EM	Life-cycle costing	U.S. Defense	Conducting a survey, this paper assesses the effects of various factors on defense R&D contractor performance. The authors give advice on which type of contract to choose for major development programs and whether to initiate competition between several contractors. LCC is recommended to ensure cost effectiveness.	Empirical: Survey	None
(Usher & Whitfield, 1993) IIE	Life-cycle costing	Not specified	This paper proposes a model for estimating the total life of each component in a used, multi-component system through the use of fuzzy set theory and linguistic variables. The resulting component life estimates provide the times at which a cost for component replacement is incurred. Based on this assessment, a cost model is set up to estimate the annual costs for owning and operating the system. This enables selecting the least expensive system. The model is demonstrated with a hypothetical example.	Non-empirical: Analytical	None
(Y. Zhang, 1999) IJPR	QFD Life-cycle costing	Automotive	See Appendix B, Table 3: Results for Quality Function Deployment.	Non-empirical: Simulation	None

Appendix B, Table 7: Results for Total Cost of Ownership

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Goffin, 1998) JPIM	TCO Design for X	High-technology companies (+ case study at Hewlett-Packard)	Based on a survey, this paper investigates how companies assess product support requirements within the design stage. Additionally, a case study was undertaken, and evidence suggests that by considering a variety of these requirements in design, reducing the complexity of the product may save costs. For instance, facilitating software upgrades of the product (termed Design for Upgradability) resulted in considerable cost savings, also in terms of cost of ownership for the company's customers.	Empirical: mix	Case study
(Goffin, 2000) RTM	Life-cycle costing TCO, DFX	Multiple industries	See Appendix B, Table 6: Results for Life-Cycle Costing.	Empirical: Qualitative	Management practice
(Heilala, Helin, & Montonen, 2006) IJPR	TCO	Manufacturing	A TCO analysis tool is introduced to improve the design of modular assembly systems. It is based on selected industrial standards and the authors' own experience of assembly system design and simulation. The TCO method is claimed to be useful in system-supplier and end-user communication, and helps in trade-off analyses of system concepts. A fictitious case study illustrates the use of the TCO method.	Non-empirical: Simulation	None
(Plank & Ferrin, 2002) IMM	Target costing TCO	Mainly manufacturing industries	See Appendix B, Table 1: Results for Target Costing.	Empirical: Survey	None
(Sohn & Kim, 2011) IEEE-EM	TCO	Not specified	This paper applied an adapted cost-of-ownership model (Y. Kim, Kim, Jeon, & Sohn, 2009) to address the international standardisation of related technologies. The model helped to identify the most promising projects and enabled their joint, effective development under consideration of budget constraints. Joint development might lead to higher benefits while at the same time lowering costs. The model was applied in an example of radio-frequency identification (RFID) technology development.	Non-empirical: Simulation	None
(Wouters, Anderson, Narus, & Wynstra, 2009) JOM	TCO	Diverse	The subject of the paper is monetary quantification of points of difference. Interviews and a survey are conducted to investigate the use of such information during NPD projects. TCO, although beneficial in principle, is very hard to implement in the design process. The need for information is too large and it takes too much time for most NPD projects.	Empirical: Qualitative	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Baker & Bourne, 2014) RTM	Stage-gate reviews	Footwear and apparel industry	This paper proposes a governance framework to be applied during stage-gate processes, specifically to assist managers at gate-decisions. Through feedforward control, this framework gives signals to managers to consider a reassessment of the current product portfolio. The application in a footwear and apparel company resulted in scaled down product portfolios, improved productivity and increased profit.	Empirical: Observations	Engineering, "how to"
(Boardman & Clegg, 2001) IJOPM	Stage-gate reviews	Aerospace	The paper investigates the product development process for aerospace products and an extended enterprise. These products are usually too complex for a single company. A framework for structuring and synchronizing phases and stage-gates is proposed as solution for several problems, including the coordination of different companies within the NPD process. Benefits from the stage-gate process are pointed out as maximum return on substantial investments.	Empirical: Observations	Case study
(F. P. Boer, 2003) RTM	Stage-gate reviews	Not specified	This paper proposes a method to value projects adjusting for high risk, by applying discounted cash flows, decision trees and real options. The method is presented in a fictive business case using extensive calculations and explanations. The stage-gate concept is not specifically emphasised, yet the author recommends applying this method in stage-gate management systems. He sees benefits for decision-making in cases where projects yield zero or slightly negative net present values.	Non-empirical: Theoretical	None
(Bremser & Barsky, 2004) RADMA	Stage-gate reviews	Not specified	Building on the notion that R&D is a determining factor in strategy implementation, this paper proposes the integration of the stage-gate approach with the balanced scorecard. This aim is to link resource commitments with strategic objectives through a balanced mix of financial and non-financial metrics in R&D. In a theoretical example, the authors illustrate how R&D- and stage-gate-related metrics can be mapped to strategic indicators in the balanced scorecard. This integrated scorecard is to be cascaded top-down to achieve agreement across several management levels.	Non-empirical: Theoretical	None

Appendix B, Table 7: Results for Total Cost of Ownership

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(K. H. Chai, Wang, Song, Halman, & Brombacher, 2012) JPIM	Stage-gate reviews Product platforms	Multiple non-service industries (U.S.)	See Appendix B, Table 14: Results for Product Platform.	Empirical: Survey	None
(Coldrick, Longhurst, Ivey, & Hannis, 2005) Techn	Stage-gate reviews	Not specified	This paper applies an earlier model (Lockwood, 1999) to a sample of projects. The model includes scoring models, a risk assessment, a cost-benefit analysis and discounted cash flows. The model aims to make the project selection process more transparent and to support decision-making. The authors suggest incorporating the model in stage-gate systems as a method for go/kill-decisions.	Empirical: mix	Engineering, "how to"
(R. G. Cooper, 2006) RTM	Stage-gate reviews	Multiple industries	This paper describes how a selection of companies has approached fundamental research or technology management projects with adapted stage-gate processes. Cost management is not specifically in focus, but the author criticizes the excessive use of financial tools and data. Because of the highly uncertain nature of the projects, numerical estimates of expected sales, costs, investment, and profits are likely to be very inaccurate. Instead, the author suggests a predominantly qualitative scorecard method to support decision-making at gates.	Empirical: Qualitative	Management practice
(R. G. Cooper, 2013) RTM	Stage-gate reviews	Multiple industries	This paper addresses the question how to manage and foster breakthrough innovations. The author draws on models and tools used in leading companies to show different approaches to portfolio management. For the stage-gate model, the use of scoring models instead of sophisticated financial metrics at early stages, and an option-based investment model at later stages are proposed. The overall intent is to guard venturesome, but promising projects against kill-decisions during early stages.	Empirical: Qualitative	Management practice
(R. G. Cooper & Kleinschmidt, 1991) IMM	Stage-gate reviews	Multiple industries	This paper reports the impact on performance achieved by five different companies after implementing stage-gate and other new product processes. Improved product success rates, higher customer satisfaction and meeting time, quality and cost objectives were the most frequently cited areas of positive impact. Furthermore, other aspects of new product processes are explored (e.g., deficiencies, suggested improvements, and the motivation for implementing the process).	Empirical: Qualitative	Case study
(R. G. Cooper & Kleinschmidt, 1995) JPIM	Stage-gate reviews	Multiple industries	This paper is based on a benchmarking study among 135 companies active in product development. The study included 10 different performance metrics (e.g., on sales, profits etc.), which were reduced to two underlying performance	Empirical: Survey	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			dimensions and illustrated on a "new product performance map." Four groups of firms were identified, associated with distinct success factors in NPD. The authors concluded among that successful firms employ well-executed, thorough and flexible NPD processes.		
(R. G. Cooper & Kleinschmidt, 2007) RTM	Stage-gate reviews	Multiple industries	This is a reprint of an earlier paper (R. G. Cooper & Kleinschmidt, 1996) with reflections of the authors. They comment that their research has led them to develop a "performance diamond," intended to represent the four key success drivers of NPD.	Empirical: Survey	None
(Ettlie & Elsenbach, 2007b) JPIM	Stage-gate reviews	Automotive industry (assemblers and suppliers)	Conducting a survey among 72 automotive engineering managers supervising the NPD process of assemblers and suppliers, this study addresses various aspects of (modified) stage-gate processes. The study suggests that companies optimize trade-offs between cost and quality after they graduate from more typical stage-process management to modified regimes. This modified stage-gate was significantly related to NPD process improvement and superiority of commercialisation.	Empirical: Survey	None
(Harmancioglu, McNally, Calantone, & Durmusoglu, 2007) RADMA	Stage-gate reviews	Building materials industry	In an exploratory case study of three companies in the building materials industry, this paper investigates how the NPD processes differ across companies with a strategic objective of innovation-induced growth. Relying on in-depth interviews with managers and engineers, it is proposed the use of formal stage-gate processes is negatively related to innovation performance. This also applies to senior-level involvement, because projects with low risk and short-term rewards may more likely be selected instead of breakthrough products.	Empirical: Qualitative	Case study
(Hart, Hultink, Tzokas, & Commandeur, 2003) JPIM	Stage-gate reviews	Industrial goods companies (Netherlands and UK)	This article presents the results of a study on the evaluation criteria that companies use at several gates in the NPD process. The findings from 166 managers suggest that companies use different criteria at different NPD evaluation gates. While such criteria as technical feasibility, intuition and market potential are stressed in the early-screening gates of the NPD process, a focus on product performance, quality, and staying within the development budget are considered of paramount importance after the product has been developed. The financial dimension emerges prominently in the business analysis gate and gains importance in the short- and long-term performance evaluation after launch.	Empirical: Survey	None
(Jagle & Jägle,	Stage-gate reviews	Technology-	The paper proposes a binomial valuation framework which links the NPD process	Empirical:	Engineering,

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
1999) RADMA		intensive companies	with real options. The different phases in this process are regarded as real options on the next phase in order to model uncertainty and quantify flexibility and risk. Stage-gate is presented as an emblematic sequential NPD process, which allows for the application of the valuation framework. In two numerical examples, the results of the framework are compared those of the discounted cash flow tree. The application of the framework is also demonstrated in a case study, dealing with the options-based valuation for the initial public offering of a biotech company.	Archival	"how to"
(Kleinschmidt, de Brentani, & Salomo, 2007) JPIM	Stage-gate reviews	Multiple industries (business-to-business; North America, Europe)	The paper tests a model of the impact of organisational resources (e.g., top management involvement, NPD process formality) on global NPD program performance, mediated by global NPD process capabilities. While stage-gate processes were not in focus, NPD process formality (as applicable in stage-gate systems) did not exhibit a direct, significant impact on financial performance. Evidence suggests that a more formal process permits the effective deployment of NPD process capabilities that significantly impact global NPD program outcome. However, for very innovative or entrepreneurial projects it may impede the access to new markets, products, and technological arenas.	Empirical: Survey	None
(Kumar & Wellbrock, 2009) IJPR	Stage-gate reviews	Metals & Electronics	Based on observations in a company, the paper suggests a new way to manage the product introduction process. The model is based on Cooper's Stage-gate process with some modifications regarding the different stages. Cost savings are expressed in time reductions. These are reduction of design engineer's time, CAD service time, and general development time.	Empirical: Observations	Case study
(Ozer & Cebeci, 2010) IEEE-EM	Stage-gate reviews	Multiple industries (Chinese Hong Kong firms)	This study investigates the relationship between the development of new products with a global market focus and the performance of NPD programs, and investigates various organisational, procedural, and operational conditions that may moderate this relationship. Using a stage-gate process was found to be of high importance in global R&D. It was positively related to financial performance and it had a positive moderating role in the relationship between a firm's global market focus in its NPD and the financial performance of its NPD programs.	Empirical: Survey	None
(Schultz, Salomo, de Brentani, & Kleinschmidt, 2013) JPIM	Stage-gate reviews	Manufactured goods and services companies (Austria and	This paper evaluates NPD programs in terms of formal control mechanisms, their immediate outcomes and the influence of the degree of NPD innovativeness. Stage-gate systems did not directly impact NPD program performance, yet transparent decision-making emerged as a mediator. The results suggest that this mediated relationship also holds when the degree of innovativeness of the NPD	Empirical: Survey	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
		Denmark)	program is high. It is also found that when firms are involved in more innovative NPD programs, project management control systems should be combined with higher organisational level stage-gate-type processes.		
(Stevens, Burley, & Divine, 1999) JPIM	Stage-gate reviews	Chemical industry	This paper investigates the role of individual creativity in effectively analysing early-stage NPD project ideas. All NPD analysts taking part in the research were extensively trained in stage-gate business discipline. It was found that having creative analysts in the early stages and a high-quality NPD system increased profitability. The average profit achieved by "creative" NPD analysts exceeded that of analysts with a low creativity-measure by a factor of 12.5.	Empirical: mix	Case study
(Tzokas, Hultink, & Hart, 2004) IMM	Stage-gate reviews	Industrial and consumer goods industries (UK and Nether-lands)	This study presents empirical evidence of the evaluative criteria used by experi-enced NPD managers from the UK and the Netherlands to control performance at different gates of the NPD process. Findings show that financial criteria (profit objectives, the internal rate of return, ROI, etc.) were predominantly applied at the business analysis gate. In contrast to previous research, financial criteria were used less frequently than market-based criteria (except for the business analysis gate).	Empirical: Survey	None
(K. E. van Oorschot, Akkermans, Sengupta, & Van Wassenhove, 2013) AMJ	Stage-gate reviews	Automotive	This paper investigates failures of NPD projects. A stage-gate managed project is used as real case example. The findings suggest that teams in complex dynamic environments characterised by delays are subject to multiple "information filters" that blur their perception of actual project performance. Consequently, teams do not realise their projects are in trouble and repeatedly fall into a "decision trap" in which they stretch current project stages at the expense of future stages. This slowly and gradually reduces the likelihood of project success. However, because of the information filters, teams fail to notice what is happening until it is too late.	Empirical: Observations	Case study
(K. Van Oorschot, Sengupta, Akkermans, & Van Wassenhove, 2010) JPIM	Stage-gate reviews	Semiconductor industry	This paper seeks to examine whether using stage-gates may lead companies also to abandon some "right" projects (that could have become successful). This was tested by applying a system dynamics model on an exemplary NPD project. The simulation results suggest that when faced with asymmetrical uncertainty, relaxing constraints set up by stage-gate may save projects and ensure the timely completion within budget. Further managerial implications are derived.	Empirical: mix	Case study
(Walwyn, Taylor,	Stage-gate reviews	Chemical and	Relying on the theory of bond pricing, this paper puts forth a calculation method	Empirical:	Engineering,

Appendix B, Table 7: Results for Total Cost of Ownership

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
& Brickhill, 2002) RTM		pharmaceutical industry	to compute a risk-adjusted internal rate of return for research projects. The method can be applied at every stage in a stage-gate process and aims to improve the returns from R&D by ensuring that a portfolio of research projects achieves across time the cost of capital.	Archival	"how to"

Appendix B, Table 9: Results for Funnels

Author, date, journal	Cost Management Method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Mathews, 2010) RTM	Funnels	Aerospace and defense company (Boeing)	This paper presents a multi-phase innovation portfolio process at Boeing to address enhanced customer requirements and competition. It is set up to effectively funnel more and higher-quality ideas and concepts into the project portfolio for development and execution, based on quantitative assessments. The innovation portfolio was supported by management and represented a more methodical approach than the company's former way of concept selection.	Empirical: Observations	Management practice
(Mathews, 2011) RTM	Funnels	Aerospace and defense company (Boeing)	Building on Mathews (2010), this paper provides insight in how a business unit at Boeing values, assesses and selects concepts and ideas before full investment is made for their development. A multi-phase innovation portfolio process is presented for focusing the stream of ideas and shaping the project portfolio. The author describes attributes and metrics used by this business unit for their decision-making.	Empirical: Observations	Management practice
(Reitzig, 2011) MIT SMR	Funnels	Not specified	The paper deals with an improved way for selecting ideas for new products or other improvements related to the company. It is based on analysis of thousands of idea proposals as well as observations within a company. Problems are outlined and a framework for a customised selection funnel is proposed to save money and time for the organisation.	Empirical: mix	Management practice

Appendix B, Table 10: Results for Design for Manufacturing/Assembly

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(D. S. K. Chan & Lewis, 2000) IJPR	DFM/A	Metals & Electronics	The paper introduces a computerized DFM tool for small to medium sized enterprises for integrating information about costs and manufacturability during product development. The tool has been developed together with six companies, but actual applications are not reported in any detail.	Empirical: Qualitative	None
(Curran et al., 2007) IJPE	DFM/A	Not specified	The main contribution of the work is to present a method that facilitates the integration of design and manufacturing modelling at the concept design stage, including cost. The paper presents an illustration of the application of this method to the fuselage of a commercial regional jet.	Non-empirical: Simulation	None
(S. Das & Kanchanapiboon, 2011) IJPR	DFM/A	Consumer Goods	Pro-DFM, a multi-criteria model for manufacturability analysis that identifies cost-reduction opportunities is presented. Pro-DFM assumes the NPD team has a baseline estimate of production costs, and it evaluates how DFM issues will affect the expected unit production cost. The Pro-DFM model analyses a new design on three factors: part procurement and handling, product assembly fabrication processes, and inventory costs. A numerical example demonstrates the DFM evaluation process.	Non-empirical: Simulation	None
(Dowlatshahi, 1995) IJPE	DFM/A	Metals & Electronics	This paper details a real-life proposal that describes a design of self-contained, integrated manufacturing and assembly for pipe valves. It presents a detailed and comprehensive analysis of part design, manufacturing operations, and manufacturing system design. The part design is subjected to a set of DFM/DFA tests and it has been significantly revised and upgraded. These revisions or improvements provide for ease as well as economical manufacture and assembly operations.	Empirical: Observations	None
(Heim et al., 2012) IEEE-EM	QFD DFM/A	Manufacturing industries	See Appendix B, Table 3: Results for Quality Function Deployment.	Empirical: Survey	None
(Kessler, 2000) JETM	DFM/A	Multiple industries	This paper presents the results of a survey among large companies in multiple industries and assesses the impact of various methods on NPD costs. A significant relationship between DFM and development costs was not found. However, the study examines several other methods which are linked to this present literature review in a broader sense (e.g., team autonomy, process overlap etc.), which is why this paper is included.	Empirical: Survey	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Liker, Collins, & Hull, 1999) JPIM	DFM/A	Multiple industries	This article proposes and tests a contingency model of system integration of product design and manufacturing (DMSI) among producers of goods involving tooling development. The model predicts which combinations of organisational and technical practices will be most effective under conditions of high and low design newness. DMSI is operationalised as a combination of DFM and flexible manufacturing capability. As one result, it was found that DMSI has a strong, direct effect on manufacturing time and cost.	Empirical: Survey	None
(T. Lin, Lee, & Bohez, 2012) IJPR	DFM/A	Metals & Electronics	This paper describes an integrated model to estimate the manufacturing cost and production system performance at the conceptual design stage. A fully automated conceptual framework for DFM is developed. The model was incorporated in a computer program and tested for the design of helicopter rotor blades.	Empirical: Observations	Engineering, "how to"
(Loch et al., 1996) JPIM	Value engineering DFM/A Design for X	Electronics industry	See Appendix B, Table 2: Results for value engineering.	Empirical: Survey	None
(Lu & Wood, 2006) IJOPM	DFM/A Design for X	Metals & Electronics	Starting point of this paper is the argumentation that DFM moves in the product realisation chain from product design to the process execution, ignoring the process design stage. To overcome this issue, DFM is refined and split in diverse “design for” elements. The findings suggest a positive impact on the performance of product realisation (especially time to market) and thus operational competitiveness.	Empirical: Observations	Case study
(M. Boer & Logendran, 1999) IIE	DFM/A	Electro-mechanical assemblies company (U.S.)	This paper puts forth a “how to” method for empirical research on the effects of product development characteristics on project/product success (i.e., cost and time). The authors suggest using variables that address DFM issues, especially if the company is interested in understanding the associations with cost. The method was applied at a manufacturing company in the U.S. The approach is explained in detail and practical advice is given. In the example, it is found that cost increased, as the number of parts in a product and the number of assembly processes increased.	Empirical: Archival	Engineering, "how to"
(Madan, Rao, & Kundra, 2007) IJPR	DFM/A	Manufacturing	A computer-aided system for early cost estimation, feature-cost sensitivity and optimal machine loading for die-casting is presented. It can be used both as a DFM as well as an early cost-estimation tool for preparing quotations. The system	Non-empirical: Simulation	None

