Karlsruher Institut für Technologie

Multi-objective Optimization as a Methodology for evaluating Success Factors for Start-ups

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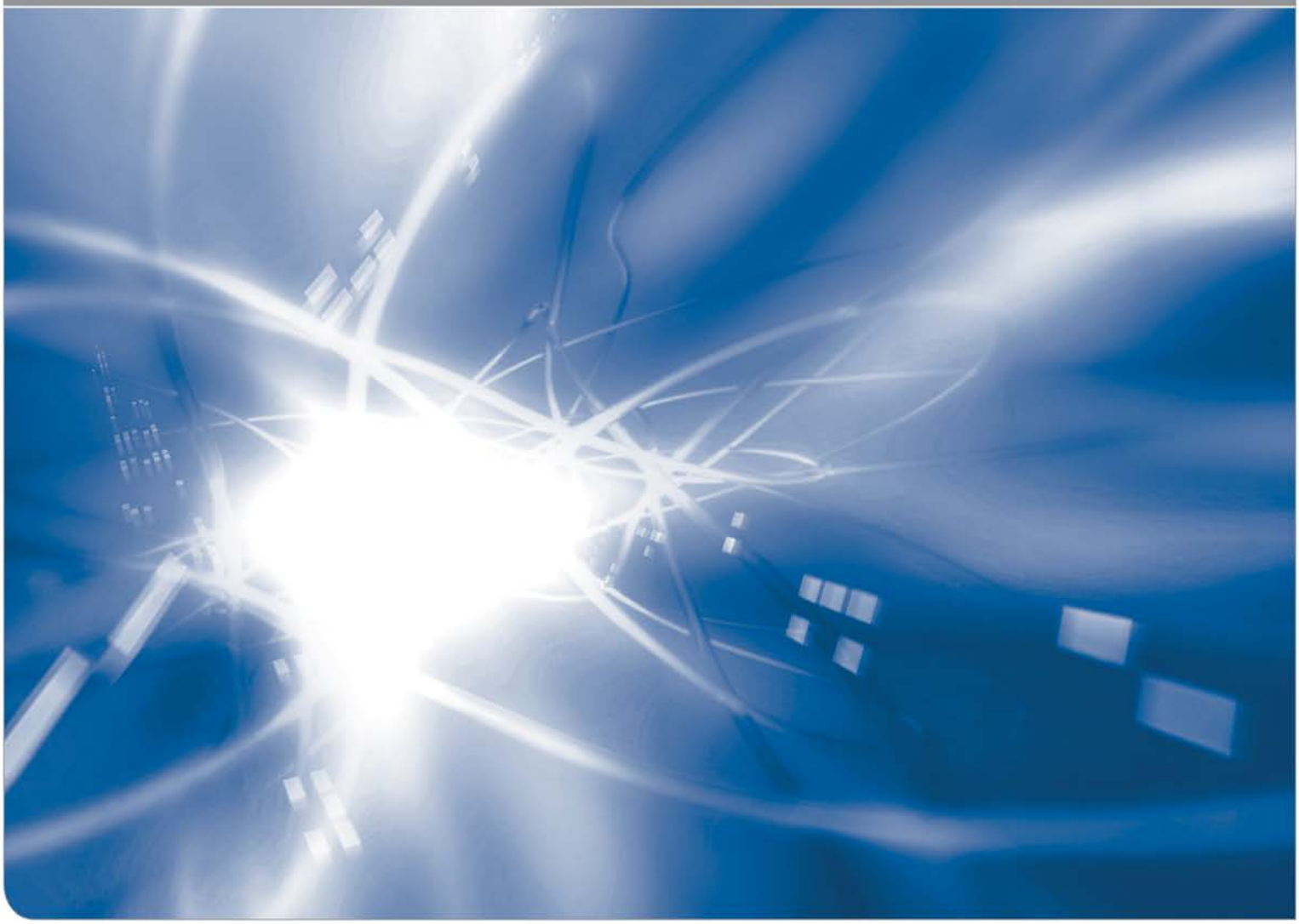

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Abstract

This study proposes a methodology for the analysis of newly created ventures. Based on previous research, 15 parameters covering the behavior of young ventures are introduced. These parameters enable the analysis of young ventures regarding the three success criteria growth in employees, growth in sales and growth in earnings before interest and taxes.

A pre-study is conducted to derive characteristic patterns in the behavior of successful ventures according to the defined parameters. The used sample consists of ventures from a former study at Karlsruhe Institute of Technology. We analyze the first four years of these firms, which have different industry backgrounds.

We found that ventures with relatively high spendings on research and development and a high share of full-time employees in this field are more successful than those ventures which show less commitment in research and development. We also conclude that a high market growth is a necessary but not sufficient requirement for the success of a newly created company.

We additionally give an outlook on implications for succeeding research in this area and practical applications of this work.

1. Introduction

The purpose of this working paper is to identify and evaluate the key success parameters of newly created, entrepreneurial ventures regarding the three performance and success criteria growth in full-time employees, growth in sales and growth in earnings before interest and taxes. This is achieved by developing a first foundation for an evaluation framework based on existing literature and a first test run with existing data from recent research at the Institute of Entrepreneurship, Technology Management and Innovation at Karlsruhe Institute of Technology.

Since there has been an increasing availability of data on young ventures, a need for appropriate analytic tools and evaluation methodologies has arisen. This paper provides a starting point for methods that may allow founders, management teams of young ventures and venture capitalists to identify and understand the key factors to achieve success.

Practical approaches, such as the Startup Compass[1], an online benchmark tool based on over tens of thousands of Internet startups, are well received projects for data based evaluation of young ventures. The Startup Compass offers young ventures from high-tech industries, such as web, software or biotech to gather data of their companies, e.g. the number of products, addressed markets, revenues and capital structure. This allows them to compare their profiles with other ventures and derive relevant metrics, reference points and actions for the improvement of their businesses.

Nowadays we face an increasing amount of data in this area. We therefore continue the discussion and want to propose ideas on how data mining concepts can help us to detect and understand patterns in relevant parameters of successful ventures. As the framework developed for this purpose is tested with data from a previous study, only a third of the required parameters are supported by data. This leads to the fact that this paper should be perceived as

[1] https://www.startupcompass.co (27/4/2013, 5:55 p.m.)

a pre-study, giving first impressions and impulses how succeeding research in this area can benefit from the introduced methodology.

This paper is structured as follows. In the next section we refer to the related work. Section 3 is dedicated to the methodology, parameters and the identified criteria for measuring success. In that section, we graphically visualize characteristic patterns of successful and unsuccessful ventures within our data set to understand the influence of the parameters on the success criteria. We analyze the results in section 4 and 5 and conclude the paper in section 6.