Appendix B, Table 10: Results for Design for Manufacturing/Assembly

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			suggests a minimum cost to manufacture a part, accounting for the possibility of using of multi-cavity dies and with available resources, namely die-casting machines.		
(Martínez Sánchez & Pérez, 2003) JPIM	Value engineering DFM/A	Automotive suppliers (Spain)	See Appendix B, Table 2: Results for value engineering.	Empirical: Survey	None
(Pullan, Bhasi, & Madhu, 2012) IJPR	DFM/A	Metals & Electronics	This paper describes an integrated manufacturing framework to link the design stage to the other stages in the manufacturing systems. A model is developed using object oriented technology, based on the fundamental elements necessary for modelling of manufacturing, process planning, and collaborative design of machine tools.	Empirical: Observations	Engineering, "how to"
(Rusinko, 1999) IEEE-EM	DFM/A	Manufacturing companies (U.S.)	This article reports results of a quantitative study of design-manufacturing integration (DMI) practices to facilitate effective new product development (NPD). Some of the DMI practices assessed are related to DFM (i.e., using manufacturability guidelines in design). The use of manufacturability guidelines was found to be positively associated with effective NPD, whereas the effect of the applicability of these guidelines (which means they are applicable to more than one project) was negative.	Empirical: Survey	None
(S. Ray & Kanta Ray, 2011) Techn	DFM/A Design for X Modular design	Automotive (Tata Motors)	The “Nano” of Tata Motors is one of the cheapest cars in the world. This paper investigates how Tata Motors’ choices regarding the use of technology, product design and organisational practices for NPD enabled it to meet the challenge of innovation for India’s masses. It is shown that the Nano is systematically optimized for cost (e.g., using less components, less material). Even though DFM and “design for cost” as a form of DFX are not explicitly mentioned, the paper in its entirety makes it evident that these methods have been employed. Moreover, a modular product architecture was used to lower assembly and logistics costs.	Empirical: mix	Case study
(Sik Oh, O’Grady, & Young, 1995) IIE	DFM/A	Not specified	Product design is subject to constraints, which may be interconnected, forming a constraint network. A DFA system is developed and programmed as a constraint network in order to support the designer. The program provides the designer with the total assembly cost and may suggest changes to the design, if a lower cost is desired.	Non-empirical: Theoretical	None
(Swink & Nair,	DFM/A	Manufacturing	This paper describes and tests a theory of complementarities between design–	Empirical:	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
2007) JOM			manufacturing integration (DMI) and usage of advanced manufacturing technologies (AMT). The study focusses on aspects of DMI such as concurrent engineering and DFM/A. The authors analyze data from 224 manufacturing plants in order to test the hypotheses that DMI moderates the relationships between AMT usage and manufacturing performance. Regression analysis results indicate that DMI plays the role of complementary asset to AMT usage when quality, delivery and process flexibility are considered. A complementary role is not observed for cost efficiency and new product flexibility. In fact, the results suggest that combined high levels of DMI and AMT usage can be costly.	Survey	
(Taylor, 1997) IIE	DFM/A Design for X	Not specified	This paper provides a mathematical model for design for global manufacturing and assembly (DFGMA) to assist designers in making optimal sourcing, capital procurement, and market timing decisions in a multi-facility, global environment. The DFGMA model incorporates various kinds of costs (e.g., design costs, inventory costs etc.) and has the objective to minimize the sum of all of these costs. It is designed to make product sourcing decisions during the design stage. It may also help in designing products in a way to exploit existing tooling capabilities at multiple facilities.	Non-empirical: Simulation	None
(Trygg, 1993) JPIM	QFD DFM/A	Manufacturing industry (Sweden)	See Appendix B, Table 3: Results for Quality Function Deployment.	Empirical: Survey	None
(J.-H. Wang & Trolio, 2001) IJPR	DFM/A	Diverse	This paper studies the benefits of DFA. It investigates 12 product cases that employed DFA method for redesign and it was found that DFA benefits correlate with product assembly properties. These were measured using manual handling and insertion assembly elements. Two sets of correlation models for estimating potential DFA benefits were developed. An example is provided to illustrate the estimation procedure and its result.	Empirical: Archival	None

Appendix B, Table 11: Results for Design for X

Appendix B, Table 11: Results for Design for X

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Bevilacqua, Ciarapica, & Giacchetta, 2007) IJPR	Design for X	Metals & Electronics	The paper proposes a new way for combining environmental and economic considerations with sustainable development. It is based on integrating Design for Environment method and the life-cycle assessment technique. A case study of an electrical distribution board manufacturer demonstrated how environmental expertise can be integrated into the design process without much extra effort. For cost management an environmental/economical break-even point was calculated.	Empirical: Observations	Engineering, "how to"
(Bordoloi & Guerrero, 2008) IJPE	Design for X	Not specified	The paper introduces "Design for Control" (DFC) to manage the costs associated with the introduction of new products to the manufacturing control system.	Non-empirical: Theoretical	None
(Brad, 2009) IJPR	QFD Design for X	Consumer Goods	See Appendix B, Table 3: Results for Quality Function Deployment.	Non-empirical: Simulation	None
(Elgh & Cederfeldt, 2007) IJPE	Design for X	Manufacturing	The paper introduces a cost estimation tool in NPD. The tool is aligned with principles of DFP (Design for Producibility), a method close to DFM. It can serve as a decisions tool that enables the evaluation of different courses of action in the early stages in the development of product variants. The tool was applied and realised through a software implementation in the case of the design of heavy welded steel structures.	Empirical: mix	Engineering, "how to"
(Fargnoli et al., 2013) JETM	QFD Design for X	Gardening equipment firm (Italy)	See Appendix B, Table 3: Results for Quality Function Deployment.	Empirical: mix	Case study
(Goffin, 1998) JPIM	TCO Design for X	High-technology companies	See Appendix B, Table 7: Results for Total Cost of Ownership.	Empirical: mix	Case study
(Goffin, 2000) RTM	Life-cycle costing TCO Design for X	Multiple industries	See Appendix B, Table 6: Results for Life-Cycle Costing.	Empirical: Qualitative	Management practice
(Grote et al., 2007) IJPR	Design for X Life-cycle costing	Consumer Goods	See Appendix B, Table 6: Results for Life-Cycle Costing.	Non-empirical:	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
				Simulation	
(Ijomah, McMahon, Hammond, & Newman, 2007) IJPR	Design for X	Diverse	The aim of this paper is the development of design-for-remanufacturing guidelines to support the development of green products. Multiple case-studies in the mechanical and electromechanical sector of the UK are used as a foundation. Findings suggest environmental issues are not the first reason to implement such a method, more likely the economic benefits are a major driver followed by the desire to have a green image.	Empirical: mix	Case study
(M. R. Johnson & Wang, 1995) IJPR	Life-cycle costing Design for X	Technology & Telecommunication	See Appendix B, Table 6: Results for Life-Cycle Costing.	Non-empirical: Simulation	None
(Loch et al., 1996) JPIM	Value engineering DFM/A Design for X	Electronics industry	See Appendix B, Table 1: Results for Target Costing.	Empirical: Survey	None
(Lu & Wood, 2006) IJOPM	DFM/A Design for X	Metals & Electronics	See Appendix B, Table 10: Results for Design for Manufacturing/Assembly.	Empirical: Observations	Case study
(Mangun & Thurston, 2002) IEEE-EM	Life-cycle costing Design for X	Not specified (example from personal computer industry)	See Appendix B, Table 6: Results for Life-Cycle Costing.	Empirical: Archival	Engineering, "how to"
(Tucker J. Marion & Meyer, 2011) JPIM	Design for X	Physical assembled products where design plays a role, less than ten years old	Using a survey and subsequent in-depth interviews, this study investigates the impact of industrial design and cost engineering (which we consider as a particular form of DFX) activities on NPD and business performance in early-stage firms. Cost engineering showed to have negative effects on product development cost, time and project breakeven timing, yet a positive impact on cumulative sales and product margins. When intensively applied jointly with industrial design, cost engineering showed positive effects in terms of product development cost and time as well as project breakeven time.	Empirical: mix	Case study
(Murthy & Blischke, 2000)	Design for X	Manufacturing	This paper provides a life-cycle framework which can be used to formulate a warranty strategy. Warranty costs can be influenced in the design stage of a	Non-empirical:	None

Author, date, journal	**Cost management method(s)**	**Industry**	**Summary (regarding the focal cost management method)**	**Type of data**	**Field work**
IEEE-EM			product. Therefore, this paper puts particular emphasis on several pre-launch stages (e.g., pre-design phase, design phase etc.). It is described how warranty costs may be influenced before product launch and which cost-tradeoffs exist. We consider this DFX, although "design for warranty" is not explicitly mentioned.	Theoretical	
(S. Ray & Kanta Ray, 2011) Techn	DFM/A Design for X Modular design	Automotive (Tata Motors)	See Appendix B, Table 10: Results for Design for Manufacturing/Assembly.	Empirical: mix	Case study
(Taylor, 1997) IIE	DFM/A Design for X	Not specified	See Appendix B, Table 10: Results for Design for Manufacturing/Assembly.	Non-empirical: Simulation	None

Appendix B, Table 12: Results for Component Commonality

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Agrawal, Sao, Kiran, Tiwari, & Kim, 2013) IJPR	Modular design Component com. Product platforms	Not specified	The paper presents a decision model for the application of modular design and component commonality. The model is tested through numerical simulation with realistic but fictitious data. In most scenarios the combination of both methods is most beneficial.	Non-empirical: Simulation	None
(Caux, David, & Pierreval, 2006) IJPR	Component com.	Manufacturing	This paper studies the implementation of delayed product differentiation in batch process industries by adding an intermediate stock with highly standardised components. The authors implement their approach as a linear-programming model and apply it to the aluminum-conversion industry. In the case the introduction of an intermediate stock was beneficial, because reducing the number of slab types from 100 to 8 enabled the implementation of a make-to-stock strategy at a reasonable cost.	Empirical: Observations	Case study
(Chakravarty, 1994) IIE	Component com.	Small electromechanical parts assembly	This paper provides a quantitative analysis of flexible assembly capacity, resulting from the choice between either product-specific assembly systems or more expensive flexible assembly systems. Higher component commonality among the parts to be assembled leads to lower fixed and operational costs.	Non-empirical: Analytical	None
(Davila & Wouters, 2007) IJPR	Component com.	Technology & Telecommunication	The paper evaluates the benefits of a postponement strategy on inventory, services and costs. The authors analyze empirical data of a disk drive manufacturer that had redesigned its supply chain by implementing a postponement strategy. An increase in the percentage of generic products had a positive impact on on-time delivery as well as on operational costs but not on inventory turns. Postponement can be used for improving customer service or reducing inventory.	Empirical: Archival	Case study
(DeCroix, Song, & Zipkin, 2009) MSOM	Component com.	Not specified	The paper considers a multiproduct assemble-to-order system with a focus on the impact of returns of components. The value of component commonality depends on how much and which components are recoverable. In most scenarios, component commonality yields cost improvements due to risk pooling.	Non-empirical: Simulation	None
(Eynan & Rosenblatt, 1996)	Component com.	Not specified	This paper employs a mathematical single-period model to examine how component commonality affects inventory cost. The optimal inventory level	Non-empirical:	None

Appendix B, Table 12: Results for Component Commonality

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
IIE			depends on the desired service level. Furthermore, component commonality results in lower inventory cost. However, it is not advisable when the common component is much more expensive.	Analytical	
(Farrell & Simpson, 2010) IJPR	Product platforms Component com. Modular design	Metals & Electronics	This paper examines how commonality within the redesign of an existing product line can be improved to achieve cost savings. The method considers manufacturing as well as implementation costs for the choice between a modular or a scaled strategy. The proposed four-step product platform portfolio optimisation method shows promise for creating a product platform portfolio from a set of candidate component platforms that is most cost effective within an existing product line.	Non-empirical: Simulation	None
(Gupta & Benjaafar, 2004) IIE	Component com. Product platforms	Not specified	This paper presents several mathematical models to examine various aspects of delayed product differentiation (e.g., costs, benefits) of a platform in series production. In one situation, it is determined whether it is more cost-effective to employ several semi-differentiated platforms for different products than a single one.	Non-empirical: Simulation	None
(Halman, Hofer, & Van Vuuren, 2003) JPIM	Component com. Modular design Product platforms	Multiple industries (OEMs; case studies at ASML, Skil, SDI)	Based on case studies in three technology-driven companies, this paper investigates how and why companies are adopting, developing, implementing, and monitoring platform and product family concepts in practice. Cost benefits were expected, for example through part or component reuse, or modular design. However, most companies mentioned increased development times, costs and complexity of the initial platform as a risk of product family development.	Empirical: Qualitative	Case study
(Heese & Swaminathan, 2006) MSOM	Component com.	Not specified	This paper discusses the benefits of component commonality when a manufacturer designs a product line consisting of two products sold in two market segments with different valuations of quality. The authors develop a model and analyze the outcomes of cost-reduction efforts. The paper shows that the common assumption commonality leads to cost savings and loss of product differentiation always leads to less attractive product lines and reduced revenues was not supported. An optimally designed product line involving common components might be more attractive and yield higher revenues than a product line based on different variants.	Non-empirical: Analytical	None
(Hillier, 2000) IIE	Component com.	Not specified	This paper applies a mathematical multi-period model to investigate the impact of component commonality on costs. Component commonality may not be	Non-empirical:	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			beneficial, in particular if the purchasing or production cost of a common component is even slightly higher than the cost of the respective conventional component which is to be replaced. Savings on inventory costs may not be sufficient to outweigh the additional cost of the common component. Numerical experiments are used to test the benefits of component commonality under varying conditions.	Simulation	
(Ismail, Reid, Mooney, Poolton, & Arokiam, 2007) IEEE-EM	Component com. Modular design Product platforms	Small and medium-sized enterprises (SMEs)	This paper introduces and demonstrates, through two case studies, how the principles of mass customisation have been adopted by SMEs n the context of manufacturing agility and product flexibility. The paper explores the issues of product configuration, component similarity, and tools and measures of performance to steer the implementation process of mass customisation. The authors find that SMEs generally lack the internal costing structures that enable them to clearly quantify the benefits of product rationalisation or mass customisation.	Empirical: mix	Case study
(Izui et al., 2010) IJPR	Component com.	Metals & Electronics	The paper analyzes the trade-off among inventory level, delivery lead-time and product performance when applying a component commonality approach. The analysis is based on a multi-objective component commonality design optimisation problem. The use of component commonality in a fictitious switchgear design case shows inventory cost reductions as well as a reduction of product delivery lead-times.	Non-empirical: Simulation	None
(Michael D. Johnson & Kirchain, 2009) IJPE	Component com. Product platforms	Automotive	The selection of alternative materials and the use of platform strategy for the design of new products are linked and discussed in this paper. A process-based cost model was applied in a case study in the automotive industry. Results indicated the cost-saving effects of component commonality can be greater than under a product strategy with a focus on cost-savings through alternative materials.	Empirical: Observations	Case study
(Michael DeShawn Johnson & Kirchain, 2010) IEEE-EM	Component com.	Automotive OEMs (U.S.)	Based on cases of two automotive instrument panel part families and applying a process-based cost-model, this study scrutinizes the relationship between component commonality and cost. Various commonality metrics are assessed to determine how they correlate with cost savings. In both case studies, component commonality resulted in considerable savings, mainly from reductions in assembly and development costs.	Empirical: Archival	Engineering, "how to"

Appendix B, Table 12: Results for Component Commonality

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Liu, Wong, & Lee, 2010) IJPR	Component com. Modular design Product platforms	Metals & Electronics	This paper presents a systematic framework to assist implementing modularity and commonality in platform development. A tractable optimisation method is used to capture and resolve the trade-off between commonality configuration and individual product performance. A family of power tool designs is used to demonstrate the potential and feasibility of the proposed framework.	Empirical: Observations	Engineering, "how to"
(T. J. Marion, Thevenot, & Simpson, 2007) IJPR	Component com. Product platforms	Diverse	Two examples involving two consumer product companies and their product lines are presented. Product family components and estimated tooling costs are analysed, as well as development time and profit margins to demonstrate why companies are moving away from product platforms in certain types of consumer products. A novel method relating component commonality decisions to major cost drivers is introduced and applied to both examples. There were fewer financial or functional benefits to develop product platforms that share common components or subsystems when these products are being manufactured offshore.	Empirical: Archival	Case study
(M. H. Meyer & Dalal, 2002) JPIM	Component com. Product platforms	Non-assembled products	By conducting a case study in three companies, this paper investigates management of platform architectures for non-assembled products. Two methods for measuring platform efficiency and platform reuse are proposed and tested. In a case study of an electronics manufacturer, a platform-centric product line with greater reuse achieved better performance (e.g., in terms of lower average product development cost, higher revenue, higher ROI) compared to the product line with less reuse.	Empirical: mix	Case study
(M. H. Meyer & Mugge, 2001) RTM	Component com. Product platforms	Computer hardware industry (IBM)	This paper describes guidance principles and success factors when implementing and managing product platforms, also considering component commonality. Particular emphasis is put on the case of IBM's hardware business, where platforms are employed extensively. Applied concurrently with other initiatives, platform management resulted in performance improvement in various aspects (e.g., 42% less NPD spending from 1994 to 1997, yet revenues were increased; less abandoned projects; shorter time-to-market). Moreover, cost considerations of product platforms in general are discussed.	Empirical: Qualitative	Management practice
(Nobelius & Sundgren, 2002) JETM	Component com. Product platforms	Manufacturing industry (Sweden)	The aim of this case study is to explore the managerial difficulties associated with the parts sharing process. Six manufacturing companies in four different industries are investigated. Managerial difficulties are divided into four categories: organisational, strategic, technology & cost related, and support-	Empirical: mix	Case study