2. Related Work

Research on the performance of young ventures and the impact of different parameters on their success has been carried out since the late 80s (Macmillan et al., 1985; Macmillan et al., 1987; Stuart and Abetti, 1987). While early approaches often looked from a venture capitalist's perspective, trying to understand the importance of different ranking criteria for investment decisions, research in the 90s accessed more extensive databases, compared larger sets of ventures (Siegel et al., 1993) and contrasted different evaluation methodologies and their sources to predict new venture performance (Brush and Vanderwerf, 1992). The perspective of venture capitalists on new ventures recurs in previous research (Sheperd, 1999), primarily examining the assessment policies of venture capitalist and business angels (Freear et al., 2002; Kakati, 2003; Sudek, 2006) and the criteria they look for in business plans (Mason and Stark, 2004).

Research on the causality of venture growth contributed to the understanding of how firms follow different patterns of growth (Delmar et al., 2003) as well as how financing rounds of startups correlate with growth in certain measures, such as the number of employees (Davila et al., 2002).

Research in recent years focused on in-depth analyses of various topics, such as the activities and characteristics of founders during the pre-startup phase and the market entry of new firms (Santarelli, 2007), the motivation of entrepreneurs in academia (D'Estea et al., 2012) as well as how market risks

are perceived (van Gelderen, 2006) or how the performance of founder-led firms is influenced by their CEOs (Adams et al., 2008).

Specific areas and functions within new ventures, e.g. research and development, became more important in the discussion, as they played a vital role in innovation and therefore in economic growth (Stam and Wennberg, 2008). Highly-innovative ventures that aim to disrupt existing markets with radical innovation have been examined in the context of critical factors for success as well (Groenewegen, 2012).

Certain industries, businesses (O'Regan et al., 2006) or countries (Chorev and Anderson, 2006) have been part of more detailed examination on the drivers of growth and success factors (Wright and Stigliani, 2012).

The role of barriers and obstacles to growth has been subject in the context of academic spin-offs (van Geenhuizen and Soetanto, 2009) and transition environments within European economies (Doern, 2009).

Davila et al. (2002) highlights the signaling effect of venture capital funding events on the quality of a startup as the number of employees increases around those financing events and is positively correlated to the change in equity value.

Delmar et al. (2003) highlights the importance of the use of different growth measures, such as relative and absolute, total and organic (excluding acquisitions) growth in employment and sales because strong growing companies grow in different ways. Due to these different patterns of growth, conflicting theories about firm growth arise depending on the observed patterns, causalities and results (Delmar et al., 2003).

Van Geenhuizen and Soetanto (2009) found that market related problems, such as the absence of marketing skills and a missing customer base, represent the most resistant obstacles in the growth of academic spin-off firms, while financial problems, such a lack of investment capital for research and development, show higher reduction rates.

3. Method

In this section, we firstly identify the success criteria and corresponding parameters for young ventures. Furthermore, we propose a new methodology for the analysis of these data.

3.1 Evaluation Framework

3.1.1 Success Criteria

Success has been defined in various forms. A very loose definition describes success as the achievement of individually set objectives, depending on what is considered as being successful or not. Macmillan et al. (1987) use this approach in their study on the venture screening process of venture capitalists, letting them decide whether a venture is regarded as successful or not.

Kakati (2003) chose a slightly more concrete definition of success, stating "[s]uccess was defined as the achievement of something desired, planned or attempted." (Kakati, 2003, p. 448)

If success is defined as the achievement of planned objectives, it might be vice versa expressed in terms of different categories of risk not to achieve these objectives. Macmillan et al. (1985) concluded that "[…] venture capitalists appear to assess ventures systematically in terms of six categories of risk to be managed. These are: risk of losing the entire investment; risk of being unable to bail out if necessary; risk of failure to implement the venture idea; competitive risk; risk of management failure; and risk of leadership failure." (Macmillan et al., 1985, p. 119)

Looking at table 1, the outcome of the study of Murphy et. al (1996) indicates a focus on the criteria efficiency, growth and profit when it comes to the frequency of performance dimensions in academia.

Table 1: Dimensions of Performance and Their Frequencies (Murphy et al., 1996, p.16).

Table 1. Dimensions of Performance and Their Frequencies

Dimension	Frequency
Efficiency	30
Growth	29
Profit	26
Size	15
Liquidity	9
Success/Failure	7
Market Share	5
Leverage	3

Ventures grow differently according to the industry and the market they come from as well as the business model they use. Labor-intensive companies, such as service companies, might follow different patterns of growth than capital-intensive companies, such as manufacturing companies. The characteristics of a firm influence the pattern of performance regarding different measures of success. The fact that ventures within the same industry might show different degrees of growth depending on when they were founded is a self-evident problem. A venture founded less than three years ago is supposed to perform differently than a similar venture founded more than five years ago. Defining a set of success criteria in order to get a more comprehensive picture mitigates this fact. Companies in their first years might e.g. show a high growth in full-time employees by simultaneously generating negative profits as they have not reached break-even yet, while more mature ventures might show a slower increase in full-time employees by already generating solid profits. In order to increase the comparability of different ventures, three success criteria are defined.

Success criterion c_1: growth in full-time employees

Davila et al. (2002) show a significant positive association between the changes in number of employees and the change in equity value. As the number of employees is an easily accessible value, it provides an appropriate basis for the first criterion, measuring the success of a venture in the context of this study. We take for granted that a change in equity value is an indicator for the change in a venture's current and future success. That means the probability of

operating successfully in the future increases as the current number of employees increases.

Success criterion c_2: growth in sales

To cope with the fact that ventures follow different paths of growth, Delmar et al. (2003) use a multi-criteria approach, defining a venture as a high-growth firm if it is "[…] among the top 10% of all firms in terms of an annual average in one, or more, of six categories: 1) absolute total employment growth, 2) absolute organic employment growth, 3) absolute sales growth, 4) relative (i.e., percentage) total employment growth, 5) relative organic employment growth, and 6) relative sales growth." (Delmar et al. 2003, p. 191)

Ignoring the source of growth – organic or external – high-growth firms are perceived as successful, because they seem to demonstrate a justified demand for their products and services, to sell more of their offerings and to therefore increase their firm value. As sales are an obvious indicator for the demand for a company's products and services, growth in sales is further defined as second success criterion.

Success criterion c_3: growth in EBIT

Profit is the third success criterion in this study. As shown above, the dimension profit is one of the most commonly used criteria in research to measure the performance of a venture (Murphy et al., 1996). It is a straightforward assumption that profit is one of the central figures a venture has to be evaluated on. Even if a venture is financed by external capital for the first years, investors expect to be paid off at some point. The return on their investment depends on the profits generated by the company. This applies for early stage and seed investors as well as for investors with focus on later stage investments. If a venture is not financed by investors because of the characteristics of its business model, e.g. by being non-scalable or by having positive cash flows from the beginning, it is even more important to start generating positive profits from the beginning. In the context of this work, profit is represented by earnings before interest and taxes (EBIT).

3.1.2 Parameters

Having identified the most important success criteria, we now study different parameters that influence the success of a young venture. We define 15 parameters out of the four categories team, product, market and financials.

Parameter category 1: team

Since Macmillan et al. (1985) stated "[…] it is the jockey (entrepreneur) who fundamentally determines whether the venture capitalist will place a bet […]" (Macmillan et al., 1985, p. 119) and regarding the fact that, from a venture capitalist's perspective, "[f]ive of the top ten most important criteria had to do with the entrepreneur's experience or personality" (Macmillan et al., 1985, p. 119), it becomes obvious that the characteristics, experiences and skills of the venture team play a fundamental role in the success of a venture. As this study focuses on newly created ventures, which are primarily led by their founders, the first category of parameters focuses on the founding team.

Parameter p_1: industry experience

Industry experience is an indicator for the network and the familiarity of an entrepreneur within a certain market (van Gelderen et al., 2006), but describes "[…] the amount, strength or diversity of the ties that a person has with the industry" (van Gelderen et al., 2006, p. 326, 327) only to a certain degree. The more years an entrepreneur has spent in a certain industry, the more knowledge he was able to achieve (Siegel et al., 1993). Being able to present a long track record within an industry "[…] can be helpful in the perception and valuation of new business ideas." (van Gelderen et al., 2006, p. 321)

From a venture capitalist's perspective it is the entrepreneur, respectively the founding team, that has to show a "[…] thorough familiarity with the target market" (Macmillan et al., 1985, p. 122) before any venture capitalist makes an investment in a young company (Macmillan et al., 1985). Regarding the causality of venture growth, the industry experience of the entrepreneurial team is one of the most distinguishing variables concerning high- and low-growth ventures (Siegel et al., 1993).

We propose to measure industry experience in five categories as follows: 0 years (1); 1 year (2); 2 – 5 years (3); 6 – 10 years (4); more than 10 years (5).

p_2: experience in venture founding

The often heard fact that some venture capitalists tend to prefer founders who already failed in starting up a business but learned their lesson, i.e. will avoid making the same mistakes again, leads to the second parameter within this framework. Although Siegel et al. (1993) did not find any distinctions between high- and low-growth ventures regarding the experience in founding a venture within their study, this kind of experience does not seem to cause any disadvantages. Van Gelderen et al. (2006) observed an advantage for people who are experienced in starting up a venture but have little industry experience otherwise.

Within this framework we introduce parameter p_2 as a binary variable, using "0" for "no experience in venture founding" and "1" for "experience in venture founding".

Parameter p_3: functionally balanced team

This parameter captures the functional balance of an entrepreneurial team. It is supposed to indicate whether an entrepreneurial team covers all relevant skills to successfully manage a young venture. Siegel et al. (1993) identified a functionally balanced team as distinguishing variable between high- and low-growth ventures.

We propose to measure functional balance according to the top four categories of the developed framework. That means a team ideally consists of at least four persons, one with background in leading teams, such as classical management skills, one with experience regarding the product, such as skills in product development, one regarding the target market, such as marketing and sales skills and one with background in the financial management of young companies.

For each existing background we add a value of “0.25”, i.e. this discrete parameter can range from “0”, “0.25”, “0.5”, “0.75” up to “1”.

Parameter category 2: products and services

Parameters covering the products and services offered by a venture are defined in the following.

Parameter p_4: product protectability

Venture capitalists look for ventures with protectable products that are able to deliver a first proof of concept by existing prototypes (Macmillan et al., 1985). Even venture teams that are “[…] not articulate in discussing the venture […]” (Macmillan et al., 1987, p. 129) nor able to show a functioning prototype demonstrate a high success rate “[…] where the venture team patents an invention that proves extremely successful […]” (Macmillan et al., 1987, p. 129).

Apart from high product protection through patents, other forms of protection can be given by low risks of competition at early stages, expensive development costs for competitors or a unique infrastructure, such as the embedment into research networks of a university.

Patents are a distinctive factor concerning a product’s protection from copies by competitors, especially in high-tech industries. We introduce parameter p_4 as a binary variable, depending on whether one or more patents underlie the product portfolio of a venture (1) or not (0), being aware of a possible discrimination of low-tech industries

Parameter p_5: product price compared to competitors

Competition on prices plays a more important role in low-tech industries or on consumer markets, as they often address more transparent mass market with high competition in general, whereas “[…] high-tech industries can charge higher price premium for their unique and customized offerings […]” (Kakati, 2003, p. 456) which leads to lower transparency and a decreased comparability of prices.

As the price of a product is a central buying criterion, we introduce parameter p_5 "product price compared to competitors" which is measured in the percentage of the price a venture charges for its products compared to competitors.

Parameter p_6: market acceptance of product

Ventures with products that have "[…] a demonstrated market acceptance are more cushioned from product and market development failures." (Macmillan et al., 1985, p. 126)

Both competitive threat as well as market acceptance of a product correlate positively with a venture's success and predict performance (Macmillan et al., 1987). Successful ventures firstly decide to develop and offer products, then go through a screening and selecting process on their markets and are ultimately rewarded with market acceptance (Kakati, 2003).

We define parameter p_6 "market acceptance of product" on a scale chosen by Macmillan et al. (1987) as follows: 0 (did not apply to venture), 1 (extremely poor), 2 (poor), 3 (satisfactory), 4 (highly satisfactory), 5 (outstanding). In future research, data for this parameter should be gathered from an external point of view, e.g. by venture capitalists or market research institutions.

Parameter p_7: full-time employees for product development

In high-tech ventures and those who operate in technology-based industries, the key determinant of success is the balance of technological expertise and business skills (Kakati, 2003). Furthermore, there is a correlation between the intensity in product development and growth in sales as well as stock returns (Anagnostopoulou and Levis, 2008).

Concerning young ventures within technology-based industries, we are interested if a high product development intensity, represented by the amount of full-time employees for product development, leads to higher success. On the other hand the "[…] over-emphasis on [the] technological side of the business or R&D efforts to make unique products may not lead to success […]" (Kakati,

2003, p. 456) once a prototype has been developed and gained protection (Kakati, 2003).

Parameter p_7 "full-time employees for product development" is represented by the share of full-time employees responsible for product development.

Parameter category 3: market

Ventures that bring well accepted and protected products to their target markets and "[…] stimulate the existing markets and anticipate and are proactive to unforeseen events […]" (Kakati, 2003, p. 452) are preferred by venture capitalists. As the existence of sufficiently large markets is crucial to new ventures and their products, we introduce the following four parameters capturing the characteristics of markets.

Parameter p_8: market growth

Operating on high growth markets reduces the venture's risk of failing and the venture capitalists' risk of losing their investments "[…] as a result of early competitive attacks." (Macmillan et al., 1987, p. 134)

High market growth seems to be a protection for young ventures that do not have the resources to outperform competitors, whilst high market growth also suggests enough demand to preserve young ventures from being crowded out by competition. Apart from the ability of stimulating existing markets, operating in high growth markets has been identified as a requirement to achieve a higher probability of achieving success (Kakati, 2003).

p_8 "market growth" is measured in percentaged growth of the venture's target market.

Parameter p_9: threat of early competition

The existence of established markets that are not fully covered by strong competitors and offer space for additional firms by avoiding direct competition is another indicator for successful companies, especially in high-tech industries (Macmillan et al., 1987).