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			system related issues. In one case, the promotion of parts sharing led to repeated redesigns of platform elements, causing a cost/performance ratio increase of more than 30%, and the time-schedule was exceeded by more than 40%. In another case, parts that were to be transferred from the most expensive model to the remaining models were found too expensive, considering the remaining models' cost strategy.		
(J. Park & Simpson, 2005) IJPR	Component com.	Metals & Electro-nics	A production cost estimation framework to support product family design is presented and illustrated with the example of a family of cordless electric power screwdrivers considering sharing various components. Using this framework enabled designers to investigate a production system and product structure for product family design, estimate production costs, and analyze the activities generated in the production system to find resources to be shared, selected, reduced, and eliminated.	Non-empirical: Simulation	None
(Jaeil Park & Simpson, 2008) IJPR	Component com. Product platforms	Metals & Electro-nics	Two cases are studied to investigate the cost effects of product family design. The first case investigates the cost effects of commonality in terms of cost allocations of overhead costs on each product. The second case investigates an architectural solution to a platform and its cost effects. As a result, an activity-based costing model is presented to support the design of cost-efficient product families.	Non-empirical: Simulation	None
(Perera, Nagarur, & Tabucanon, 1999) IJPE	Component com.	Not specified	The paper studies the effect of component part standardisation on life-cycle costs. Therefore the life-cycle phases of product development, manufacturing, distribution, usage and disposal are analysed and possible effects of standardi-sation are identified. Possible benefits and disadvantages of component part standardisation are discussed.	Non-empirical: Theoretical	None
(Perlman, 2013) IJPR	Component com.	Automotive	The paper analyzes the effect of risk on product family design for uncertain consumer segments. A model is used to analyze whether the producer's risk level affects the decision of implementing common components. The case of an automotive product family shows that common components are preferred under high market uncertainty while companies prefer unique configurations under low uncertainty.	Non-empirical: Simulation	None
(Kamalini	Component com.	Automotive	This paper presents a method for determining which versions of a set of related	Non-	None

Appendix B, Table 12: Results for Component Commonality

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Ramdas, Fisher, & Ulrich, 2003) MSOM			components should be offered to support a defined finished product portfolio. Coordinated projects, project-by-project, and a hybrid partially coordinated projects are three different organisational approaches to component sharing. It is examined how the gain from the coordinated projects approach relative to the project-by-project approach varies with the number of component versions in consideration, warranty costs, complexity costs, and demand variability.	empirical: Simulation	
(Salvador, Rungtusanatham, Forza, & Trentin, 2007) IJOPM	Component com.	Automotive	This paper investigates the factors enabling or hindering the simultaneous pursuit of volume flexibility and mix flexibility within a supply chain. through the lens of a manufacturing plant seeking to implement a build-to-order strategy. An in-depth case study of a manufacturing plant and its supply chain was conducted. The results suggest that volume flexibility and mix flexibility may be achieved synergistically, as initiatives such as component standardisa-tion or component-process interface standardisation would improve both volume flexibility and mix flexibility.	Empirical: Qualitative	Case study
(Sanchez, 1999) JM	Component com. Modular design Product platforms	Not specified	This paper broadly discusses a multitude of aspects of modular product architectures. Several properties as well as effects, benefits and opportunities enabled by modularity are described, with special emphasis on the changes it will bring to marketing strategy and processes. The author also discusses how modularity can achieve cost reductions in product creation and realisation (e.g., savings enabled through common components).	Non-empirical: Theoretical	None
(J.-S. Song & Zhao, 2009) MSOM	Component com.	Not specified	The value of component commonality in a dynamic inventory system with lead times is the research topic of this paper. A numerical simulation is used to analyze the benefits of component commonality for different inventory systems. The results can be used to evaluate the implementation of component commonality during the product design process.	Non-empirical: Simulation	None
(Ulrich, 1995) ResPol	Component com. Modular design	Not specified	This paper defines product architecture, provides a typology of product architectures, and articulates the potential linkages between the architecture of the product and five areas of managerial importance: (1) product change (2) product variety (3) component standardisation (4) product performance, and (5) product development management. The author notes that standardised components usually cost less and have a higher performance compared to specifically-designed components.	Non-empirical: Theoretical	None
(Vakharia,	Component com.	Not specified	The effects of component commonality on manufacturing firms which use a	Non-	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Parmenter, & Sanchez, 1996) JOM			material requirements planning system are the focus of this paper. Results are based on two simulated MRP systems with different lot sizing methods. Mostly positive, as well as some negative impacts are discussed.	empirical: Simulation	
(L. Wu, De Matta, & Lowe, 2009) IEEE-EM	Component com. Modular design	Not specified	This paper employs an analytical model to examine when and how to update modular products, considering the possibility to carry over parts to the next generation. Conditions are provided when updating every component or only some components or continuing selling the old product may be most effective in terms of cost management or profit contribution.	Non-empirical: Analytical	None
(Q. L. Xu, Ong, & Nee, 2007) IJPR	Component com.	Technology & Telecommunication	Within the evaluation of a proposed model for product family design re-use, the paper discovers a relation between cost-effectiveness of product-family design and component commonality. The results of a simulated scenario indicate a positive correlation for the use of commonality and lower costs.	Non-empirical: Simulation	None
(Yura, Ishikura, & Hitomi, 2000) IJPR	Component com.	Not specified	This research provides a model to evaluate the trade-off between specialized and common parts for a set of end products. The financial basis for the evaluation are manufacturing and recycle costs. A numerical example with different demand scenarios is used to demonstrate the application.	Non-empirical: Simulation	None
(X. Zhang & Huang, 2010) IJPR	Component com. Product platforms Modular design	Manufacturing	This paper discusses optimizing decision variables for simultaneously configuring not only platform-based product variants but also their supply chain. The authors developed a mixed-integer programming model that integrates both platform product design and material purchase decisions based on cost drivers related to commonality and modularity. A numerical example is presented to illustrate how manufacturers strive to dynamically adjust their product design strategies in response to changes in the market demands and/or supply base.	Non-empirical: Simulation	None
(X. Zhang, Huang, & Rungtusanatham, 2008) IJPE	Component com. Product platforms Modular design	Manufacturing	Based on earlier research (X. Zhang & Huang, 2010), a game-theoretic approach is applied to work out maximal profit over the entire supply chain. Findings suggest that if a platform strategy (regardless of whether focused on modular design or component commonality) is used for the product design, all companies in a supply chain will be better off.	Non-empirical: Simulation	None
(Zhou & Grubbström, 2004) IJPE	Component com.	Not specified	This paper focuses on the effect of commonality in multi-level production-inventory systems, especially assembly systems. The basic balance equations of MRP, and input-output analysis together with the Laplace transform, are	Non-empirical: Simulation	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			used for comparing the cases with and without commonality. Applying the net present value as the objective function, conclusions are derived in the form of conditions for when commonality is recommended, and when not.		
(Zwerink, Wouters, Hissel, & Kerssens-van Drongelen, 2007) RADMA	Component com. Modular design	Electronics indust-ry (Philips)	This paper provides a matrix framework which relates decisions about product architecture characteristics (e.g., reuse, component commonality, modularity) with product architecture capabilities, performance at the organisational level and performance at the business unit level (e.g., sales, cost of goods sold). The framework is intended to be used and discussed during a workshop to provide a structured learning experience about product architecture implications, and to generate recommendations about future product architecture decisions for similar products.	Empirical: Qualitative	Engineering, "how to"

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Agard & Bassetto, 2013) IJPR	Modular design	Metals & Electro-nics	The paper introduces a model for selecting a set of modules that allows the constraints of each product to be satisfied, while minimising the total production cost for the product family. An example of the modular design of head-lamp devices is presented for illustrating and analysing the model.	Non-empirical: Simulation	None
(Agard & Penz, 2009) IJPE	Modular design	Automotive	The paper presents a method for modular design which helps to generate a bill of materials for large products families at minimum cost, depending on the maximum assembly time of a product and the number of functions of a modular unit. Computational experiments are conducted to demonstrate the effectiveness of the model. .	Non-empirical: Simulation	None
(Agrawal et al., 2013) IJPR	Modular design Component com. Product platforms	Not specified	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Simulation	None
(Chakravarty & Balakrishnan, 2001) IIE	Modular design	OEMs	This paper presents a mathematical approach to show how the choice of module-options affects product variety, total sales, product development cost, and hence, the firm's profit, in settings where modules can be self-developed (by wholly-owned subsidiary suppliers) or bought from independent suppliers. It is demonstrated how to develop or buy the optimal number and type of module-options.	Non-empirical: Analytical	None
(Chang & Yeh, 2013) IJPR	Modular design	Not specified	The authors investigate the effects of the manufacturer's refund for the retailer's unsold products and product modularity under the decentralized and the centralized strategies. The order quantity and customer's return probability both affect the optimal modularity level of the product, and the optimal modularity level is related to the refund policy.	Non-empirical: Analytical	None
(K. Das & Chowdhury, 2012) IJPE	Modular design	Not specified	This study proposes an integrated, reverse logistics supply chain planning process with modular product design that produces and markets products at different quality levels. A mixed integer programming model formulates the overall planning process required to maximise profit by considering the collection of returned products, the recovery of modules, and the proportion of the product mix at different quality levels. This study uses a total supply-chain	Non-empirical: Simulation	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			view that considers the production, transportation and distribution of products to customers. A numerical example illustrates the applicability of the models.		
(Farrell & Simpson, 2010) IJPR	Product platforms Component com. Modular design	Metals & Electro-nics	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Simulation	None
(Garud & Munir, 2008) ResPol	Modular design	Photography equipment |(Polaroid)	Studying the case of a Polaroid camera, this paper examines the transformation costs that arise when competencies across a production network are reorgan-ised because of design changes. These costs may exceed the anticipated benefits, when only transaction costs are considered for decision-making. Especially for radical, modular design changes and in- or outsourcing consid-erations that come with it, considering the transformation costs is advised.	Empirical: mix	Case study
(Gil, 2009) IEEE-EM	Modular design	Airport industry	This study defines safeguard as the design and physical development work for ensuring, or enhancing, the embedment of an option in the project outcome. An option to change the design can be exercised if environmental uncertainties resolve favorably in the future. An example of a safeguard is additional space in a master plan. The paper includes a case study of an airport expansion program. A lower degree of modularity of the architecture of the infrastructure made investments in safeguards more attractive.	Empirical: mix	Case study
(Halman et al., 2003) JPIM	Component com. Modular design Product platforms	Multiple industries	See Appendix B, Table 12: Results for Component Commonality.	Empirical: Qualitative	Case study
(He & Kusiak, 1996) IJPR	Modular design	Not specified	This paper studies the impact of modular product designs on the performance of a manufacturing system. The performance of product designs is measured by the makespan of the corresponding schedule. Three design rules for the improvement of performance of product designs are developed. The selection problem of modular designs is formulated as an integer programming model. The problem can be solved by an existing heuristic algorithm. Examples illustrate the model.	Non-empirical: Simulation	None
(Hopp & Xu, 2005) MSOM	Modular design	Not specified	This paper addresses the strategic impact of modular design on the optimal length and price of a differentiated product line. Two crucial aspects can be derived from the model: First, the potential of modular design is not only reduction of development cost, but also enlargement of product variety, higher	Non-empirical: Analytical	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			market share and the possibility to charge higher prices. Second, clear differentiation of products is needed for success of modularity.		
(Huang, Stewart, & Chen, 2010) IJOPM	Modular design	Metals & Electronics	This paper investigates the relationships between integrated supplier management, new product development, knowledge sharing practices and the business performance of company. A survey and semi-structured interviews in the Taiwanese electronics manufacturing industry were conducted. Findings show that the implementation of modular design had great positive influence on manufacturing performance and consequently on business performance.	Empirical: mix	Case study
(Ismail et al., 2007) IEEE-EM	Component com. Modular design Product platforms	Small and medium-sized enterprises (SMEs)	See Appendix A, Table 13: Technology Roadmaps.	Empirical: mix	Case study
(Jacobs, Vickery, & Droge, 2007) IJOPM	Modular design	Automotive	This paper examines the effects of product modularity on four aspects of competitive performance: cost, quality, flexibility, and cycle time, based on a survey of the automotive sector. The relationships between product modularity and performance are tested with three different integration strategies as mediators. Modularity positively and directly influences each aspect of competitive performance for each integration strategy tested. Indirect effects were found for each integration strategy for cost and flexibility; and for manufacturing integration and cycle time.	Empirical: Survey	None
(Jacobs, Droge, Vickery, & Calantone, 2011) JPIM	Modular design	Automotive suppliers (U.S.)	By conducting a survey among first-tier automotive suppliers in the U.S., this study assesses the effects of product and process modularity on firm growth performance (includes measures such as ROI, ROS, and market share) and manufacturing agility. Several models with different assumed relationships are tested. The results suggest that product modularity directly and positively influences process modularity, firm growth performance and manufacturing agility. Product modularity did not influence firm growth performance indirectly through manufacturing agility.	Empirical: Survey	None
(Jiao, 2012) IIE	Modular design Product platforms	Not specified (framework tested in an electronics company)	This paper provides a mathematical real-options framework, which integrates financial and engineering analysis. The framework supports product platform planning by evaluating the flexibility within product platforms. The proposed approach has been applied in an electronics company.	Empirical: Archival	Engineering, "how to"

Appendix B, Table 13: Results for Modular Design

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(John, Weiss, & Dutta, 1999) JM	Modular design Product platforms	Companies in technology-intensive markets	This paper examines technology-intensive markets (e.g., semiconductors) from a marketing perspective. The decision to decide between platform-products and tailored products is briefly discussed. It is suggested to align the platform to high-end users to recover development costs first, in order to be able to offer lower-price platform products for little incremental cost at a later stage. Furthermore, the decision to choose between integral and modular designs is discussed.	Non-empirical: Theoretical	None
(Kamrad, Schmidt, & Ülkü, 2013) IEEE-EM	Modular design	Not specified	This paper applies an economic model to determine under which conditions it may be advantageous for a firm to employ modularly upgradeable product architecture, while particularly considering technological change. Different conditions are investigated to understand when a modular, upgradeable product is more beneficial or profitable than an integral product. In particular, these are: 1) market scale is small; 2) the firm's cost of redesigning an integral product is high; 3) production costs are high; 4) the firm's pricing power is limited; 5) the components evolve at very different rates; 6) the performance loss due to modularity is low; and 7) user integration costs are low.	Non-empirical: Analytical	None
(Kaski & Heikkila, 2002) IJTM	Modular design	Cellular network industry	This paper investigates a way to improve supply-chain efficiency based on a case study of a cellular network base station. Different product structure alternatives are compared using two design metrics, and simulation methods (an inventory value model and an activity-based costing model) are applied to estimate the inventory and operating costs of the alternative structures. The simulation results indicate that operating costs are closely linked to the number of physical modules and the dependencies within the product structure. As for inventory costs, both metrics have an effect, yet only if both are improved jointly.	Empirical: mix	Engineering, "how to"
(Lau Antonio, Yam, & Tang, 2007) IJPE	Modular design	Manufacturing	The impact of modular design on product performance is examined, based on a survey with 251 participants from the plastics, electronics and toys industries in Hong Kong. Results indicate that product modularity influences the capabil-ities of delivery, flexibility and customer service, and the capabilities of delivery and flexibility positively relate to product performance. These find-ings show that modular product design cannot improve each capability simul-taneously, as existing literature suggests.	Empirical: Survey	None
(Lau, Yam, &	Modular design	Manufacturing	The paper examines the relationship between supply chain integration (SCI)	Empirical:	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Tang, 2010) IJOPM			and modular product design, as well as their impact on product performance. Survey data from 251 manufacturers in Hong Kong are analysed with structural equation modelling. Results show that information sharing, product co-development and organisational coordination are crucial organisational processes within SCI. Companies that have high levels of product modularity appear to be good at product co-development and organisational coordination directly and at information sharing indirectly. Furthermore, companies that have high levels of product co-development or product modularity appear to have better product performance.	Survey	
(Liu et al., 2010) IJPR	Component com. Modular design Product platforms	Metals & Electronics	See Appendix B, Table 12: Results for Component Commonality.	Empirical: Observations	Engineering, "how to"
(Magnusson & Pasche, 2014) JPIM	Modular design Product platforms	Manufacturing industry (Sweden)	The paper investigates contingencies influencing the applicability of modularisation and product platforms. Moreover, the paper addresses how different organizing solutions are interrelated with the use of modularisation and product platform approaches. The case study shows that platforms were applied for products where the speed of change is low and cost-efficient functionality is demanded, whereas modularity was employed for products which are subject to frequent changes and which should be customizable. Also, modularity was perceived to reduce coordination costs for integrating components.	Empirical: Qualitative	Case study
(Mukhopadhyay & Setoputro, 2005) JOM	Modular design	Not specified	This paper introduces a model to increase profits on built-to-order markets. A numerical simulation shows how to find a proper level of modularity and suitable return policy to manage the trade-off between increasing sales and revenues and growing costs of returned goods and development. In addition the paper includes a number of managerial guidelines.	Non-empirical: Simulation	None
(Nepal, Monplaisir, & Singh, 2005) IJPE	Modular design	Consumer Goods	This paper presents a formal method for optimizing the performance attributes of prospective modules while modularizing the product architecture early in the concept development phase. Although the paper illustrates the procedure for minimising the cost of modular architecture, the method can also be used for optimisation of other attributes such as quality, reliability, manufacturability, etc. A case example is presented to demonstrate the proposed method.	Non-empirical: Simimulation	None

Appendix B, Table 13: Results for Modular Design

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(P. K. P. K. Ray & Ray, 2010) IEEE-EM	Modular design	Indian telecommu-nication industry	This paper assesses the case of an Indian telecommunication company in order to investigate what kind of innovation models effectively suit the needs of emerging markets. A modular design strategy enabled the case company to achieve savings in terms of costs of innovation, R&D and materials. Further positive effects were observed (e.g., facilitation of the training of operators).	Empirical: mix	Case study
(Patel & Jayaram, 2014) JOM	Modular design	Not specified	This research focuses on the antecedents and consequences of product variety in new ventures. As one result of a survey among 141 new ventures from the U.S., modular design was underlined as relevant driver for more product variety. The study also gave some practical implications on what must be considered with the introduction of modular design.	Empirical: Survey	None
(Rai & Allada, 2003) IJPR	Product platforms Modular design	Metals & Electro-nics	This paper provides a two-step approach to tackle the modular product family design problem. The first step performs a multi-objective optimisation using a multi-agent framework to determine the Pareto-design solutions for a given module set. The second step performs post-optimisation analysis that includes a novel application of the quality loss function to determine the optimal platform level for a related set of product families and their variants. The proposed method is applied to a product family design example to demonstrate its validity and effectiveness.	Non-empirical: Simulation	None
(Ramachandran & Krishnan, 2008) MSOM	Modular design	Technology & Telecommunication	The challenges for markets with short innovation cycles are studied, compar-ing integrated and modular design architectures. Modular design is an efficient method to keep pace of innovation and ensuring constant profitability. Further the paper distinguishes between proprietary and nonproprietary approaches for the design of modular products. Recommendations for the appropriate use of modular design in different scenarios are given.	Non-empirical: Analytical	None
(Ro et al., 2007) IEEE-EM	Target costing Modular design	Automotive OEMs and suppliers (U.S.)	See Appendix B, Table 1: Results for Target Costing.	Empirical: Qualitative	Management practice
(S. Ray & Kanta Ray, 2011) Techn	DFM/A Design for X Modular design	Automotive industry (Tata Motors)	See Appendix B, Table 10: Results for Design for Manufacturing/Assembly.	Empirical: mix	Case study
(Sanchez, 1999) JM	Component com. Modular design Product platforms	Not specified	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Theoretical	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Sanderson, 1991) JETM	Modular design	Example from television industry	This paper identifies and evaluates the cost implications of two complementary approaches to information management in the design of new products: virtual design and modular design. An analytical model is developed to show the dependence of product development cost on the design management strategy, characterised by investment in tools and infrastructure for virtual design and modular technology methods. Modular design through group technology is considered to reduce costs for designing and manufacturing standard parts.	Non-empirical: Analytical	None
(Sanderson & Uzumeri, 1995) ResPol	Modular design Product platforms	Consumer electronics (Sony)	This paper represents an in-depth study of the case of the Sony Walkman product family and seeks to investigate what led to the Walkman's worldwide success. Modular designs and the use of platforms enabled Sony to achieve low costs while ensuring high quality for a wide range of models.	Empirical: mix	Case study
(Sundgren, 1999) JPIM	Modular design Product platforms	Manufacturing industry (Sweden)	By conducting a longitudinal case study among two Swedish manufacturing companies, this paper investigates how interface management is practically managed in new platform development. In one case, a product cost reduction of 30% was achieved among a product family through a highly configured platform, however, to the disadvantage of extended development time.	Empirical: mix	Case study
(Thyssen, Israelsen, & Jørgensen, 2006) IJPE	Modular design	Diverse	The paper reports an activity-based costing (ABC) analysis supporting decision-making about product modularity. The ABC analysis is communicated to decision-makers by telling how much higher the variable cost of the multi-purpose module can be compared to the average variable cost for the product-unique modules that it substitutes to break even in total cost. Three general rules of cost efficiency of modularisation are formulated.	Empirical: mix	Engineering, "how to"
(Ulrich, 1995) ResPol	Component com. Modular design	Not specified	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Theoretical	None
(Uskonen & Tenhiälä, 2012) IJPE	Modular design	Consumer Goods	This paper shows how change orders in the make-to-order manufacturing industry can be handled cost efficiently. The production of refrigeration machineries and remotely refrigerated display cabinets are the topic of a case study. A mix of empirical data was used to show, for example, that modularity in many cases can reduce the costs of a change order.	Empirical: mix	Case study
(Wouters,	Modular design	Medical equipment	This article presents an approach to financially assess the product architecture	Empirical:	Case study