Early competition and competitive threat seem to be a cause for early failure, even if the team is highly skilled and capable (Macmillan et al., 1987).

We introduce p_9 “threat of early competition” as a binary variable depending on the existence of early market competitors offering the same products as the examined venture (1) or not (0).

Parameter p_{10}: timing of entry

Timing, i.e. the entering of a market at the right time is a central challenge for new ventures. A pioneer enters a market first, often by creating a new industry, leading to higher risk of failure as well as higher rewards in the case that market sufficiency can be shown (Shepherd, 1999). Strategic cooperation, such as alliances with customers or marketing organizations, can help introduce new products and services at the right time (Chorev and Anderson, 2006). Highly innovative academic spin-off firms seem to have an advantage in avoiding obstacles on their way to success by leveraging their early monopoly-like market position (van Geenhuizen and Soetanto, 2009).

Providing highly skilled teams might be especially more appropriate for late followers to enter already existing and sustained markets, as lost time can be compensated by a more professional and faster execution. In this case the risk of losing initial investments by creating new markets mitigates while the threat of competition after market entry increases.

Parameter p_{10} “timing of entry” is introduced as binary variable distinguishing between pioneers (0) and late followers (1).

Parameter p_{11}: existing sales channels

The existence of distribution channels and the expertise in distributing products become important for the success of a venture, especially in low-tech consumer markets (Macmillan et al., 1987).

Distribution and marketing become expensive where there is a lack of or no access to appropriate distribution infrastructure, which leads to limited geographical sales opportunities (Kakati, 2003).

p_{11} “existing sales channels” is introduced as binary variable depending on whether the venture has access to established distribution channels (1) or not (0).

Parameter category 4: financials

A highly skilled and experienced team is one of the most important factors in a young venture, as this category often dominates financial, product or market categories. Apart from the factor team, financial criteria are rarely less important than the right team (Macmillan et al., 1985). In the following we introduce four parameters covering financial aspects of a young venture.

Parameter p_{12}: sales per customer

As sales in total is one of our success criteria we are interested in where these sales come from and how they are structured. Do successful ventures generate their revenue from few but high profitable customers or do they have a broad customer base with smaller basket sizes?

We introduce p_{12} “sales per customer” as variable measured by the percentage one customer averagely contributes to the venture’s total sales.

Parameter p_{13}: acquisition costs per customer

Costs are one of the most important key performance indices in the early life of a venture (Macmillan et al., 1987). As highly growing markets seem to be attractive for young ventures, acquisition costs per customer are still one of the central figures concerning the suitability of scaling a business.

We suggest p_{13} “acquisition costs per customer” to be a share of the product price. This can also contribute to the transparency of product margins and is more easy to capture than measuring it as share of a customer’s total revenue, as this figure strongly depends on the customer life cycle.

Parameter p_{14}: administrative costs

In contrast to low-growth ventures, those with high growth often show a lean administration in early stages of development (Siegel et al., 1993) and an attention of the management team to details (Kakati, 2003). Having leaner processes means having more time and resources for core business activities and therefore enables to focus on what is important for the success of the business.

p_{14} "administrative costs" is suggested to be measured in percentage of total costs.

Parameter p_{15}: costs for research and development

Having introduced p_7 "full-time employees for product development", we are interested in whether the success of a venture correlates with financial efforts for research and development, e.g. salaries, rent for labors, payments for instruments and other research and development related spending.

We suggest measuring p_{15} "costs for research and development" as share of total costs.

3.2 Data Analysis

In order to detect certain patterns in the parameters of successful and unsuccessful ventures according to the given definition of success, the data set is analyzed by clustering the ventures in terms of their qualities according to the three criteria "growth in full-time employees" (c_1), "growth in sales" (c_2) and "growth in EBIT" (c_3). In this study, the ventures with maximal values in each of the three criteria are identified as the best ones.

We need to refer to the methodologies in the area of multi-objective optimization in order to optimize (in this case maximize) several criteria that can partly stand in conflict with each other.

The solution of a multi-objective problem usually is a set of pareto-optimal solutions. In the context of this study, the ventures that are the best in terms of

all three criteria build the optimal set. We call it the non-dominated set of ventures which means that there is no other venture in our dataset that outperforms (or dominates) the members of the non-dominated set.

Formally, the concept of domination is defined according to Deb (2009) as follows:

Venture $v_{(1)}$ dominates venture $v_{(2)}$, if both conditions 1 and 2 are true:

1: Venture $v_{(1)}$ is no worse than venture $v_{(2)}$ in all criteria, or $c_i(v_{(1)}) \geq c_i(v_{(2)})$ for all criteria c_i, i = 1,2,3.

2: Venture $v_{(1)}$ is strictly better than venture $v_{(2)}$ in at least one criterion, or $c_i(x_{(1)}) > c_i(x_{(2)})$ for at least one $i \in \{1,2,3\}$.

Venture $v_{(1)}$ does not dominate venture $v_{(2)}$ if any of the two conditions is violated. In the case of more than two ventures, those that do not dominate other ventures can be pooled together into different sets. The non-dominated set contains all ventures that are not dominated by any venture outside this set.

3.3 Data Set

In this study, we analyze 5 of the 15 defined parameters on a dataset containing information on 20 ventures. These parameters are: “product price compared to competitors” (p5), “number of full-time employees for product development” (p7), “market growth” (p8), “sales per customer” (p12), “costs for research and development” (p15).

The used data was gathered in a former study by Weisensee (2012) that examined the impact of market properties and strategy on new venture performance. In that study ventures were analyzed regarding their strategy and the market properties they were surrounded by. These ventures entered their target markets averagely nine years prior to the study; however, they provide data for at least three out of their first four years as a venture. The ventures from different industries in the Karlsruhe area answered a questionnaire on

different aspects of their strategy and markets. Although this data set of ventures was gathered independently from this study, it provides the three defined success criteria and six out of 15 defined underlying parameters for our analysis, namely “product protectability” (p_4), “product price compared to competitors” (p_5), “full-time employees for product development” (p_7), “market growth” (p_8), “sales per customer” (p_{12}) and “costs for research and development” (p_{15}). The three success criteria were measured on a scale ranging from 1 to 7; 1 for negative growth, 7 for high growth. The values represent the average growth of the first four years after starting the venture. The parameters were captured on different scales as follows.

“Product price compared to competitors” (p_5): Compared to the average price of the three leading competitors, the examined ventures were asked to locate their prices in five categories:

1: lower than 50%.
2: from 50% to 80%.
3: from 81% to 120%.
4: from 121% to 150%.
5: higher than 150%.

“Number of full-time employees for product development” (p_7): The number of full-time employees for product development is represented by the share of all full-time employees for research and development activities and was captured in six categories.

1: 0%.
2: from 0% to 5%.
3: from 5% to 25%.
4: from 25% to 50%.
5: from 50% to 75%.
6: higher than 75% to 100%.

"Market growth" (p_8): The ventures were asked for the average growth rate of the relevant market according to eight categories:

1: lower than 0%.
2: from 0% to 5%.
3: from 5% to 10%.
4: from 10% to 30%.
5: from 30% to 50%.
6: from 50% to 75%.
7: from 75% to 100%.
8: higher than 100%.

"Sales per customer" (p_{12}): The companies were asked to state the average sales per customer per year in absolute numbers.

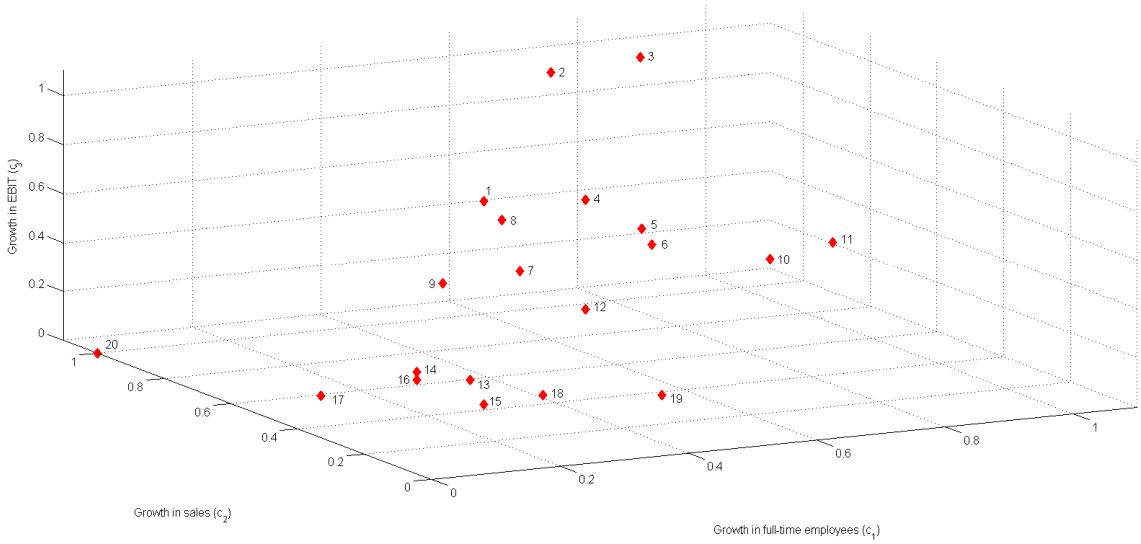
"Costs for research and development" (p_{15}): Costs for research and development were captured in absolute numbers, cumulated over the years from the first idea onwards, in seven categories:

1: no costs for research and development.
2: from 0 to 50,000 Euros.
3: from 50,000 to 150,000 Euros.
4: from 150,000 to 300,000 Euros.
5: from 300,000 to 1 million Euros.
6: from 1 million to 5 million Euros.
7: more than 5 million Euros.

3.4 Clustering of Data

The concept of domination is used to cluster the data and rank the different ventures according to the given success criteria. In figure 1, the ventures are plotted in a three-dimensional diagram according to the three normalized success criteria. The concept of normalization is introduced in section 3.5.

Figure 1: Growth in full-time employees, sales and EBIT.



As this way of plotting tends to be more complex, we split the process of clustering. Two two-dimensional diagrams are defined to visualize the data set more clearly: the diagram on the criteria growth in EBIT and growth in sales (figure 2) and the diagram on the criteria growth in EBIT and growth in full-time employees (figure 3). The criterion EBIT is allocated along the horizontal axis and the analyzed ventures are plotted according to their deposited values in both diagrams.

Figure 2: Growth in EBIT and sales.

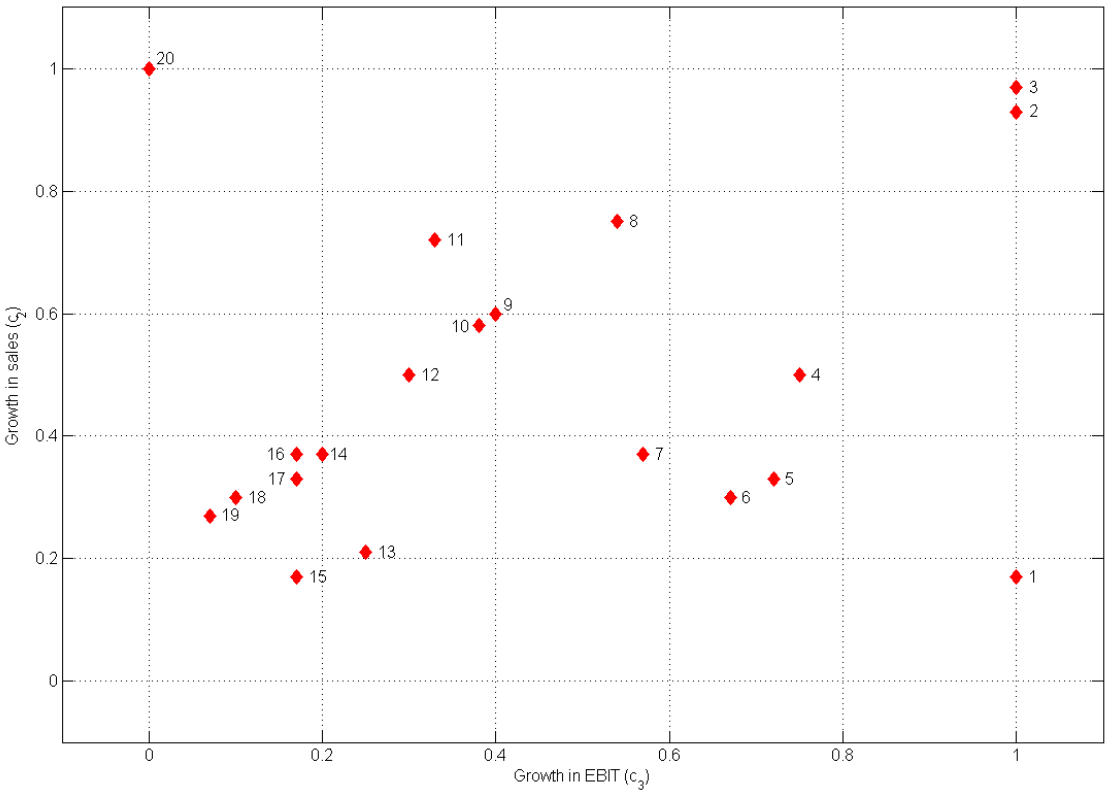
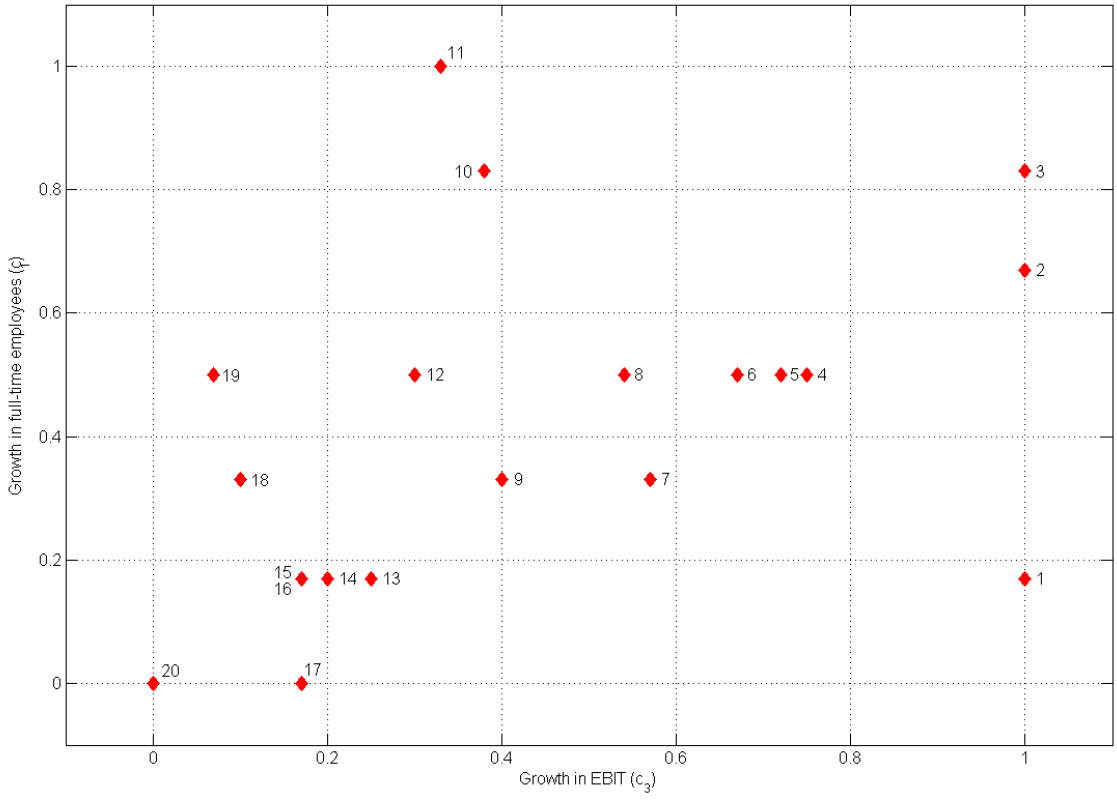