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Workum, & Hissel, 2011) RADMA		industry (Philips)	decision about the incorporation of a product feature. The case company employed modularity to prepare their product for the easy incorporation of a product feature at a later stage quickly and at low cost, if customers desired this feature. However, the case results suggest that preparing for the product feature was expensive, and would pay off only if demand for the feature came up shortly after product launch.	mix	
(L. Wu et al., 2009) IEEE-EM	Component com. Modular design	Not specified	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Analytical	None
(S. X. Xu, Lu, & Li, 2012) IJPE	Modular design	Not specified	This paper introduces a model for the optimal employment of modular design under the constraints of a volatile market. The model is based on real options theory and was applied in a fictitious case study. The results show that when market is more volatile, it is optimal for a firm to postpone modularisation; when a firm's investment efficiency at the preparation stage is higher, the firm can start modular production earlier with relatively low product modularity. An increase in market uncertainty will stimulate the firm to improve its product modularity. Comparing the predictions from the net present value method (NPV) to the results from the real options model shows that traditional NPV method underestimates a firm's value for modular production and might mislead a firm to modularize earlier.	Non-empirical: Simulation	None
(X. Zhang & Huang, 2010) IJPE	Component com. Product platforms Modular design	Manufacturing	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Simulation	None
(X. Zhang et al., 2008) IJPR	Component com. Product platforms Modular design	Manufacturing	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Simulation	None
(Zwerink et al., 2007) RADMA	Component com. Modular design	Electronics industry (Philips)	See Appendix B, Table 12: Results for Component Commonality.	Empirical: Qualitative	Engineering, "how to"

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Agrawal et al., 2013) IJPR	Modular design Component com. Product platforms	Not specified	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Simulation	None
(Ben-Arieh, Easton, & Choubey, 2009) IJPR	Product platforms	Metals & Electronics	A method for selecting one or multiple platforms for a product family is proposed. It minimizes production costs of the products, which include the costs of components, costs of mass assembly, and costs for adding/removing components from the individual products, while considering the individual demand for each product type. A numerical example shows the effectiveness of the algorithm and indicates it can be advantageous to use more than one platform for a product family.	Non-empirical: Simulation	None
(Bhandare & Allada, 2009) IJPR	Product platforms	Metals & Electronics	A method is proposed to determine the minimum number of scalable platforms needed for creating known product variants by considering the tradeoff between cost effectiveness and performance degradation. The method also provides values of several design variables for each platform. The objective function is based on the total cost of providing each variant, which is a function of the cost of each product variant and the cost associated with performance loss owing to platforming. The method is demonstrated using the example of a family of axial piston pumps.	Non-empirical: Simulation	None
(Cao, Luo, Kwong, & Tang, 2014) IJPR	Product platforms	Metals & Electronics	A supplier pre-selection method for platform-based products is proposed to obtain the minimal overall outsourcing cost and supply risk probability from the perspective of whole product, to help engineers evaluate and improve early product designs, and to reduce the probability of design change at the stage of production. Analytic hierarchy process and reliability matrix are applied to evaluate the supply risk of candidate suppliers, and a genetic algorithm is adopted to solve the optimisation model. A case study is provided to illustrate the effectiveness of the model and algorithm.	Empirical: Experimental	Engineering, "how to"
(K. H. Chai et al., 2012) JPIM	Stage-gate reviews Product platforms	Multiple non-service industries (U.S.)	This paper investigates platform-based product development. It is found that product platform extensibility is positively linked to platform development cycle time and cost efficiency. Factors that have a significant effect on platform development cost are statistically different from those that have a significant	Empirical: Survey	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
			effect on platform development time. For example, a formalised development process positively affected cycle time, but not development cost.		
(Farrell & Simpson, 2010) IJPR	Product platforms Component com. Modular design	Metals & Electronics	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Simulation	None
(Guiltinan, 2011) JPIM	Product platforms	Not specified	This paper provides a literature review about models and empirical evidence on product line pricing, and referring to platform-based development, cost and profit issues seem to be especially problematic.	Non-empirical: Theoretical	None
(Gupta & Benjaafar, 2004) IIE	Component com. Product platforms	Not specified	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Simulation	None
(Halman et al., 2003) JPIM	Component com. Modular design Product platforms	Multiple industries	See Appendix B, Table 12: Results for Component Commonality.	Empirical: Qualitative	Case study
(Hauser, 2001) JPIM	Product platforms	Office equip-ment industry	This paper provides recommendation on how much relative importance to attach to various performance metrics (e.g., customer satisfaction, time to market etc.). The proposed method was applied in an office equipment company, which used platform reuse as a performance metric. It was found the case company put too much emphasis on platform reuse and thereby lost focus on customer satisfaction, thus hindering innovation. Decreasing focus on reuse would increase profits.	Empirical: mix	Engineering, "how to"
(Ismail et al., 2007) IEEE-EM	Component com. Modular design Product platforms	Small and medium-sized enterprises	See Appendix B, Table 12: Results for Component Commonality.	Empirical: mix	Case study
(Jiao, 2012) IIE	Modular design Product platforms	Not specified	See Appendix B, Table 13: Results for Modular Design.	Empirical: Archival	Engineering, "how to"
(John et al., 1999) JM	Modular design Product platforms	Companies n technology-intensive markets	See Appendix B, Table 13: Results for Modular Design.	Non-empirical: Theoretical	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Michael D. Johnson & Kirchain, 2009) IJPE	Component com. Product platforms	Automotive	See Appendix B, Table 12: Results for Component Commonality.	Empirical: Observations	Case study
(Kang, Hong, & Huh, 2012) IIE	Product platforms	Not specified	The paper presents a model to determine the optimal lifetime of platforms by trading-off the cost efficiency of platform development and lost sales due to obsolete technologies. A numerical study is conducted to assess a platform's economic value over its life. A multitude of results and implications are attained, such as companies with low platform development costs should replace platforms in short intervals.	Non-empirical: Simulation	None
(V. Krishnan, Singh, & Tirupati, 1999) MSOM	Product platforms	Metals & Electronics	A model for the design of a product family, sharing a common platform, is presented. The model balances development cost including feasible investments against the financial benefits in the production stage, in order to determine the optimal level of commonality. The model is tried in a real case application with encouraging results. However the authors mention reliable information as the major difficulty for its use.	Empirical: mix	Engineering, "how to"
(Liu et al., 2010) IJPR	Component com. Modular design Product platforms	Metals & Electronics	See Appendix B, Table 12: Results for Component Commonality.	Empirical: Observations	Engineering, "how to"
(Luo, Kwong, Tang, Deng, & Gong, 2011) IJPR	Product platforms	Metals & Electronics	This research considers the joint optimisation of component selection and supplier selection for a platform-based product family. Components of a product platform can have various functionalities or features to satisfy diversified customer requirements. The goal is to determine optimal configurations of individual product variants offered in a product family while considering the products revenue in a multiple-segment market and outsourcing-related cost. A mixed-integer nonlinear programming model with the objective of maximizing the total product family profit is formulated and a genetic algorithm and a tabu search algorithm are proposed to solve the model.	Empirical: Observations	Engineering, "how to"
(Magnusson & Pasche, 2014) JPIM	Modular design Product platforms	Manufacturing industry (Sweden)	See Appendix B, Table 13: Results for Modular Design.	Empirical: Qualitative	Case study

Appendix B, Table 14: Results for Product Platform

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(T. J. Marion et al., 2007) IJPR	Component com. Product platforms	Diverse	See Appendix B, Table 12: Results for Component Commonality.	Empirical: Archival	Case study
(M. H. Meyer & Dalal, 2002) JPIM	Component com. Product platforms	Non-assembled products	See Appendix B, Table 12: Results for Component Commonality.	Empirical: mix	Case study
(M. H. Meyer & Mugge, 2001) RTM	Component com. Product platforms	Computer hardware industry (IBM)	See Appendix B, Table 12: Results for Component Commonality.	Empirical: Qualitative	Management practice
(Moore, Louviere, & Verma, 1999) JPIM	Product platforms	Electronic test equipment company	This paper applies conjoint analyses in order to gain relevant data for product platform design decisions. In the case study, it is shown that introducing a product platform for two products would yield a profit six times greater than when launching only one product (the second one would have been unprofitable, if it had been developed fully independently). Also, products can be equipped with more features (to better meet customer requirements), if the necessary fixed costs (e.g., for engineering) are shared among several products.	Empirical: Observations	Case study
(Muffatto, 1999) IJPE	Product platforms	Automotive	The paper analyses the introduction of a platform strategy in new product development with an application in the automobile industry. A definition of platform and associated core concepts, such as product architecture, modularisation and standardisation is given. The implication and benefits of a platform strategy are then discussed both from the technical and organisational points of view.	Empirical: Qualitative	Case study
(Nobelius & Sundgren, 2002) JETM	Component com. Product platforms	Manufacturing industry (Sweden)	See Appendix B, Table 12: Results for Component Commonality.	Empirical: mix	Case study
(Jaeil Park & Simpson, 2008) IJPR	Component com. Product platforms	Metals & Electronics	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Simulation	None
(Rai & Allada, 2003) IJPR	Product platforms Modular design	Metals & Electronics	See Appendix B, Table 13: Results for Modular Design.	Non-empirical: Simulation	None
(Robertson & Ulrich, 1998) MIT SMR	Product platforms	Diverse	This paper covers fundamentals, challenges as well as benefits of product platforms. The importance of sound balance between commonality and uniqueness is underlined and practical advocacies on the implementation are given.	Non-empirical: Theoretical	None

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Sanchez, 1999) JM	Component com. Modular design Product platforms	Not specified	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Theoretical	None
(Sanderson & Uzumeri, 1995) ResPol	Modular design Product platforms	Consumer electronics (Sony)	See Appendix B, Table 13: Results for Modular Design.	Empirical: mix	Case study
(Sundgren, 1999) JPIM	Modular design Product platforms	Manufacturing industry (Sweden)	See Appendix B, Table 13: Results for Modular Design.	Empirical: mix	Case study
(X. Zhang & Huang, 2010) IJPE	Component com. Product platforms Modular design	Manufacturing	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Simulation	None
(X. Zhang et al., 2008) IJPR	Component com. Product platforms Modular design	Manufacturing	See Appendix B, Table 12: Results for Component Commonality.	Non-empirical: Simulation	None

Appendix B, Table 15: Results for Technology Roadmap

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
(Albright & Kappel, 2003) RTM	Target costing Technology roadmaps	Telecommunication industry (Lucent Technologies)	This paper describes the structure and the setup of technology roadmaps at a telecommunication company. Detailed, practitioner-oriented explanations are given and success factors in crafting and implementing roadmaps, and benefits are outlined. For the hardware industry, it is suggested to apply experience curves to provide support in setting price and cost targets.	Empirical: mix	Management practice
(Choi, Kim, Yoon, Kim, & Lee, 2013) RADMA	Technology roadmaps	Not specified	This paper builds on the notion that conventional technology roadmap creation is costly, because it requires a lot of information and expert involvement. A semi-automatic text-mining approach is presented. Complex interrelationships between technology, functions (the development purpose of technologies) and products are extracted from text-based patent information in order to develop a particular technology roadmap. This approach facilitates decision-making in technology projecting by reducing time and costs involved in crafting technol-ogy roadmaps.	Non-empirical: Theoretical	None
(Kostoff & Schaller, 2001) IEEE-EM	Technology roadmaps	Science and industries (not specified)	This intends to bring some common definition to roadmapping practices and display the underlying unity of seemingly fragmented roadmap approaches. Many different practices and aspects of roadmapping are presented, and guiding principles for successful and effective roadmaps are explained. The major cost of crafting a roadmap is the time of all the individuals involved in developing and reviewing it..	Non-empirical: Theoretical	None
(S. Lee, Lee, Seol, & Park, 2008) RADMA	Technology roadmaps	Not specified	This paper provides a keyword-based text-mining approach to extract relevant information from broadly distributed patents to create technology roadmaps for incremental innovation. This enabled experts to save on the time and costs of retrieving and understanding all the patents from related technical fields.	Non-empirical: Theoretical	None
(Perdue, McAllister, King, & Berkey, 1999) Interf	Technology roadmaps	Public sector	The paper focusses on the valuation of R&D projects using options pricing and decision analysis models. Within this valuation process, technology roadmaps are used for better communication. They serve as the ultimate plan, so if milestones are not reached in time the entire project is canceled. This strict line is advocated to maintain an effective utilisation of scarce scientific talent.	Empirical: Observations	Engineering, "how to"
(Sarangee, Woolley,	Technology roadmaps	High-technology companies	This study seeks to identify mechanisms that prevent managers from carrying on (and thereby assigning further budget to) projects, which have become	Empirical: Qualitative	Case study

Author, date, journal	Cost management method(s)	Industry	Summary (regarding the focal cost management method)	Type of data	Field work
Schmidt, & Long, 2014) JPIM			unlikely to produce satisfactory results. Monitoring the roadmap and comparing it with those of other companies or with the competitive landscape in general was among these de-escalation mechanisms.		
(Simonse, Hultink, & Buijs, 2014) JPIM	Technology roadmaps	Multiple industries	This paper assesses 12 practitioner-cases in the literature in order to examine innovation roadmapping and its impact on innovation performance. Based on the case assessment, it is hypothesized that the application of roadmapping improves the competitive timing of market entry.	Non-empirical: Theoretical	None

Appendix C

Appendix C, Table 1

*Accounting journals from Bonner's list.
**Abbreviations for research context: CM = cost management, CM-in-PD = cost management in product development, PD = product development.
***Conceptualisation of the adoption.

Author, date	Journal*	Cost management methods	Research Context**	CoA***	Item(s)	Measured Items	Anchors	Usable Responses
Afonso et al. (2008)	International Journal of Production Economics	- Target costing - Functional cost analysis - Kaizen costing	CM-in-PD	Use of	Multi-items	Construct: extent of use of target costing practices Items: • For the development of new products, it is usual to compute the desirable production cost of the new product from the following formula: "maximum allowable cost = potential market price–margin expected for this product" • During the design process of a new product, they are made many changes in the product in order to not exceed a predetermined maximum production cost. • During the New Product Development process, product's attributes which are considered too costly when compared with the value attributed by the client are reduced/eliminated (e.g. package, warranties, after sales service, etc.). • The company usually negotiates with suppliers and clients changes on product design and/or its functionalities in order to be achieved a predetermined product cost. • During the New Product Development	1= very low to 5= very high	82 Portuguese manufacturing firms

Author, date	Journal*	Cost management methods	Research Context**	CoA***	Item(s)	Measured Items	Anchors	Usable Responses
						process, the company tries to add additional features or functionalities to the product if it is not possible to offer a lower price than competitors. • During the New Product Development process, the company aims to beat competitors designing competitive products in price, functionality and quality. • Comparing with competitors, this company has a higher level of use of target costing techniques in the New Product Development process. Responses.		
Ahmad et al. (2010)	European Journal of Innovation Management	- Modular design	CM-in-PD	Use of	Multi-items	Construct: use of product modularity "Please indicate the extent to which you agree or disagree with the following statements": • Our products are modularly designed, so they can be rapidly built by assembling modules • We have defined product platforms as a basis for future product variety and options • Our products are designed to use many common modules • When we make two products that differ by only a specific feature, they generally require only one different subassembly/component • We do not use common assemblies and components in many of our products	1 = strongly disagree, 2 = disagree, 3= slightly disagree, 4= neutral, 5= slightly agree, 6= agree, and 7= strongly agree	208 Manufacturing firms

Author, date	Journal*	Cost management methods	Research Context**	CoA***	Item(s)	Measured Items	Anchors	Usable Responses
Al Chen et al. (1997)	*The International Journal of Accounting	- Target costing - Value engineering	CM	Use of	Single item	Single item: "Please indicate all of the following management tools in use or planned for use by your business unit:"	Consistently used for all purposes; used only for special purposes; plan to use; and does not use	66 Manufacturing firms
Alkaraan & Northcott (2006)	*The British Accounting Review	- Technology roadmap	CM	Relevance	Single item	Single item: "Please indicate the importance placed on coordination with investments decisions of other firms through the use of industry level data/technology roadmaps"	1= not important to 5= very important	271 UK Manufacturing firms
Ax et al. (2008)	International Journal of Production Economics	- Target costing - Value engineering - QFD - DFM	CM-in-PD	Use of	Single item	The variable: "adoption of" was asked for each technique	Binominal scale yes / no - answer	57 Manufacturing firms
Baines & Langfield-Smith (2003)	*Accounting, Organisations and Society	- Target costing	CM	Use of	Single item	Single item: "Indicate the extent to which your use of a range of nine contemporary management accounting practices have changed over the past three years"	-5= used significantly less, to +5= used significantly more	141 Manufacturing firms (SME)
Bhimani (2003)	*Accounting, Organisations and Society	- Target costing	CM	Effectiveness	Single item	Single item: "Please assess the overall success of process based target costing"	1= totally successful, 2= mainly successful, 3= neither successful nor unsuccessful, 4= mainly unsuccessful, 5= totally unsuccessful.	33 Responses from Siemens