Figure 3: Growth in EBIT and full-time employees.



Applying to the concept of domination for a maximization problem as in the context of this paper, it is obvious that values in the upper right corner dominate the values in the lower left corner concerning the given definition of success, which means these ventures are more successful than those in the lower left corner.

According to the concept of non-dominated sets, each diagram contains a set that is not exceeded by any other value regarding both criteria. In figure 2, the non-dominated set consists of ventures 3 and 20. In figure 3, the Pareto-optimal set comprises ventures 3 and 11. Venture 11 is removed from the following examination because it might not be representative for a successful venture due to its average performance regarding growth in EBIT and growth in sales and therefore might lead to a misleading conclusion. Venture 20 is also removed because of its low performance regarding growth in EBIT and growth in full-time employees. As venture 2 is closely located to venture 3 in both diagrams, and as we have some uncertainties in the data, we consider venture 2 in the non-dominated set. These two points are summarized by defining them as the successful set of ventures in the context of this study.

In order to conduct a first comparison, a set of unsuccessful ventures is defined. This set stands for poorly performing ventures according to the given definition of success. Ventures located in the lower left area in both diagrams are therefore pooled into this set, providing full information on the captured parameters. Ventures 13 and 17 fulfill these requirements and represent the set of unsuccessful ventures.

3.5 Heatmap Analysis

The ventures have now been classified along the three success criteria and unsuccessful as well as non-dominated, successful sets have been identified. In order to detect patterns of parameter characteristics between and within the identified sets, the data is visualized using heatmap visualization method in the following.

A heatmap provides an intuitive visualization of a large amount of data by allocating color grades to observed values. In order to ensure comparability between the different success criteria and parameters, the values in the data set are normalized within the interval [0,1]. We find the minimum and the maximum of the values recorded among the 20 ventures for each parameter p and denote them as Min(p) and Max(p) respectively.

The normalized value for each entry is calculated as:

$$x_{normalized} = \frac{x - Min\ (p)}{Max\ (p) - Min\ (p)}$$

According to the normalized values within the interval [0,1], the parameters of the compared set are colored in different grades of white to dark blue, indicating zero to one respectively.

Table 2: Heatmap for successful set of ventures.

Venture	**p_5**	**p_7**	**p_8**	**p_{12}**	**p_{15}**	**c_1**	**c_2**	**c_3**
Venture 2	1	0.72	0.6	0.6667	1	0.6667	0.9333	1
Venture 3	0.5	0.28	0.6	0.0006	0.8	0.8333	0.9667	1

Table 3: Heatmap for unsuccessful set of ventures.

Venture	**p_5**	**p_7**	**p_8**	**p_{12}**	**p_{15}**	**c_1**	**c_2**	**c_3**
Venture 13	0.5	0	0.4	0	0.2	0.16666667	0.20833333	0.25
Venture 17	0	0	0.6	0.00830028	0	0	0.33333333	0.16666667

As stated above, heatmaps are appropriate to visualize large amounts of data. Due to the fact that this study only accesses a small number of partially fragmentary data, the following heatmap is supposed to give an impression on how a possible visualization of a larger amount of ventures could look like. The following heatmap visualizes success criteria and underlying parameters of the 20 ventures. It is sorted according to the success criterion c_3 “growth in EBIT”. Although the underlying data is fragmented it gives a sufficient impression.

Table 4: Heatmap consisting of all 20 ventures, ranked according to criterion "growth in EBIT" (c_3).

Venture	p_5	p_7	p_8	p_{12}	p_{15}	c_1	c_2	c_3
Venture 1	0.5	0	0	0.00030001	0	0.16666667	0.16666667	1
Venture 2	1	0.72	0.6	0.66665556	1	0.66666667	0.93333333	1
Venture 3	0.5	0.28	0.6	0.00063335	0.8	0.83333333	0.96666667	1
Venture 4	0	0.35	0.4	0.39998	0.2	0.5	0.5	0.75
Venture 5	0.5	0	0	n.n.	0	0.5	0.33333333	0.72222222
Venture 6	0.5	1	0.6	0.00030001	0	0.5	0.3	0.66666667
Venture 7	0	0.76	0.6	0.00930031	0.6	0.33333333	0.36666667	0.56666667
Venture 8	0.5	0.8	0.6	0.02663422	0.4	0.5	0.75	0.54166667
Venture 9	0	0.84	0.4	0.00163339	0.2	0.33333333	0.6	0.4
Venture 10	n.n.	0.9	0.4	0.0519684	0	0.83333333	0.58333333	0.375
Venture 11	0	0.5	0.6	n.n	0.8	1	0.72222222	0.33333333
Venture 12	0.5	0.4	0.6	0.00330011	0.8	0.5	0.5	0.3
Venture 13	0.5	0	0.4	0	0.2	0.16666667	0.20833333	0.25
Venture 14	n.n.	0	0.4	0.01996733	0.2	0.16666667	0.36666667	0.2
Venture 15	0	0	0.2	n.n.	0	0.16666667	0.16666667	0.16666667
Venture 16	1	0	0.6	0.03330111	0.2	0.16666667	0.36666667	0.16666667
Venture 17	0	0	0.6	0.00830028	0	0	0.33333333	0.16666667
Venture 18	n.n.	1	0.4	n.n.	0.8	0.33333333	0.3	0.1
Venture 19	0.5	0.56	0.8	n.n.	0.8	0.5	0.26666667	0.06666667
Venture 20	0	0.08	1	n.n.	0.2	0	1	0