Appendix C, Table 1

Author, date	Journal*	Cost management methods	Research Context**	CoA***	Item(s)	Measured Items	Anchors	Usable Responses
Chai et al. (2010)	IEEE International Conference on Management of Innovation & Technology	- Quality function deployment - Technology roadmap	PD	Effectiveness	Single item	Single item: "How do you describe your company's innovation management practices used in the selected product development project/series?"	1 = not useful to 5= strongly useful	153 Manufacturing firms
Chenhall & Langfield-Smith (1998)	*Management Accounting Research	- Target costing	CM	Use of, Perceived benefits, Relevance	Single item	Single item: "Indicate the whether business had adopted each of the following management accounting practices". Single item: "Indicate the benefits gained from the technique over the last 3 years". Single item: "Indicate the degree of emphasis the business unit will place on each technique over the next 3 years". Results for these items are reported separately and these seem to be meant as three different constructs.	To assess the adoption: the authors did not explicitly mention. Hence, we assumed a binominal scale: yes / no - answer To assess benefits: 1= no benefit, to 7= high benefit To assess future emphasis (for the adopted techniques): 1= no emphasis, to 7= high emphasis	78 Manufacturing firms
Dekker & Smidt (2003)	International Journal of Production Economics	- Target costing	CM-in-PD	Use of, Perceived benefits	Single item	The variable "adoption of": respondents were asked to examine whether they used systems matching the description of target costing The variable "perceived benefits" from adopting target costing was asked	1= not at all to 7= very much	32 Manufacturing firms
Duh et al. (2009)	Journal of International Accounting Re-	- Target costing - Kaizen costing	CM	Use of	Single item	Single item: "Please indicate the extent to which your company currently applies each of the following:"	1= not at all to 5= very extensively	219 Chinese firms (multiple industries)

Author, date	Journal*	Cost management methods	Research Context**	CoA***	Item(s)	Measured Items	Anchors	Usable Responses
	search							
Dunk (2004)	*Management Accounting Research	- Life cycle costing	CM	Use of	Multi-items	Construct: use of life cycle costing • "Please indicate the extent to which product life cycles are considered in product design" • "Please indicate the extent to which life cycle cost analyses are performed on products" • "Please indicate the extent to which recycling and disposal costs are considered in product design"	1= no extent to 7= a great extent	77 Manufacturing firms
Eatock et al. (2009)	Journal of Manufacturing Technology Management	- Quality function deployment - Stage-gates - Design for manufacturing	CM-in-PD	Use of	Single item	Single item: "Which of the following … did you use, and to what extend during the development of this product?"	Yes; limited implementation; no; don't know	38 Companies (medical device industry)
Ettlie & Elsenbach (2007)	Journal of Product Innovation Management	- Stage-gates	CM-in-PD	Use of	Single item	Single item: "Do you use a traditional form of the Stage-Gates process for developing and introducing new products or a modified form of Stage-Gates (e.g., we allow back-tracking through a gate if warranted)?"	No process; informal process; traditional Stage-Gates; modified (please describe modifications)	72 Automotive engineering managers
Ettlie (1995)	*Management Science	- DFM	PD	Experience	Single item	Single item: "We have people who are trained in DFA or DFM"	1= no, 2= in process and 3= yes	43 Manufacturing firms

Appendix C, Table 1

Author, date	Journal*	Cost management methods	Research Context**	CoA***	Item(s)	Measured Items	Anchors	Usable Responses
Fayard et al. (2012)	*Accounting, Organisations and Society	- Target costing - Kaizen costing	CM	Relevance	Single item	Single item: “Indicate your agreement with the following statements: … engage in continuous improvement processes (e.g. Kaizen) to control inter-organisational costs”	1= strongly disagree to 7= strongly agree	77 Firms (multiple industries)
Fullerton et al. (2013)	*Accounting, Organisations and Society	- Kaizen costing	CM	Implementation	Single item	Single item: “To what extent has your facility implemented the following:”	1= not at all, 2= little, 3= some, 4= considerable and 5= great deal	244 Manufacturing firms
Guilding et al. (2000)	*Management Accounting Research	- Target costing - Life cycle costing	CM	Use of, Effectiveness	Single item	Single item: “To what extent does your organisation use the following practices?” Single item: “To what extent do you consider the following practices could be helpful to your organisation?”	1= not at all, to 7= to a great extent Respondent could also indicate “N.A.” if a particular practice does "Not Apply" to their organisation.	314 Firms from U.S, U.K and N.Z (multiple industries)
Holmes & Ferrill (2005)	Technological Forecasting and Social Change	- Technology roadmap	PD	Implementation	Single item	Single item: “How far did you get with roadmapping?”	Did not complete first application; done once, don’t plan to do again; done once, plan to do again; has been done more than once; is an ongoing process (e.g. part of annual strategy)	30 Manufacturing firms
Joshi (2001)	Journal of International Accounting, Auditing and Taxation	- Target costing	CM	Use of, Perceived benefits, Relevance	Single item	Single item: “Indicate to whether your company had adopted the following management accounting practices” Single item: “For those adopted management accounting practices, asses the benefits gained over the past three years” Single item: “Indicate to which degree of emphasis that your company would give to each practice over the next three years”	To assess adoption: 1= low adoption to 3= high adoption To assess benefits: 1= no benefits to 7= high benefits To assess future emphasis: 1= no emphasis, to 7= high emphasis	60 Manufacturing firms (large and medium size)

Author, date	Journal*	Cost management methods	Research Context**	CoA***	Item(s)	Measured Items	Anchors	Usable Responses
Joshi et al. (2011)	Accounting Perspectives	- Target costing - Kaizen costing - Life cycle costing	CM	Implementation, Effectiveness	Single item	Single item: "The extent of implementation of following management accounting practices for your firm" Single item: "The degree of success achieved in implementing management accounting practices"	To assess implementation: 1= not adopted, 2= to some extent, 3= to a large extent, 4= to a very large extent To assess success: 1= unsuccessful to 4= very successful	57 Corporate sector companies
Kim et al. (2005)	Technovation	- Product platforms	CM-in-PD	Use of	Multi-item	Construct: use of product platforms Item 1: "Please rate your firm's platform-based product variety strategy Item 2: "Please rate your platform variety"	To assess item 1: 1= compared to competition, we offer a lower number of variants sharing the platform, to 7= compared to competition, we offer a higher number of variants sharing the platform. To assess item 2: 1= the firm has a lower number of platforms than mayor competitors, to 7= the firm has a higher number of platforms than mayor competitors.	103 Manufacturing firms
Miranda Gonzáles & Banegil Palacios (2002)	Industrial Marketing Management	- QFD - Stage-gates - Design for Manufacturing - Modular design	PD	Use of	Single item	Variable "use" was asked for each technique	Binominal scale yes / no - answer	195 Spanish firms (multiple industries)

Appendix C, Table 1

Author, date	Journal*	Cost management methods	Research Context**	CoA***	Item(s)	Measured Items	Anchors	Usable Responses
Narasimhan et al. (2006)	Journal of Operations Management	- Design for manufacturing	CM-in-PD	Implementation	Single item	Single item: "Please rate the extent to which statements regarding practice implementation applied to their plant, as compared to their industry average"	1= much less, 4= about the same, 7= to a much greater extent	57 Manufacturing firms
Salvador & Villena (2013)	Journal of Supply Chain Management	- Modular design	CM-in-PD	Use of	Multi-items	Construct: use of modular design competence Items: • Our products are modularly designed, so they can be rapidly built by assembling modules • We have defined product platforms as a basis for future product variety and options • Our products are designed to use many common modules • When we make two products that differ by only a specific feature, they generally require only one different subassembly/component. • We do not use common assemblies and components in many of our products	1=strongly disagree, to 7=strongly agree	165 NPD projects
Swink (2003)	Journal of Engineering and Technology Management	- Quality function deployment	PD	Use of	Single item	Single item: "Please indicate the degree of use of the design integrations method: Quality function deployment"	1= not used, to 7= used extensively	131 Manufacturing Firms
Tan (2001)	*Decision Sciences	- Value engineering - Modular design	CM-in-PD	Relevance	Single item	Single item: "How important are the following issue/tools in your firm's new product design and development activities"	1= low, 5= high	310 Firms (multiple industries)

Author, date	Journal*	Cost management methods	Research Context**	CoA***	Item(s)	Measured Items	Anchors	Usable Responses
Terjesen et al. (2012)	*Decision Sciences	- Modular design	PD	Use of	Multi-items	Construct: use of product modularity and process modularity see multi-items from Tu et al. (2004)	1 = strongly disagree and 5 = strongly agree	261 Manufacturing firms
Tu et al. (2004)	*Decision Sciences	- Modular design	PD	Use of	Multi-items	Construct: use of modularity-based manufacturing practices: • Product modularity (7 items): our products use modularized design, our products share common modules, our product features are designed around a standard base unit, product modules can be reassembled into different forms, product feature modules can be added to a standard base unit. • Process modularity (6 items): our production process is designed as adjustable modules, our production process can be adjusted by adding new process modules, production process modules can be adjusted for changing production needs, pure production process can be broken down into standard sub-processes that produce standard base units and customisation sub-processes that further customise the base units, production process modules can be rearranged so that customisation sub-processes occur last. • Dynamic Teaming (7 items): production teams that can be reorganised are used in our plant, production teams can be reorganised in response to product/process changes, production teams can be reassigned to	Not provided	303 Manufacturing firms

Author, date	Journal*	Cost management methods	Research Context**	CoA***	Item(s)	Measured Items	Anchors	Usable Responses
						different production tasks, production teams are not permanently linked to a certain production task, production team members can be reassigned to different teams, production team members are capable of working on different teams, production teams have no difficulty accessing necessary resources.		
Wijewardena & De Zoysa (1999)	*The International Journal of Accounting	- Target costing	CM-in-PD	Relevance	Single item	Single item: "Please indicate the degree of importance you attach to a set of major management accounting tools in planning and controlling product costs in your organisation"	1= much less important, to 5= much more important	231 Australian and 217 Japanese manufacturing firms
Wouters et al. (2005)	*Accounting, Organisations and Society	- Total cost of ownership	CM	Use of	Multi-items	Construct: the adoption of TCO for sourcing decisions Items: • Reducing total cost of ownership (TCO) is a significant component of your performance review and reward system (Question nr.15). • The total cost of ownership for acquired goods and services and your performance evaluation and compensation are strongly linked (Question nr.16).	For question nr.15; 1= complete agree, to 7= completely disagree For question nr.16; 1= completely disconnected to 7= very strongly connected	310 Manufacturing firms (160 purchasing managers and 150 maintenance representatives)
Wu et al. (2007)	*The International Journal of Accounting	- Target costing	CM	Use of, Perceived benefits, Relevance	Single item	...items adopted from Chenhall & Langfield-Smith (1998)	To assess the adoption: the authors did not explicitly mention. Hence, we assumed a binominal scale: yes / no - answer To assess benefits: 1= no benefit, to 7= high benefit	179 Firms (multiple industries)

Author, date	Journal*	Cost management methods	Research Context**	CoA***	Item(s)	Measured Items	Anchors	Usable Responses
							To assess future emphasis (for the adopted techniques): 1= no emphasis, to 7= high emphasis	
Yalcin (2012)	Accounting in Europe	- Target costing - Quality function deployment - Kaizen costing - Life cycle costing	CM	Use of	Single item	Single item: "Evaluate your adoption of management accounting practices:"	1= not used, 2= considering and 3= in use	80 Manufacturing firms (Accounting department managers)
Yazdifar & Askarany (2012)	International Journal of Production Economics	- Target costing	CM	Use of, Implementation	Single item	Single item: "Indicate the extent to which target costing was used in their organisations" Single item: "Indicate the level of implementation of target costing"	To assess usage: Discussions have not taken place regarding the introduction of TC; A decision has been taken not to introduce TC; Some consideration is being given to the introduction of TC in the future; TC has been introduced on a trial basis and TC has been implemented and accepted. To assess implementation: Level 1: Identification of target product cost as the difference between expected price and required profit. Level 2: Adoption of cost-cutting	584 Management accountants

Author, date	Journal*	Cost management methods	Research Context**	CoA***	Item(s)	Measured Items	Anchors	Usable Responses
							strategies at the production stage to approach target. Level 3: Examination of all cost-reducing strategies at the planning and pre-production stages. Level 4: Adoption of value engineering to incorporate customer requirements.	
Yeh et al. (2010)	Quality & Quantity	- Value engineering - Quality function deployment - Design for manufacturing - Design for X - Modular design	CM-in-PD	Use of, Effectiveness	Single item	Single item: "Please indicate the degree of usage frequency of the following NPD tools and techniques" Single item: "Please indicate the degree of effectiveness of the following NPD tools and techniques"	1= low, to 5= high	88 High-tech companies

Appendix D

The questionnaire

Institut für Unternehmensführung
Lehrstuhl für Management Accounting
Prof. Wouters
+49 (0) 721 608-41850
http://www.ibu.kit.edu/

Dipl.Wi.Ing. Susana Morales
Telefon: +49 721 608-41851
E-Mail: susana.morales@kit.edu

Studie über den Einsatz und die Nützlichkeit von Kosten-Management Methoden bei der Produktentwicklung in der deutschen Industrie

Teil A: Fragen zum Unternehmen und zur Auskunftsperson.

1. Informationen zur Auskunftsperson.

Wir würden niemals Daten aus dieser Umfrage zusammen mit einem Unternehmensnamen veröffentlichen, dennoch möchten wir die Möglichkeit geben, diese Online-Umfrage anonym auszufüllen. Falls Sie hier keinen Unternehmensnamen angeben, bleiben Sie voll kommen anonym. In diesem Fall sehen wir allerdings auch nicht, ob Sie den Fragebogen ausgefüllt haben oder nicht. Daher werden wir Ihnen nicht die Ergebnisse der Studie zuschicken und können Sie auch nicht in der Verlosung berück-sichtigen.

1.1. Unternehmen: ____________________

1.2. Falls wir Ihnen die Ergebnisse der Studie an eine abweichende E-Mail Adresse zuschicken sollen, geben Sie diese bitte hier ein: ____________________

1.3. Branche Ihres Unternehmens:

○ Automobilindustrie	○ Elektrotechnik	○ Mess- und Regelungstechnik	○ Pharmazeutische Industrie
○ Chemische Industrie	○ Gummi- und Kunststoff-industrie	○ Metallerzeugung- und Verarbeitung	○ Textilgewerbe
○ Elektrische Ausrüstung	○Maschinenbau	○ Mineralölverarbeitung	Andere:

1.4. Anzahl der Mitarbeiter:

- ○ weniger als 10
- ○ 10 - 19
- ○ 20 - 49
- ○ 50 - 99
- ○ 100 - 249
- ○ 250 - 499
- ○ 500 - 999
- ○ 1000 - 4999
- ○ mehr als 5000

1.5. Hauptarbeitsbereich:

○ Forschung und Entwicklung	○ Produktion	○ Controlling	Andere:

1.6. Welche Hauptfunktion nehmen Sie bei Produktentwicklungsprojekten ein?

○ Geschäftsführer	○ Abteilungsleiter	○ Projektleiter	○ Teammitglied	Andere:

KIT – Universität des Landes Baden-Württemberg und nationales Forschungszentrum in der Helmholtz-Gemeinschaft

www.kit.edu

Teil B: Methoden des Kostenmanagement im Bereich Forschung und Entwicklung bzw. Produkt-entwicklung. Jetzt folgen je 2 Fragen zu 15 verschiedenen Methoden, die Sie nach Ihrer eigenen Einschätzung bewerten können.

2.1. Bitte bewerten Sie die folgenden Kostenmanagement-Methoden die Ihr Unternehmen bei der Produkt-entwicklung einsetzt:

Nie	Selten	Manchmal	Oft	Immer	Weiß ich nicht, oder trifft nicht zu
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

Kostenmanagement-Methoden und Definition	Frage 1: Bitte geben Sie an, in welchem Umfang Ihr Unternehmen die folgenden Kosten-management-Methoden <u>in der Produkt-entwicklung einsetzt.</u>						Frage 2: Bitte geben Sie an, in welchem Um-fang Ihr Unternehmen die folgenden Kostenmanagement-Methoden in der <u>Produktentwicklung</u> als <u>hilfreich</u> erachtet.					
1. **Zielkostenrechnung (Target Costing), um ein Kostenziel zu setzen:** Die erlaubten Herstellungs-kosten eines Produkts und seiner Komponenten werden bestimmt, indem vom Verkaufspreis des Endprodukts die Zielmarge sowie die nicht herstel-lungsbezogenen Kosten entlang der Supply Chain subtrahiert werden.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
2. **Wertanalyse (Value Engineering):** Die Kosten-struktur des Produkts wird analysiert, um Wege zu identifizieren das Design anzupassen und die Ziel-kosten zu erreichen.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
3. **Qualitätsfunktionendarstellung (Quality Function Deployment):** Kundenanforderungen werden als notwendige technische Merkmale ausgedrückt. Die Anforderungen und technischen Merkmale werden dann in Matrixform zueinander in Beziehung gesetzt.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
4. **Functional Cost Analysis:** Die Kostenstruktur der Produkte oder Dienstleistungen wird analysiert, um Wege zu finden, das Produktdesign oder den Pro-duktionsprozess zu verbessern und die Kosten der geforderten Funktionalität und Leistung zu reduzie-ren.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
5. **Kontinuierliche Verbesserung (Kaizen Costing):** Ein fortlaufender Kostenreduktionsprozess in der Herstellungsphase des Produkts wird angestrebt. Das Kostensenkungsziel kann als festgelegter Betrag oder als Quote vorher spezifiziert sein.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
6. **Lebenszykluskostenrechnung (Life Cycle Costing):** Es werden während der Produktentwick-lung und in der Herstellungsphase des Produkts nicht nur Herstellungskosten betrachtet, sondern auch weitere Kosten miteinbezogen, die im Lebenszyklus der Produktnutzung anfallen (z.B. Abfall und Ent-sorgung).	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
7. **Gesamtbetriebskosten (Total Cost of Ownership):** Alle aus dem Erwerb und der Nutzung eines Ange-bots resultierenden Kosten für den Kunden (in die-sem Fall Ihr Unternehmen) werden quantifiziert.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
8. **Stage-Gate-Modell:** Nach der Fertigstellung jeder Entwicklungsphase wird das aktuelle Produktdesign anhand zuvor definierter Kriterien durch das Ma-nagement geprüft, für welche zu Beginn der Ent-wicklungsphase Ziele formuliert wurden (z.B. Entwicklungskosten, Funktionalität, Entwicklungs-zeiten oder Leistung).	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

9. **Trichtermodell (Funnels)**: Eine Selektion der alternativen Produktentwicklungsmöglichkeiten wird vorgenommen. Die Auswahl der alternativen Möglichkeiten wird graduell reduziert, je näher das Ende des Entwicklungsprozesses heran rückt.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
10. **Fertigungs- und montageorientiertes Produktdesign (Design for Manufacturing / Assembly)**: Entwickler-Teams erhalten Leitlinien und Auflagen zur Verbesserung des Produktdesigns, um die Herstellung zu niedrigen Kosten zu ermöglichen.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
11. **Design for X**: Entwickler-Teams erhalten Leitlinien und Auflagen zur Verbesserung des Produktdesigns, um Kosten in einer Vielzahl von Aspekten niedrig zu halten, z.B. Logistik, Entsorgung, Umweltverträglichkeit und Wartung.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
12. **Gleichteile (Component commonality)**: In der Produktdesignphase werden Auflagen festgelegt, die eine begrenzte Menge an Teilen, Komponenten und Materialien während der Entwicklungsphase erlauben, um Gleichteile in mehreren Endprodukten zu erhalten.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
13. **Baukastenprinzip (Modular design)**: Produkte werden so entwickelt, dass eine Vielzahl an Endprodukten produziert werden kann, die aus einer begrenzten Menge an Modulen zusammengesetzt sind, die mit weiteren Modulen oder Teilen kombiniert oder angepasst werden können.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
14. **Produktplattform**: Technische Designs werden umgesetzt, um als Basisarchitektur für eine Reihe verschiedener Produkte zu dienen.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
15. **Technologie Roadmaps**: Mögliche Zukunftstechnologien bestimmter Branchen werden beschrieben, um die Produktentwicklungen voraus zu planen, damit bestimmte Entwicklungsstufen und geforderte Leistungsanforderungen zu bestimmten Zeitpunkten in der Zukunft erreicht werden.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

2.2. Weitere Anmerkungen bezüglich des Einsatzes oder der Nützlichkeit von Methoden des Kostenmanagements in ihrem Unternehmen:

Teil C: Managementansätze und strategische Ausrichtung des Unternehmens.

3.1 Bitte geben Sie an, inwieweit die folgenden Aussagen für Ihr Unternehmen zutreffen:

	Stimme überhaupt nicht zu	Stimme nicht zu	Stimme eher nicht zu	Neutral	Stimme eher zu	Stimme zu	Stimme voll und ganz zu
	1	2	3	4	5	6	7
16. Lieferanten wurden häufig bei der Entwicklung dieses Produkts zu Rate gezogen. *(item: Supp1)*							
17. Die Produktionsabteilung ist bei der Schaffung neuer Produktkonzepte involviert. *(item: Cross1)*							
18. Für die Produktenwürfe gehen wir Partnerschaften mit Zulieferern ein. *(item: Supp2)*							
19. Die Designteams von Neuprodukten interagieren häufig mit der Produktionsabteilung. *(item: Cross2)*							
20. Wir konsultierten Kunden schon in den frühen Phasen des Entwurfs dieses Produktes. *(item: Cuss1)*							
21. Die Produktionsabteilung ist an den frühen Phasen neuer Produktentwicklungen beteiligt. *(item: Cross3)*							
22. Unsere Lieferanten wurden in diesem Projekt bereits früh in die Entwicklungsanstrengungen involviert. *(item: Supp3)*							
23. Die Kunden waren ein integraler Bestandteil der Entwicklungsbemühungen für dieses Projekt. *(item: Cuss2)*							
24. Die Lieferanten waren ein integraler Bestandteil der Entwicklungsbemühungen. *(item: Supp4)*							
25. Kunden wurden an diesem Projekt beteiligt, bevor der Entwurf fertiggestellt wurde. *(item: Cuss3)*							
26. Wir sind Partnerschaften mit Kunden für den Entwurf dieses Produktes eingegangen. *(item: Cuss4)*							
27. Neue Produktkonzepte werden durch die Beteiligung verschiedener Abteilungen entwickelt. *(item: Cross4)*							

3.2 Haben Sie weitere Anmerkungen bezüglich der Managementansätze des Unternehmens:

3.3 Wie beurteilen Sie die folgenden Fähigkeiten in Bezug auf deren Wichtigkeit für Ihr Unternehmen:

	Nicht wichtig 1 Punkt	2	3	Sehr wichtig 4 Punkte	5	6	Absolut entscheidend 7 Punkte
28. Design-Änderungen schnell durchführen *(item: Flex1)*							
29. Arbeitsproduktivität erhöhen *(item: Cost1)*							
30. Toleranzen der Design-Spezifikationen in der Produktion verkleinern *(item: Q1)*							
31. Auslastung der Produktionskapazität erhöhen *(item: Cost2)*							
32. Produktionskosten reduzieren *(item: Cost3)*							
33. Hochleistungsprodukte bereitstellen *(item: Q2)*							
34. Eine große Anzahl an Produktfunktionen anbieten *(item: Flex2)*							
35. Produktportfolio anpassen *(item: Flex3)*							
36. Beständige und zuverlässige Qualität anbieten *(item: Q3)*							
37. Lagerbestände reduzieren *(item: Cost4)*							
38. Eine große Produktvielfalt anbieten *(item: Flex4)*							

3.4 Haben Sie weitere Anmerkungen bezüglich der strategische Ausrichtung des Unternehmens:

Vielen Dank, dass Sie sich zur Beantwortung der Fragen Zeit genommen haben.

Mit freundlichen Grüßen

Marc Wouters und Susana Morales

Appendix E

The questionnaire - English translation

Karlsruher Institut für Technologie

Institut für Unternehmensführung
Lehrstuhl für Management Accounting
Prof. Wouters
+49 (0) 721 608-41850
http://www.ibu.kit.edu/

Dipl.Wi.Ing. Susana Morales
Telefon: +49 721 608-41851
E-Mail: susana.morales@kit.edu

Study on the use and helpfulness of cost management methods for new product development at the German industry

Section A: questions regarding the organization and respondent characteristics.

1.1 Respondent contact information

We would never publish data gathered from the questionnaire together with the name of your company. Still, we offer you the option to fill in this questionnaire anonymously. If you decide to omit your company's name, you will remain completely anonymous, hence, we would not be able to keep track of you had answer the questionnaire or not. Therefore, we will not send you the results of this study and you cannot participate in the draw.

1.1. Please indicate the name of your organization: ______________________________

1.2. If you have a different email address to send you the results. Please write it here: ____________

1.3. Please indicate the type of industry of your organization:

○ Automotive engineering	○ Electronic	○ Measuring, & controlling instruments	○ Pharmaceutical
○ Chemical industry	○ Rubber & Plastic	○ Metals production & processing	○ Textile industry
○ Electrical equipment	○ Mechanical engineering	○ Mineral oil processing	Other:

1.4. How many employees are there in your organization:

- ○ less than 10
- ○ 10 - 19
- ○ 20 - 49
- ○ 50 - 99
- ○ 100 - 249
- ○ 250 - 499
- ○ 500 - 999
- ○ 1000 - 4999
- ○ more than 5000

1.5. What is your main functional area:

○ R&D	○ Production	○ Controlling	Other:

1.6. What is your main role on new product development projects?

○ Director	○ Department manager	○ Project manager	○ Team member	Other:

Section B: cost-management practices at R&D i.e., product development.

2.1. Please evaluate each of the cost management methods used for product development in your organization

Not at all	Rarely	Sometimes	Often	Always	I Don't know
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

Cost-management methods and definitions	Question 1: Please indicate to what extent does your organization **<u>uses</u>** each of the following cost management methods for **<u>product development.</u>**						Question 2: Please indicate to what extent the following cost-management methods are **<u>helpful</u>** for **<u>product development</u>** in your organization.					
1. **Target costing for setting the cost target:** The allowable manufacturing costs of a product and of its components are determined starting with the sales price of the product for end users and subtracting target profit margins and nonmanufacturing costs at various stages downstream in the supply chain.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
3. **Value engineering**: Product cost structures are analyzed to identify ways to change the design of the product so that it can be manufactured at its target cost.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
4. **Quality function deployment (QFD):** Customer requirements are formulated in terms of required technical attributes, and the relationships between these customer requirements and technical attributes are displayed through a matrix.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
5. **Functional cost analysis**: Cost structures of products or services are evaluated to find ways for improving either the product design or the production process in order to reduce the cost of providing the required functionality and performance.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
6. **Kaizen costing (continuous improvement):** Efforts are made to ensure continuous cost reduction process during the manufacturing phase of a product, and the cost reduction goal might be a pre-specified amount or rate.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
7. **Life-cycle costing**: Cost measurements and estimations are extended from manufacturing costs to also include non-manufacturing costs, which may be incurred at different stages of the use of a product (e.g., waste and disposal).	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
8. **Total cost of ownership**: Cost accounting is applied to combine price and value to support purchasing decisions such as monetary quantification of all costs incurred to the customer (here your organization) as a result of acquiring and using supplier offerings.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
9. **Stage-gate reviews**: After completion of each development stage, the latest design is reviewed by management on a wide variety of aspects. Targets and other objectives have been formulated at the start of the development process (such as product cost, development cost, functionality, performance, project lead time).	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
10. **Funnels**: A selection process for product development is followed, in which the number of alternatives that a firm is committed to, will gradually decrease as the development process moves toward completion.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

KIT – Universität des Landes Baden-Württemberg und nationales Forschungszentrum in der Helmholtz-Gemeinschaft

2

www.kit.edu

Not at all	Rarely	Sometimes	Often	Always	I Don't know
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

Cost-management methods and definitions	Question 1: Please indicate to what extent does your organization **uses** each of the following cost management methods for **product development.**						Question 2: Please indicate to what extent the following cost-management methods are **helpful** for **product development** in your organization.					
11. **Design for manufacturing/assembly:** Product development teams are provided with guidelines and constraints to improve product designs such that these can be manufactured at a low cost.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
12. **Design for X:** Product development teams are provided with guidelines and constraints to improve product designs in such a way, that costs can be kept low on a wide range of aspects, for example: logistics, disposal, environment and service.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
13. **Component commonality:** A selection of constraints is stipulated during product design phase, thus, limited sets of allowed materials, parts, components, packaging etc. are shared across a set of final products.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
14. **Modular design:** Products are designed in such a way, that wide variety of final products can be produced while using a limited number of modules that are adjusted and/or combined with different parts and other modules.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
15. **Product platforms:** Technical designs are physically implemented to serve as the base architecture for a series of derivative products.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
16. **Technology roadmaps:** Candidate technologies from particular industry are described to plan the development of products to fulfill levels of specification and required performance that has to be reached at different points in the future.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

2.2. Do you have further comments regarding the use and helpfulness of cost-management practices at your organization:

Section C: managerial approaches and strategic orientation at the organization.

3.1 Please indicate your agreement with each one of the following statements at the organization level:

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
	1	2	3	4	5	6	7
16. Suppliers were frequently consulted about the design of this product. *(item: Supp1)*							
17. The manufacturing function is involved in the creation of new product concepts. *(item: Cross1)*							
18. We partnered with suppliers for the design of this product. *(item: Supp2)*							
19. New product design teams have frequent interaction with the manufacturing function. *(item: Cross2)*							
20. We consulted customers early in the design efforts for this product. *(item: Cuss1)*							
21. Manufacturing is involved in the early stages of new product development. *(item: Cross3)*							
22. Suppliers were involved early in the design efforts, in this project. *(item: Supp3)*							
23. Customers were an integral part of the design effort for this project. *(item: Cuss2)*							
24. Suppliers were an integral part of the design effort. *(item: Supp4)*							
25. Customers became involved in this project before the design was completed. *(item: Cuss3)*							
26. We partnered with customers for the design of this product. *(item: Cuss4)*							
27. New product concepts are developed as a result of the involvement of various functions. *(item: Cross4)*							

3.2 Do you have further comments regarding the managerial approaches of your organization:

KIT – Universität des Landes Baden-Württemberg und nationales Forschungszentrum in der Helmholtz-Gemeinschaft

4

www.kit.edu

3.3 Please indicate how important is for your organization the ability to:

	Not important *1 points*	*2*	*3*	**Very** important *4 points*	*5*	*6*	**Absolutely** critical *7 points*
28. Make rapid design changes *(item:Flex1)*							
29. Increase labor productivity *(item:Cost1)*							
30. Improve conformance to design specifications *(item: Q1)*							
31. Increase production capacity utilization *(item: Cost2)*							
32. Reduce production costs *(item: Cost3)*							
33. Provide high-performance products *(item: Q2)*							
34. Offer a large number of product features *(item: Flex2)*							
35. Adjust product mix *(item: Flex3)*							
36. Offer consistent, reliable quality *(item:Q3)*							
37. Reduce inventory *(item: Cost4)*							
38. Offer a large degree of product variety *(item: Flex4)*							

3.4 Do you have further comments regarding the strategic orientation of your organization?

Thank you very much for your time

Best regards

Marc Wouters und Susana Morales

Appendix F

Kompass data bank: sample selection criteria

Filter criteria of German companies Industry sectors with major volume of sales (800 companies sample)				
Index	Kompass code	Count*	Business Activities (Geschäftstätigkeit)	Label
1	Localisation	254129		Deutschland (Produzenten)
27	NomenclatureKompass	1410	Chemikalien, Arzneimittel & Kunststoffe	18 P - Kautschukwaren und Gummiwaren
24	NomenclatureKompass	7477	Chemikalien, Arzneimittel & Kunststoffe	20 P - Erzeugnisse aus Kunststoff
16	NomenclatureKompass	4065	Chemikalien, Arzneimittel & Kunststoffe	23 P - Gesundheit, Pharmazeutika und Medikamente
25	NomenclatureKompass	1477	Chemikalien, Arzneimittel & Kunststoffe	52 P - Anlagen und Ausrüstungen für die chemische Industrie
26	NomenclatureKompass	1002	Chemikalien, Arzneimittel & Kunststoffe	53 P - Maschinen und Anlagen für die Gummiindustrie und Kunststoffindustrie
2	NomenclatureKompass	2570	Metalle, Maschinen & Ingenieurwesen	25 P - Metallgrundprodukte
4	NomenclatureKompass	4566	Metalle, Maschinen & Ingenieurwesen	32 P - Motoren und mechanische Teile
3	NomenclatureKompass	3991	Metalle, Maschinen & Ingenieurwesen	37 P - Maschinen und Anlagen für die Metallbearbeitung
5	NomenclatureKompass	16934	Metalle, Maschinen & Ingenieurwesen	65 P - Industrielle Zulieferer
19	NomenclatureKompass	5376	Elektrik, Elektronik & Optik	39 P - Elektrotechnische und kerntechnische Ausrüstungen
20	NomenclatureKompass	4508	Elektrik, Elektronik & Optik	40 P - Elektronische Ausrüstungen. Ausrüstungen für die Telekommunikation
21	NomenclatureKompass	4531	Elektrik, Elektronik & Optik	42 P - Messgeräte und Prüfgeräte
22	NomenclatureKompass	1241	Elektrik, Elektronik & Optik	43 P - Optische, fotografische und kinematografische Ausrüstungen
23	NomenclatureKompass	448	Energie, Umwelt	59 P - Maschinen und Anlagen für die Erdölindustrie und Erdgasindustrie
16	NomenclatureKompass	4369	Transport & Logistik	62 P - Fördermittel und Lagereinrichtungen
18	NomenclatureKompass	1029	Transport & Logistik	63 P - Verpackungsanlagen, Verpackungsmaschinen und Verpackungsdienste
17	NomenclatureKompass	4000	Transport & Logistik	66 P - Transportmittel
8	EffectifsEntreprise	73081		Von 10 bis 19
10	EffectifsEntreprise	55931		Von 20 bis 49
9	EffectifsEntreprise	23160		Von 50 bis 99
11	EffectifsEntreprise	16301		Von 100 bis 249
12	EffectifsEntreprise	4838		Von 250 bis 499
13	EffectifsEntreprise	2509		Von 500 bis 999
15	EffectifsEntreprise	1676		Von 1000 bis 4999
14	EffectifsEntreprise	221		Mehr als 5000
6	FonctionDirigeant	1391		Forschung und Entwicklung

*Companies may be classified under several business activities, this explains the high total count of firms per sector and why the number do not add up to the final count of 800 unique companies.

Appendix G

Survey invitation (E-mail)

Betreff: Studie über den Einsatz von Controlling in der Produktentwicklung

Sehr geehrter Herr „Mustermann“,

der Einsatz von Methoden des Kostenmanagements in der Forschung und Entwicklung (FuE) ist Thema meiner Dissertation am Karlsruhe Institut für Technologie (KIT) (Universität Karlsruhe). Ich habe Ihr Unternehmen sorgfältig aufgrund Ihrer Ausrichtung in der Produktentwicklung ausgewählt. Ich würde Sie gerne dafür gewinnen, einen kurzen Fragebogen (etwa 10 Minuten) auszufüllen.

Die Ergebnisse werden für Sie sehr interessant sein: Die Ergebnisse dieser Studie werden aufzeigen, aus welchen Gründen bestimmte Kostenmanagement-Methoden in der deutschen Industrie eingesetzt werden. Als Dankeschön für Ihre Teilnahme an dieser Umfrage bereite ich alle Ergebnisse für Sie auf und stelle sie Ihnen unmittelbar nach der Auswertung zur Verfügung. Diese ermöglichen es Ihnen, Ihre Controlling-Methoden zu vergleichen und zu bewerten. Außerdem verlose ich ein iPad Air 2 unter den circa 150 Teilnehmern der Umfrage – es besteht also eine faire Chance zu gewinnen.

Mir ist bewusst, dass „Unternehmen XY“ wahrscheinlich oft zu Umfragen eingeladen wird, und Sie im Alltagsgeschäft hierfür kaum Zeit finden. Allerdings ist akademische Forschung ohne Unterstützung von Unternehmen, wie dem Ihren, nicht möglich. Umfragen mit niedrigen Rücklaufquoten führen zu nicht repräsentativen oder falschen Ergebnissen. Wir machen diese Forschung nicht zum Selbstzweck, sondern wollen Unternehmen wie das Ihre methodisch voranbringen.

Selbstverständlich werden Ihre Daten vertraulich behandelt und nicht an Dritte weitergegeben. Die Daten werden anonym nur zu Publikationszwecken ausgewertet.

Dieser Link führt Sie zur Umfrage (Teilnahmeschluss 15.Januar 2015):

http://www.ibu.kit.edu/Umfrage2014.php

Weitere Information zum Forschungsprojekt

In diesem Forschungsprojekt am Lehrstuhl für Management Accounting von Prof. Wouters erforschen wir Controlling-Methoden des Kostenmanagements, die von deutschen Industrieunternehmen bei ihrer Produktentwicklung eingesetzt werden. Das Controlling im Bereich F&E ist komplex: Einerseits benötigen innovative Prozesse der Produktentwicklung weitreichende Flexibilität, kreative Freiheit und partizipative Entscheidungsprozesse. Andererseits ist in diesem Bereich das Controlling entscheidend, um Ressourcengrenzen einzuhalten und Entwicklungsrichtungen entsprechend der Unternehmensstrategie zu steuern. Gleichzeitig soll vermieden werden, dass entsprechende Abteilungen sich in zahllosen Optimierungsprozessen verlieren.

Bisher gibt es nur wenige Daten zu Best Practices in diesem Bereich. Durch eine Datenerhebung möchten wir untersuchen, welche Methoden verwendet werden und aus welchen Gründen sie jeweils zum Einsatz kommen. Zur Erzeugung aussagekräftiger Ergebnisse benötigen wir eine fundierte Datenbasis.

Ich hoffe, ich konnte Sie überzeugen an der Umfrage teilzunehmen – dafür schon einmal herzlichen Dank für die Unterstützung!