4. Results

The values of the parameters are normalized to the interval [0,1] to ensure comparability, whilst the binary variable p_4 “product protectability”, which states whether the company’s products are protected by one or more patents or not, is ignored, as we face a variety of industries that are not all related to high-tech products and therefore linked to patents. No venture in our data sample uses patents to protect their products. For succeeding research, this parameter could be used as a multiplier within a quantitative evaluation regarding the venture’s probability of success.

The successful and unsuccessful sets are compared to clarify whether a characteristic pattern of parameter values can be observed or not. Concerning the defined success criteria, the chosen ventures of the successful set are located in the normalized interval as seen in table 2. The chosen ventures of the unsuccessful set are located as seen in table 3.

A tendency towards characteristic patterns of the measured parameter values can be observed as follows.

p_5: product price compared to competitors

In the underlying data set, p_5 represents the average price compared to the three leading competitors.

The successful set of ventures covers the upper area of the interval (venture 2: 1.00; venture 3: 0.50), the unsuccessful set covers the lower area (venture 13: 0.50; venture 17: 0.00). Although the impression might evolve that a lower price strategy compared to the other ventures does not necessarily lead to a successful venture performance, a clear statement regarding the correlation between price compared to competitors and success of ventures is avoided, as not enough data are available to derive a general hypothesis. The question whether the positioning of prices is directly correlated to the success of a venture or just an occurrence of the venture’s strategy remains.

p_7: number of full-time employees for product development

In the underlying data set, p_7 represents the share of full-time employees for research and development.

The set of successful ventures shows an above-average amount of full-time employees in the area of product development (venture 2: 0.72; venture 3: 0.28), whereas the set of unsuccessful ventures is positioned at the lower boundary of the normalized interval (venture 13: 0.00; venture 17: 0.00).

Regarding the fact that the set of successful venture has relatively high prices compared to the unsuccessful set, the higher share of full-time employees for product development might be a first indicator for a higher product quality that justifies a higher price.

p_8: market growth

In the underlying data set p_8 represents the average growth rate of the related product market.

The successful set (venture 2: 0.60; venture 3: 0.60) as well as the unsuccessful set of ventures (venture 13: 0.40; venture 17: 0.60) are both located in markets with slightly under- and above-average growth. Therefore, a minimum of market growth might be a necessary but not sufficient requirement for successful ventures.

p_{12}: sales per customer

In the underlying data set, p_{12} represents the average of absolute sales per customer per year.

Regarding the average sales per customer it is difficult to derive a clear conclusion. We only have access to absolutes in our data sample (average sales per customer) and not to total sales of the examined ventures. Therefore we are not able to calculate the corresponding share but used the absolute amount instead, which strongly depends on the venture's industry, business model and customer structure. As the successful set (venture 2: 0.66; venture

3: 0.00) does not show a clear tendency compared to the unsuccessful venture (venture 13: 0.00; venture 17: 0.01) due to its size, a conspicuous pattern cannot be detected.

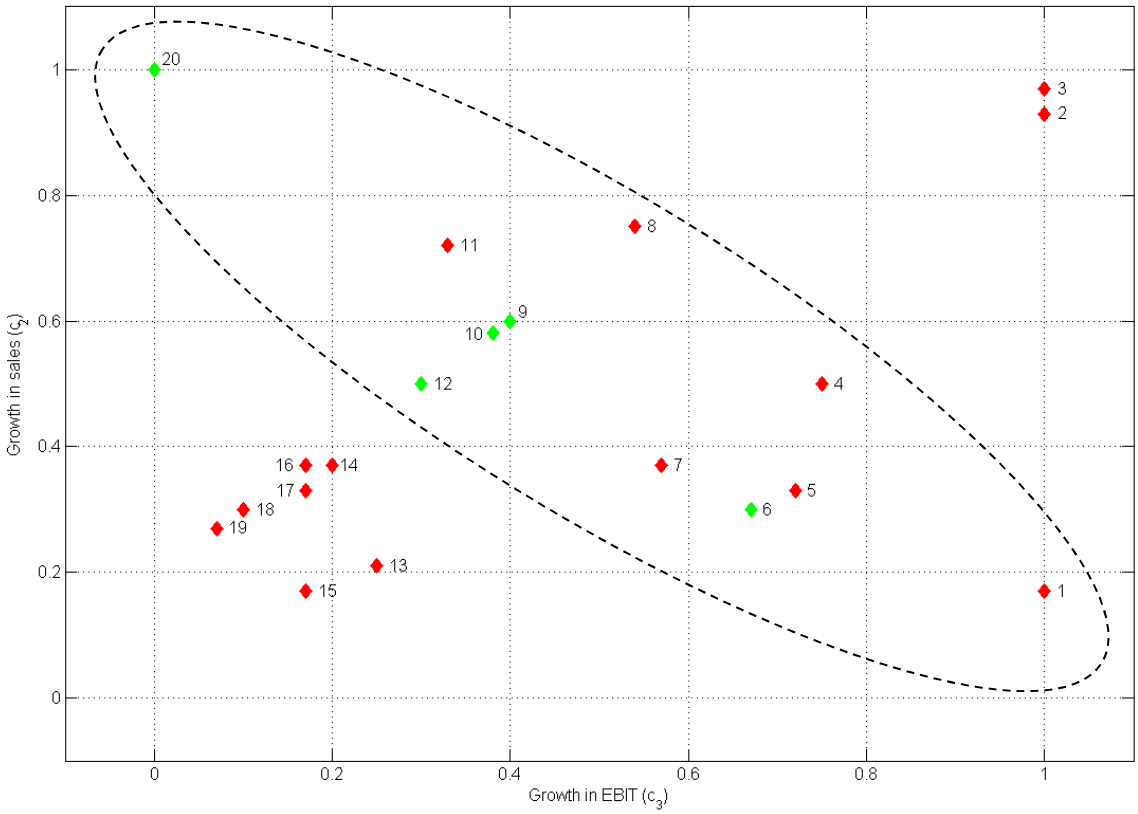
p_{15}: costs for research and development

In the underlying data set, p_{15} represents the aggregated costs for research and development cumulated from the first idea of founding the company to the fourth year after the foundation of the venture. In the data set at hand, this parameter was captured in absolute numbers.