Mit freundlichen Grüßen

Dipl.Wi.Ing. Susana Morales

Karlsruher Institut für Technologie (KIT)
Institut für Unternehmensführung

Lehrstuhl für Management Accounting

Dipl.Wi.Ing. Susana Morales
Wissenschaftliche Mitarbeiterin

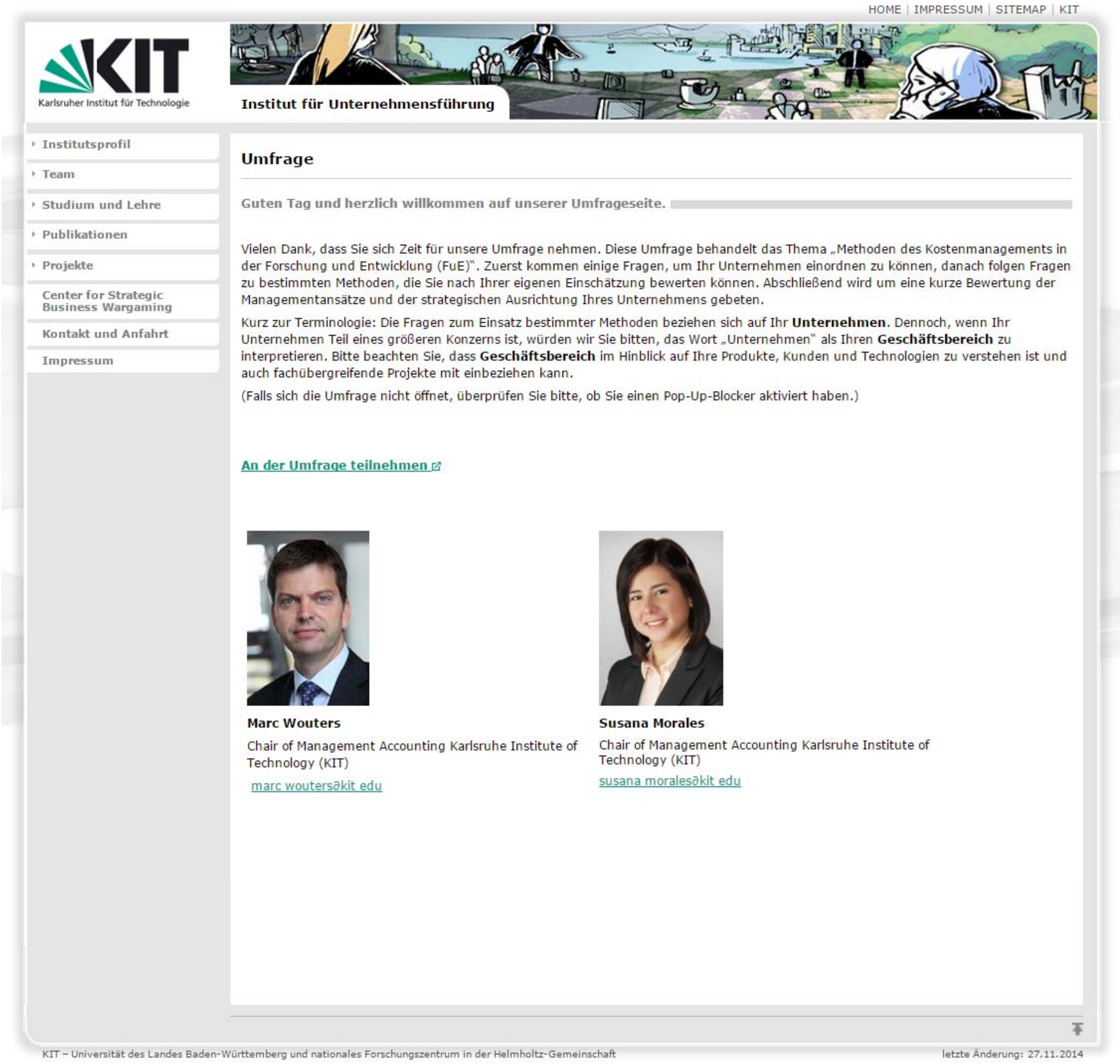
Kaiserstraße 89
Gebäude 05.20
76131 Karlsruhe

Telefon: +49 721 608-**41851**
Fax: +49 721 608-41857
E-Mail: susana.morales@kit.edu
Web: www.ibu.kit.edu

KIT – Universität des Landes Baden-Württemberg und nationales Forschungszentrum in der Helmholtz-Gemeinschaft

Appendix H

Link to the online survey



HOME | IMPRESSUM | SITEMAP | KIT

KIT Karlsruher Institut für Technologie

Institut für Unternehmensführung

- Institutsprofil
- Team
- Studium und Lehre
- Publikationen
- Projekte
- Center for Strategic Business Wargaming
- Kontakt und Anfahrt
- Impressum

Umfrage

Guten Tag und herzlich willkommen auf unserer Umfrageseite.

Vielen Dank, dass Sie sich Zeit für unsere Umfrage nehmen. Diese Umfrage behandelt das Thema „Methoden des Kostenmanagements in der Forschung und Entwicklung (FuE)". Zuerst kommen einige Fragen, um Ihr Unternehmen einordnen zu können, danach folgen Fragen zu bestimmten Methoden, die Sie nach Ihrer eigenen Einschätzung bewerten können. Abschließend wird um eine kurze Bewertung der Managementansätze und der strategischen Ausrichtung Ihres Unternehmens gebeten.

Kurz zur Terminologie: Die Fragen zum Einsatz bestimmter Methoden beziehen sich auf Ihr **Unternehmen**. Dennoch, wenn Ihr Unternehmen Teil eines größeren Konzerns ist, würden wir Sie bitten, das Wort „Unternehmen" als Ihren **Geschäftsbereich** zu interpretieren. Bitte beachten Sie, dass **Geschäftsbereich** im Hinblick auf Ihre Produkte, Kunden und Technologien zu verstehen ist und auch fachübergreifende Projekte mit einbeziehen kann.

(Falls sich die Umfrage nicht öffnet, überprüfen Sie bitte, ob Sie einen Pop-Up-Blocker aktiviert haben.)

An der Umfrage teilnehmen

Marc Wouters
Chair of Management Accounting Karlsruhe Institute of Technology (KIT)
marc wouters∂kit edu

Susana Morales
Chair of Management Accounting Karlsruhe Institute of Technology (KIT)
susana morales∂kit edu

KIT – Universität des Landes Baden-Württemberg und nationales Forschungszentrum in der Helmholtz-Gemeinschaft

letzte Änderung: 27.11.2014

Appendix I

Survey' desertions per survey page

Analysis of survey' desertions per survey page		
Page (Seite)	Break off (Abbrüche)	Progress until page (Fortgeschritten bis Seite)
Section A - Default page	66 (34.74%)	190 (100.00%)
Section B **(Methods in random order)**	2 (1.05%)	124 (65.26%)
Method 1	4 (2.11%)	122 (64.21%)
Method 2	0 (0.00%)	118 (62.11%)
Method 3	2 (1.05%)	118 (62.11%)
Method 4	1 (0.53%)	116 (61.05%)
Method 5	1 (0.53%)	115 (60.53%)
Method 6	1 (0.53%)	114 (60.00%)
Method 7	2 (1.05%)	113 (59.47%)
Method 8	3 (1.58%)	111 (58.42%)
Method 9	5 (2.63%)	108 (56.84%)
Method 10	2 (1.05%)	103 (54.21%)
Method 11	2 (1.05%)	101 (53.16%)
Method 12	1 (0.53%)	99 (52.11%)
Method 13	2 (1.05%)	98 (51.58%)
Method 14	0 (0.00%)	96 (50.53%)
Method 15	8 (4.21%)	96 (50.53%)
Comments on the methods	1 (0.53%)	88 (46.32%)
Section C	0 (0.00%)	87 (45.79%)
Collaborative competences (Statements in random order)	1 (0.53%)	87 (45.79%)
Strategic priority (Statements in random order)	3 (1.58%)	86 (45.26%)
End page	0 (0.00%)	83 (43.68%)
Overall	Uncompleted	107 (56.32%)
Overall	Completed	82 (43.16%)
Overall	Finished after interruption	1 (0.53%)

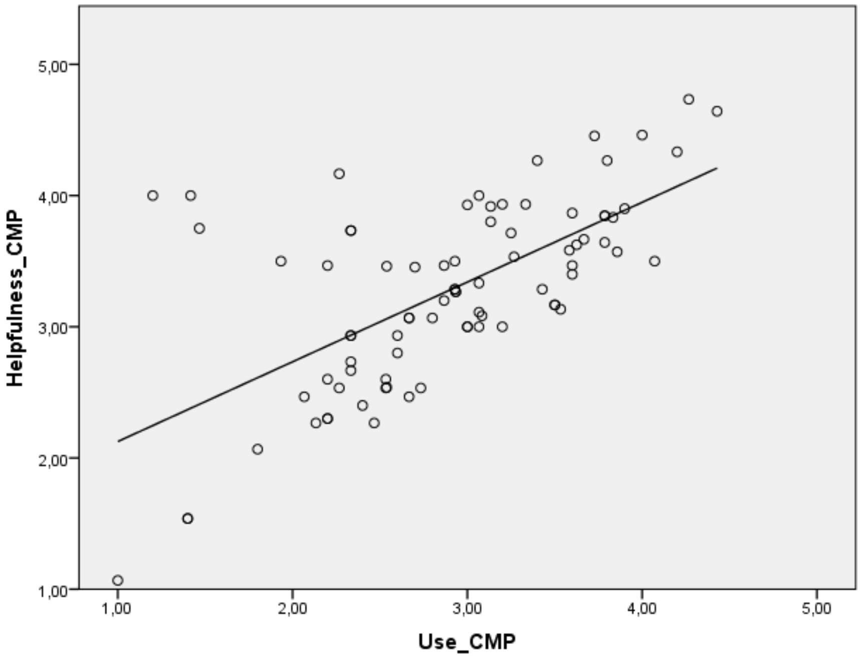
Appendix J

Scatterplots –

Hypotheses 1

Dependent variable: helpfulness of all methods

Independent variable: use of all methods



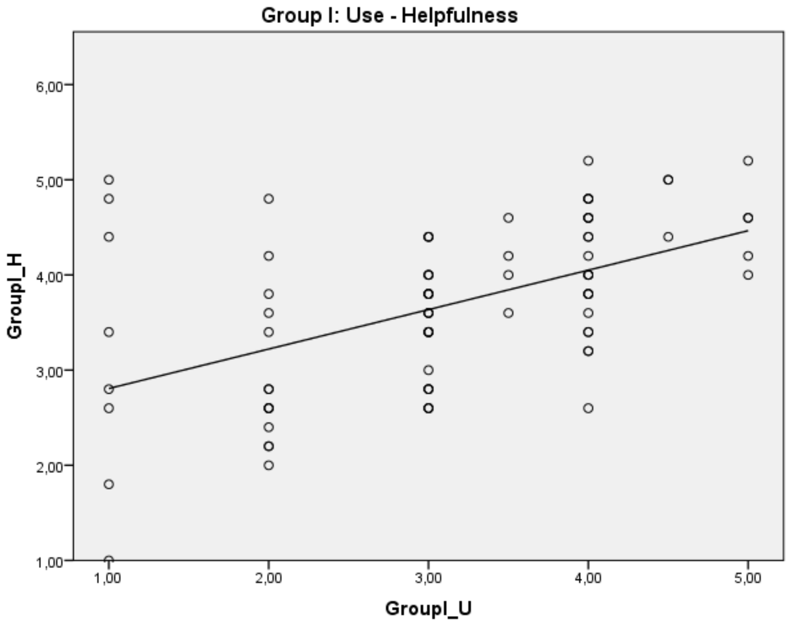
Appendix K

Scatterplotts

Hypothesis 2a

Dependent variable: helpfulness of methods classified in Group–I

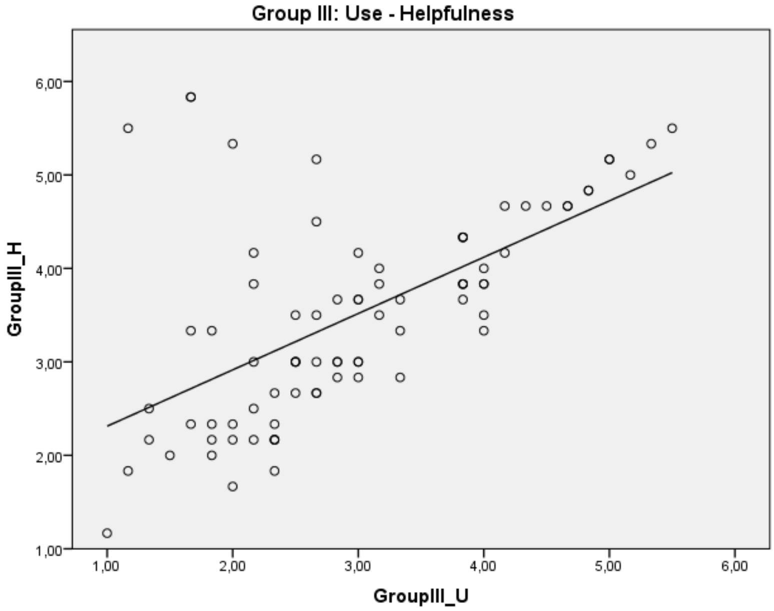
Independent variable: use of methods classified in Group–I



Hypothesis 2b and H2c

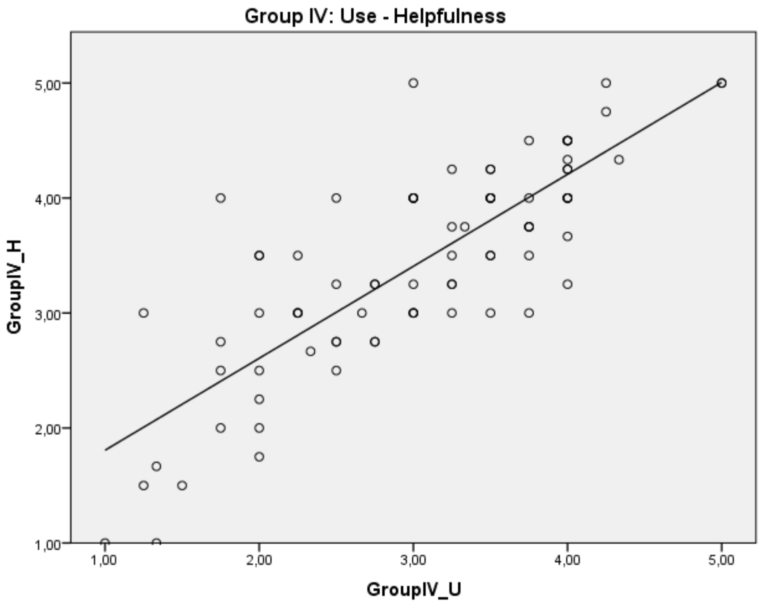
Dependent variable: helpfulness of methods classified in Group–III

Independent variable: use of methods classified in Group–III



Dependent variable: helpfulness of methods classified in Group–IV

Independent variable: use of methods classified in Group–IV



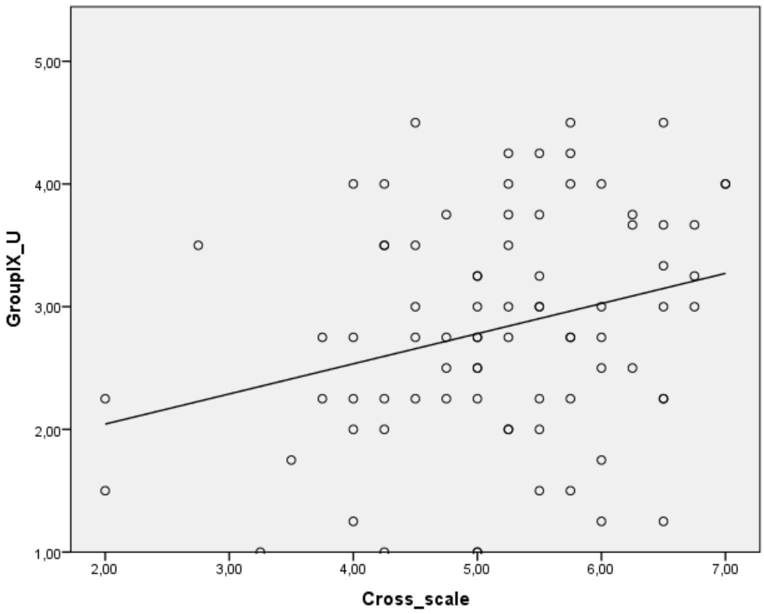
Appendix L

Scatterplotts

Hypothesis 6a and H6b

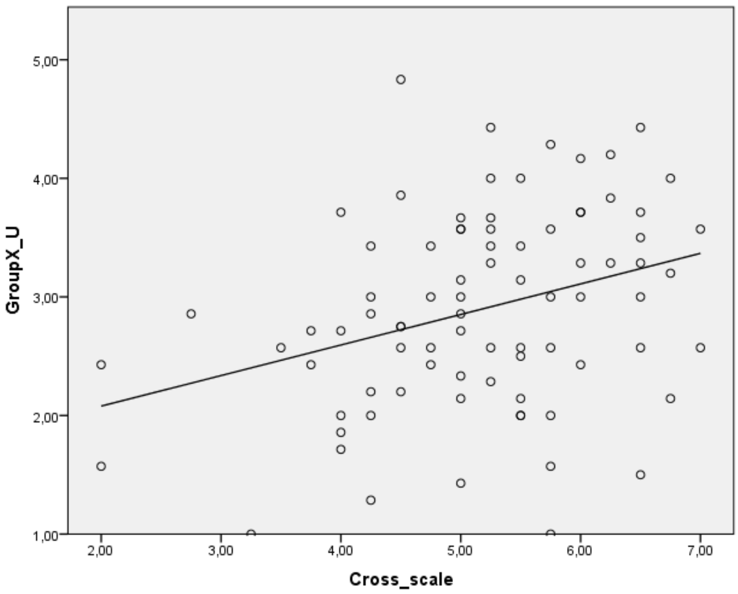
Dependent variable: use of - Group–IX

Independent variable: cross-functional integration



Dependent variable: use of - Group–X

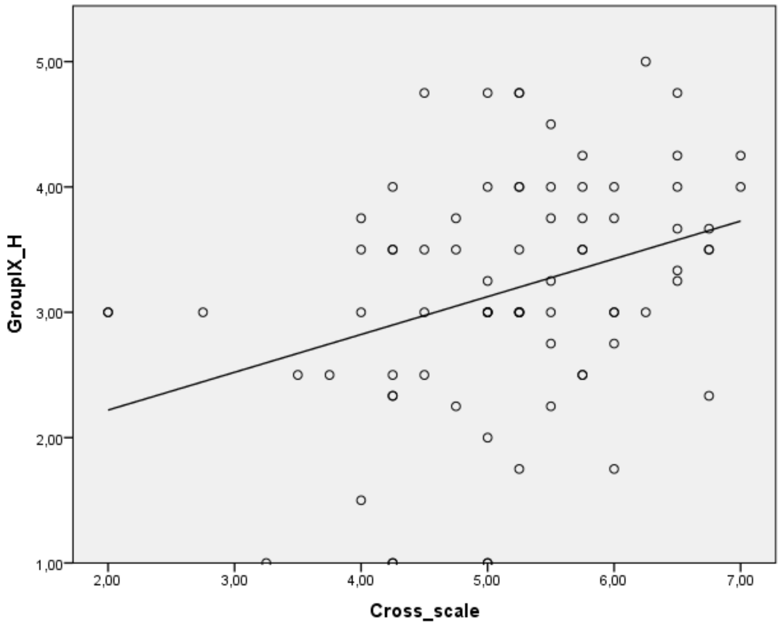
Independent variable: cross-functional integration