Successful companies seem to have a higher research and development intensity for the improvement of their products and services (venture 2: 1.00; venture 3: 0.80) whereas unsuccessful ventures tend to avoid spending in this area compared to the other ventures (venture 13: 0.20; venture 17: 0.00). As the underlying set of data points is highly differentiated regarding industries and business models, higher costs for research and development may be mistaken as a reason for success, but as the measured value is an cumulated value of several years it could otherwise emphasize the importance of continuous or intense research and development in high-tech industries, at least.

When comparing the set of successful ventures to the unsuccessful one, one pattern becomes conspicuous. p_7 and p_{15} are positively correlated in these two sets, with high values in the successful and low values in the unsuccessful set. As stated before, efforts on research and development might have an impact on the success of a venture. However, we observe a negative correlation between p_7 and p_{15} in some ventures located between the two sets. As seen in figure 4, we introduce set 3.

Figure 4: Growth in EBIT and sales. Set 3 is circled.



In set 3, ventures 6, 9, 10, 12 and 20 have a high share of full-time employees for research and development and low costs for research and development or vice versa. This leads to another conclusion. Assuming that the intensity of research and development does not have any impact on success as long the values of p_7 and p_{15} are balanced, a different shape of these two parameters might lead to a position in set 3. Ventures 6, 9, 10, 12 and 20, all located in set 3, have unbalanced values in parameters p_7 and p_{15}, which could be interpreted as an inefficient allocation of resources. Either a high share of employees responsible for research and development faces a lack of appropriate infrastructure (represented by low cost for research and development) or an expanded infrastructure for research and development cannot be fully utilized due to missing human resources for research and development. This could be a reason why some of the ventures of set 3 are only located in the middle field, which means they only reach average values in growth in EBIT and growth in sales or high values in sales but low values in EBIT and vice versa.

5. Discussion

As we cannot derive a statement on which price compared to competitors (p_5) leads to success and because market growth (p_8) seems to be a necessary but not a sufficient condition for growth, we pick a successful and an unsuccessful venture from figure 2 and compare them according to three remaining parameters. We choose venture 2 as the successful venture, which is also part of our successful set of ventures, and we choose venture 16 as the unsuccessful venture. As p_{12} does not seem to be meaningful in this study we ignore it in the following analysis: venture 2 and 16 have the same values in p_5 and p_8. We see a difference in parameter p_7 and p_{15}. Venture 2 has high values in both parameters p_7 and p_{15}, venture 16 has low values. Whilst both ventures have high prices compared to their competitors, the high price only seems justified for venture 2 because of its a higher intensity of research and development. This increased intensity could stand for a higher product quality, which leads to a higher price. A practical suggestion for venture 16 to become more successful could be to increase efforts on research development and decrease their prices in order to balance both areas respectively.

This conclusion is confirmed by the following findings. Although venture 1 is located in non-growing markets, it is one of the most successful ventures regarding the success criterion “growth in EBIT” (c_3). Like venture 16, it has a low intensity of research and development and even similar absolute average sales per customer per year (p_{12}). In contrast to venture 16, venture 1 has a lower product price. Again we find a low intensity of research and development linked to a low to average price compared to competitors. The importance of balancing these parameters is evident yet again.

6. Conclusion and Outlook

This paper facilitates new methodologies of analyzing data in the context of entrepreneurial ventures by combining existing approaches regarding success related parameter and multi-objective optimization. We introduced a way of detecting characteristic patterns of successful ventures and concluded first findings.

Successful ventures within our study show an emphasis on intense research and development which is reflected in higher spending and headcount for these efforts. This can be interpreted as a higher success probability for technology-based companies with innovative products as well as the urgency for continuous improvement of existing products. This higher intensity of research and development often comes with higher prices, which seems to be an indicator for increased product quality. Looking at the intensity of research and development, we detected the importance of the balance of employees for research and development, the surrounding infrastructure and related costs in order to optimize the allocation of different resources within research and development. Furthermore, prices have to be adjusted to the resources for research and development. Successful ventures show high prices along with high intensity of research and development.

There seems to be a minimum of market growth required for the success of young ventures, but we cannot find a significant difference in the market growths of industries in which successful and unsuccessful ventures operate. Market growth does not seem to guarantee the success of a venture.

Regarding the used sample of ventures, we see evidence of the significance of the parameters “costs for research and development” (p_{15}), “number of full-time employees for product development” (p_7) and “product price compared to competitors” (p_5).

The other two parameters that are used in the analysis, namely “market growth” (p_8) and “sales per customer” (p_{12}) should be tested for their informative value in further studies.

As we solely analyze the first four years after foundation of still existing ventures, we face the problem of survival bias. Therefore, this study contributes to the discussion on successful growth of companies rather than to the explanation of crucial factors to avoid the early failure of newly created ventures. The focus lies on the clarification of the used methodology to facilitate succeeding research in this area rather than claiming a final statement on the

characteristics of success related parameters. Since the threshold for the sustainable existence of a firm seems to be reached after four years for highly innovative firms and after about six years for low to medium innovative firms (van Geenhuizen and Soetanto, 2009) we also might have missed a decisive period of firm growth. This question should be additionally covered by future long-term studies.

Tracking the defined parameters provides a basic mapping of a venture's performance and results derived by the developed framework make a first statement on the reasons for the failure or success of a venture and reveal possible starting points for going back into the venture in order to conduct a successional in-depth analysis. Therefore, the introduced methodology might also be seen as a first iteration in a continuing process of firm analysis.

The lack of a large data base and a high diversity of industries and markets is a limitation of this study. The application of the introduced methodology for the analysis of newly created ventures is particularly appropriate for the handling of large data sets, as concepts, e.g. the visualization of large data sets, facilitates the recognition of characteristic patterns and behavior. Further long-term studies should take larger amounts of data in account in order to fill the framework sufficiently. At the same time, succeeding research should prioritize the examination of single industries or similar business models. This study includes different industries ranging from service industries, such as software development consulting up to retail firms; this complicates and reduces the comparability of the examined ventures. This work only uses five of the defined parameters; in order to access more parameters, succeeding studies should collect such additional information accordingly.

Regarding the practical application of our research, the results of this study and following ones may help founders improve the use and management of resources, as they can develop a better measurement system to track their performance and anticipate the development of their ventures more exactly. Future research based on this paper could also help to develop a systematic tool for the tracking and comparison of the performance of portfolio companies

of venture capitalists and business angels in addition to their own rating criteria. Based on a larger amount of collected data, best practice examples of successful ventures could be derived by the utilization of search algorithms and the identification of comparable ventures.

In recent years, the area of firm creation and entrepreneurship in general has gained attraction from politics and research institutions. This development provides an excellent environment for following long-term studies to which this paper aims to contribute a first base of appropriate methodology and an impulse for the scope and focus of future research.

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