Hypothesis 6c and H6d

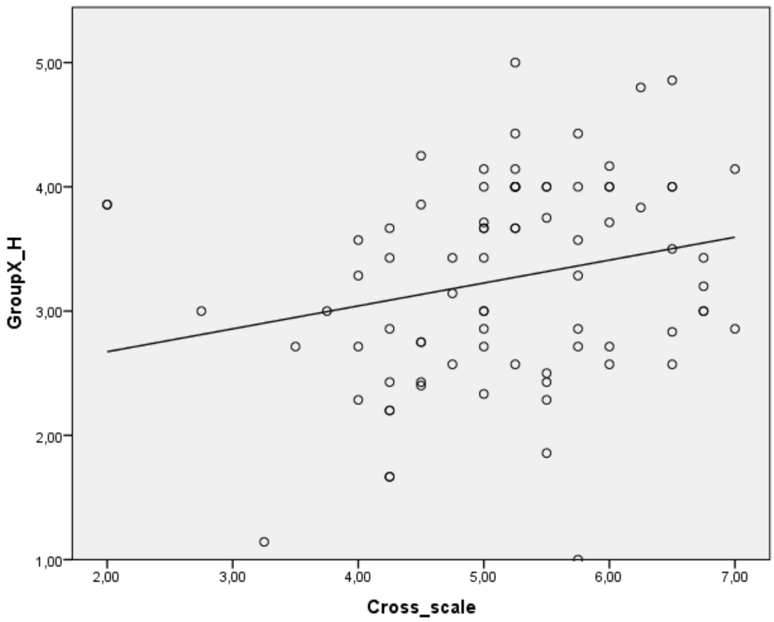
Dependent variable: helpfulness - Group–IX

Independent variable: cross-functional integration



Dependent variable: helpfulness - Group–X

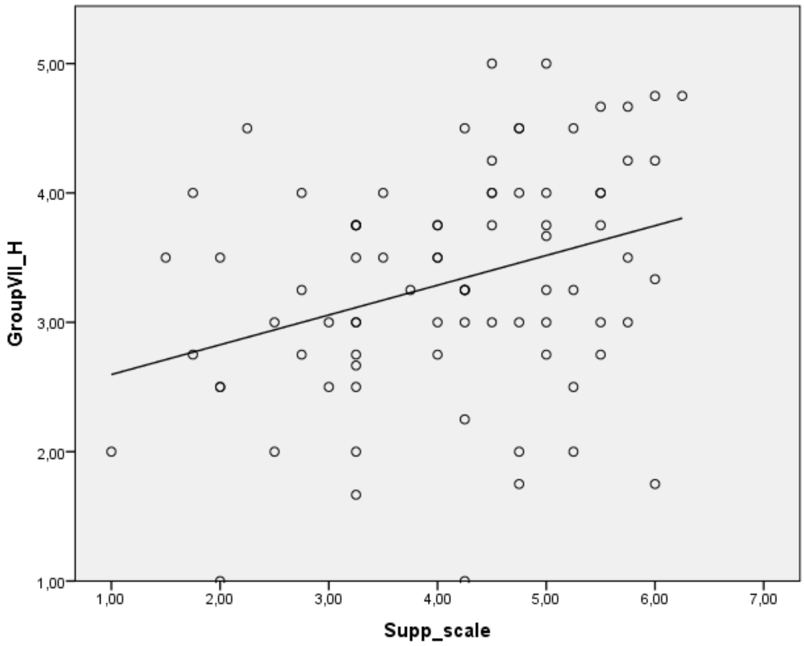
Independent variable: cross-functional integration



Hypothesis 7a and H7b

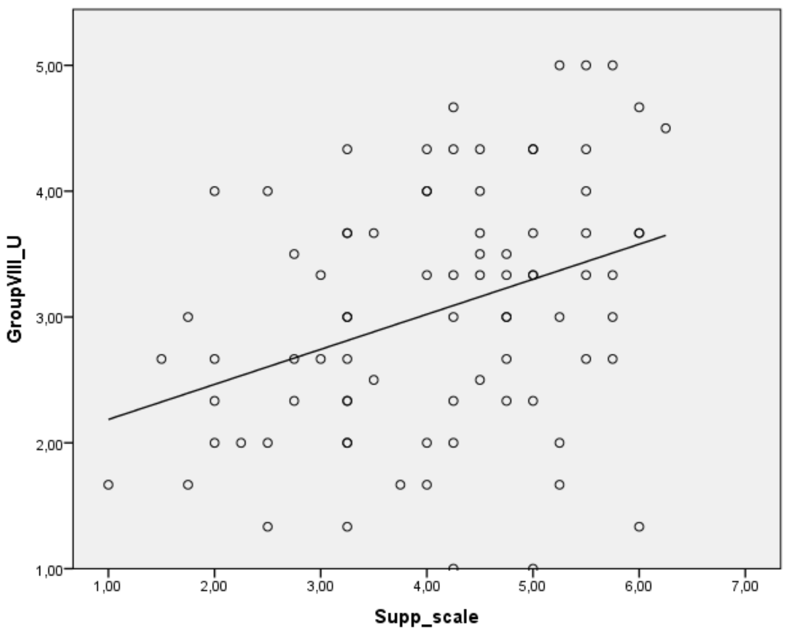
Dependent variable: Use of - Group–VII

Independent variable: supplier integration



Dependent variable: use of - Group–VIII

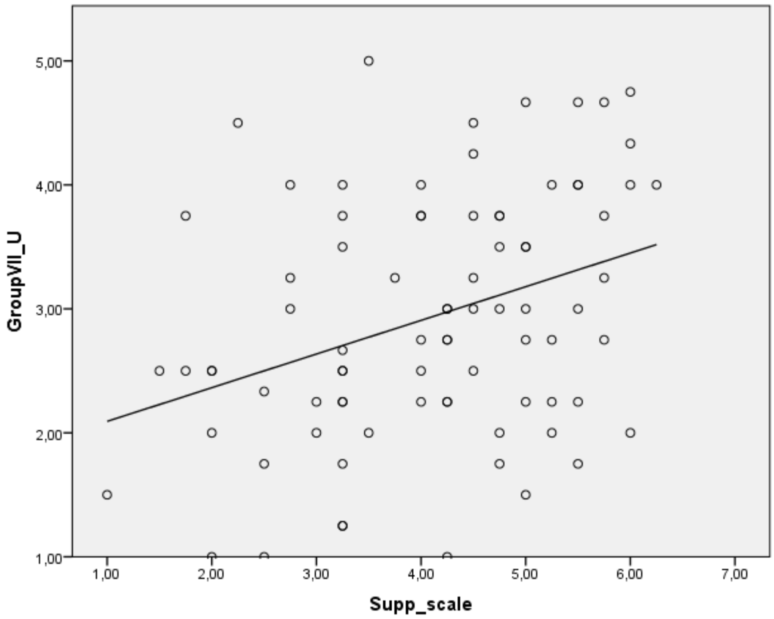
Independent variable: supplier integration



Hypothesis 7c and H7d

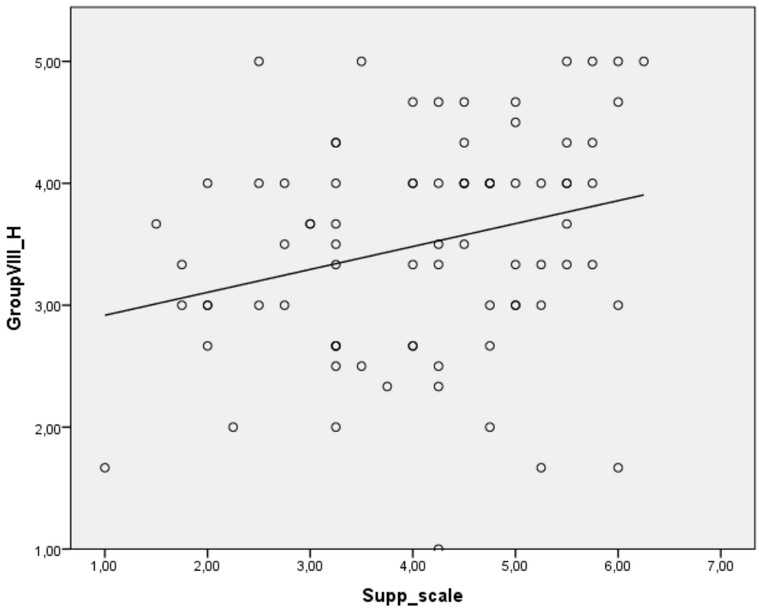
Dependent variable: helpfulness - Group–VII

Independent variable: supplier integration



Dependent variable: helpfulness - Group–VIII

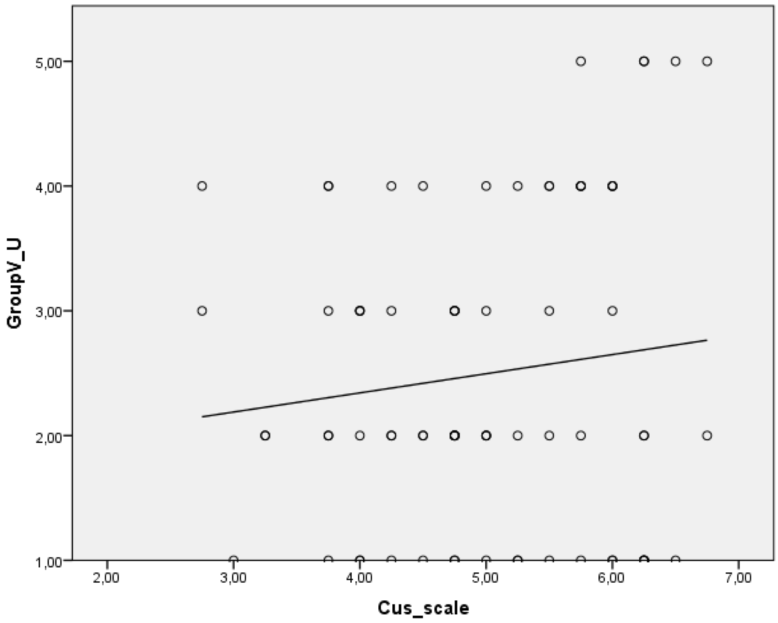
Independent variable: supplier integration



Hypothesis 8a and H8b

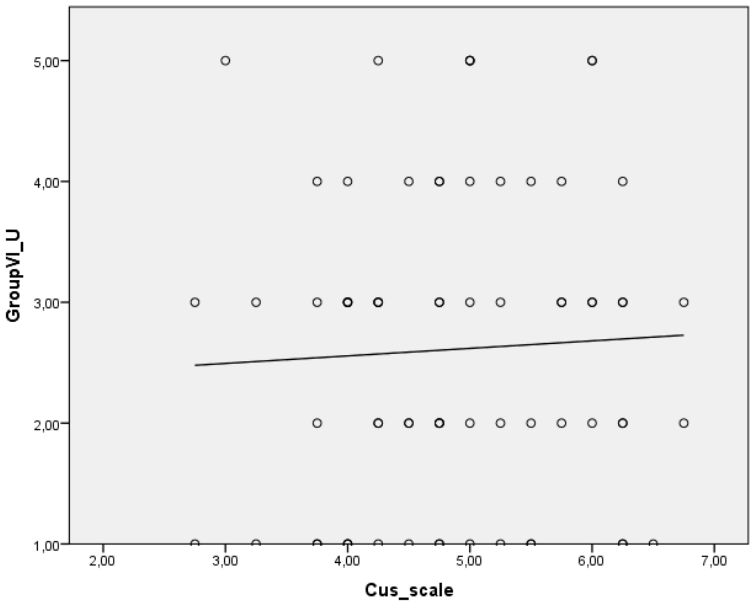
Dependent variable: use of - Group–V

Independent variable: customer integration



Dependent variable: Use of - Group–VI

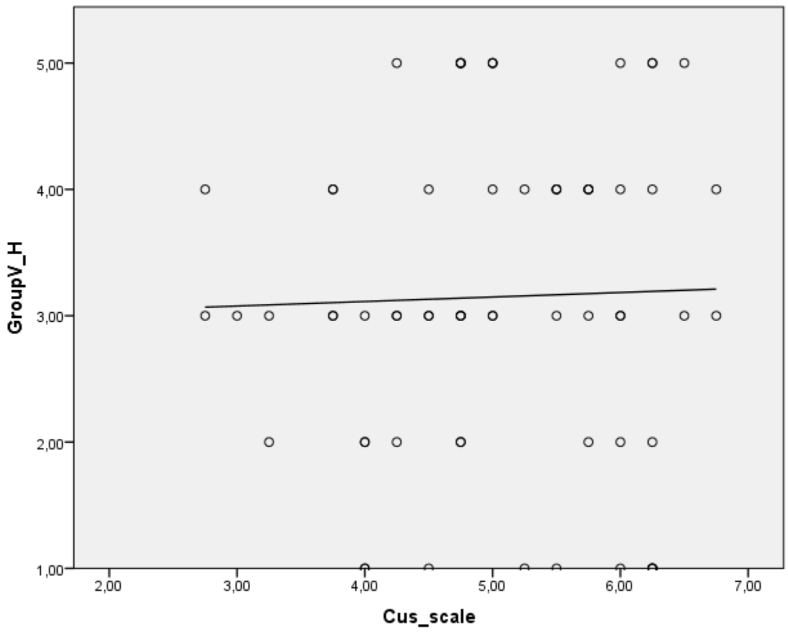
Independent variable: customer integration



Hypothesis 8c and H8d

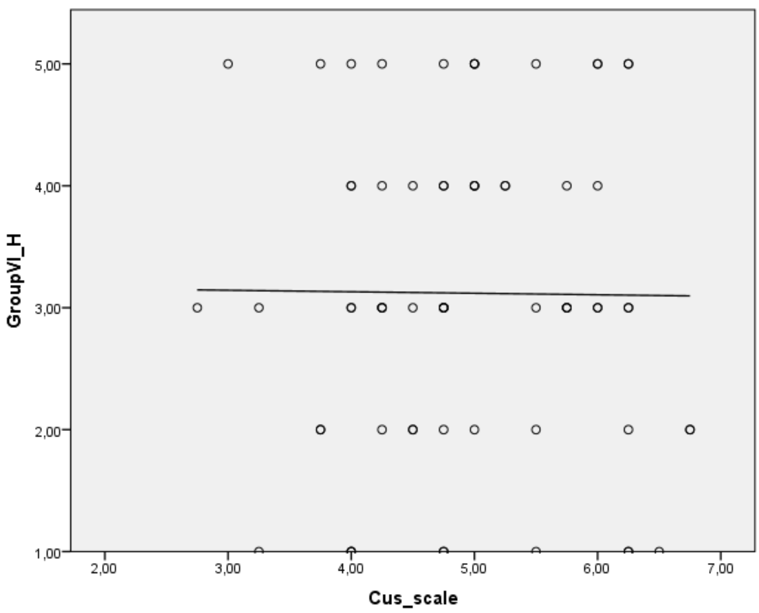
Dependent variable: helpfulness - Group–VI

Independent variable: customer integration



Dependent variable: helpfulness - Group–VI

Independent variable: customer integration



Appendix M

Adoption of cost management methods and the organisation's collaborative competences within small, medium and large firms

Variables: collaborative competences – use of

Small firms

Correlations[a]			H6		H7		H8	
			GroupIX_U	GroupX_U	GroupVII_U	U	GroupV_U	GroupVI_U
Spearman's rho	Cross_scale	Correlation	**,465****	**,496****	.260	.243	.054	.239
		Sig. (2-tailed)	.008	.004	.150	.180	.782	.261
		N	31	32	32	32	29	24
	Supp_scale	Correlation	.016	.194	.209	.186	-.119	.328
		Sig. (2-tailed)	.932	.288	.251	.309	.539	.117
		N	31	32	32	32	29	24
	Cus_scale	Correlation	.196	.331	.208	.189	.050	-.135
		Sig. (2-tailed)	.290	.064	.254	.300	.796	.530
		N	31	32	32	32	29	24

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Medium sized firms

Correlations[a]			H6		H7		H8	
			GroupIX_U	GroupX_U	GroupVII_U	U	GroupV_U	GroupVI_U
Spearman's rho	Cross_scale	Correlation	.084	.290	.184	**,458***	.125	.263
		Sig. (2-tailed)	.677	.143	.358	.016	.553	.203
		N	27	27	27	27	25	25
	Supp_scale	Correlation	**,436***	.333	**,419***	**,502****	.337	.340
		Sig. (2-tailed)	.023	.089	.030	.008	.100	.096
		N	27	27	27	27	25	25
	Cus_scale	Correlation	.099	.039	.060	.126	-.098	.334
		Sig. (2-tailed)	.622	.849	.765	.531	.643	.103
		N	27	27	27	27	25	25

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Large firms

Correlations[a]			H6		H7		H8	
			GroupIX_U	GroupX_U	GroupVII_U	U	GroupV_U	GroupVI_U
Spearman's rho	Cross_scale	Correlation	.136	.046	.168	.112	-.052	.181
		Sig. (2-tailed)	.536	.836	.442	.611	.822	.409
		N	23	23	23	23	21	23
	Supp_scale	Correlation	.353	,489*	**,466***	.304	.140	.258
		Sig. (2-tailed)	.098	.018	.025	.159	.546	.235
		N	23	23	23	23	21	23
	Cus_scale	Correlation	-.015	-.267	.140	-.189	.169	-.121
		Sig. (2-tailed)	.945	.217	.525	.387	.463	.584
		N	23	23	23	23	21	23

*. Correlation is significant at the 0.05 level (2-tailed).

a. newFirm_size = Large firms

Variables: collaborative competences – helpfulness

Small firms

Correlations[a]			H6		H7		H8	
			GroupIX_H	GroupX_H	GroupVII_H	H	GroupV_H	GroupVI_H
Spearman's rho	Cross_scale	Correlation	.349	.219	.133	.279	-.229	.199
		Sig. (2-tailed)	.054	.228	.469	.123	.260	.363
		N	31	32	32	32	26	23
	Supp_scale	Correlation	.116	.019	.176	.104	-.080	.161
		Sig. (2-tailed)	.533	.919	.336	.571	.698	.464
		N	31	32	32	32	26	23
	Cus_scale	Correlation	-.061	.176	-.014	.128	-.080	-.166
		Sig. (2-tailed)	.746	.336	.937	.484	.699	.449
		N	31	32	32	32	26	23

a. NewFirm_size = Small firms

Medium sized firms

Correlations[a]			H6		H7		H8	
			GroupIX_H	GroupX_H	GroupVII_H	H	GroupV_H	GroupVI_H
Spearman's rho	Cross_scale	Correlation	.284	.300	.289	**,549****	.325	.308
		Sig. (2-tailed)	.160	.128	.152	.003	.140	.153
		N	26	27	26	27	22	23
	Supp_scale	Correlation	**,521****	.209	**,488***	**,468***	.221	.303
		Sig. (2-tailed)	.006	.296	.011	.014	.324	.161
		N	26	27	26	27	22	23
	Cus_scale	Correlation	.073	-.072	.020	.125	.041	.332
		Sig. (2-tailed)	.722	.720	.921	.535	.856	.121
		N	26	27	26	27	22	23

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

a. NewFirm_size = Medium firms

Large firms

Correlations[a]			H6		H7		H8	
			GroupIX_H	GroupX_H	GroupVII_H	H	GroupV_H	GroupVI_H
Spearman's rho	Cross_scale	Correlation	.064	.195	.088	.181	.308	.080
		Sig. (2-tailed)	.773	.374	.688	.421	.200	.729
		N	23	23	23	22	19	21
	Supp_scale	Correlation	.188	.366	.287	.266	.010	.056
		Sig. (2-tailed)	.389	.086	.184	.232	.967	.810
		N	23	23	23	22	19	21
	Cus_scale	Correlation	-.324	-.303	-.093	-.185	.179	-.083
		Sig. (2-tailed)	.132	.160	.674	.409	.465	.721
		N	23	23	23	22	19	21

a. NewFirm_size = Large firms