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OF MANAGEMENT

Dissertation

The Development of German New Technology-Based Firms from a Resource-Based View

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Abstract:

The author analyzed three different perspectives of the development of new technology-based firms (NTBFs) from the resource-based view.

The first article discusses how the resource base impacts the internationalization behavior of German NTBFs. Some companies go international early, some internationalize only after a few years. We argued that the resource base is a substantial factor determining if a NTBF will internationalize or not.

In the second article, we analyze how the resource base impacts the survival of German NTBFs. We argued that a lack of sufficient resources can lead to early business failure. We further state that the different resources are necessary to fulfill the requirements within the development phases of the NTBF. To broaden our perspective we combined the resource-based view with the market view.

In the third article, we analyzed how the resource base impacts the business model innovation of NTBFs. The business model for NTBFs must often be tailored to fulfill the requirements of potential customers or to further grow the business. A sufficient resource base is necessary to be able to change the business model and buffer the transition phase.

The Development of German New Technology-Based Firms from a Resource-Based View

Publication-based dissertation submitted in partial fulfillment of the requirements for the degree

Doctor of Economics (Dr. rer. oec.)

at
HHL Leipzig Graduate School of Management
Leipzig, Germany

submitted by

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Leipzig, December 11, 2014

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List of abbreviations

HHL	HHL Leipzig Graduate School of Management
NTBF	new founded technology-based firms
PC	portfolio company
PLS	partial least squares
pp.	pages
TU Dresden	Technische Universität Dresden
VCF	venture capital fund

"This defines entrepreneur and entrepreneurship - the entrepreneur always searches for change, responds to it, and exploits it as an opportunity."

Peter F. Drucker (1909 - 2005)

1 Introduction

New founded technology-based firms (NTBFs) are a crucial part of the German economy. They create new jobs and a significant amount of these companies experience substantial growth. Some of them have the potential to become the so-called German "Mittelstand" or a DAX-company of tomorrow and therefore they are an important part of the German business community. Further, NTBFs develop new technologies and therefore are an important source for innovations and technological growth.

Not only German politics have recognized the importance of supporting NTBFs but this topic is also discussed at the European Union andthis led to various national and international efforts to support these firms. In Germany the High-Tech Gründerfonds (a public-private partnership venture capital funds (VCF)), was established in 2005[1] to improve the capital base for NTBFs. The European Union launched the program for Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME) in 2014 and plans to invest 2.3 billion Euros to support the creation of new businesses in Europe; many of them will fall into the area of NTBFs[2].

To be able to support the creation and growth of NTBFs it's necessary to better understand their development process. The development of NTBFs often differs from other new venture. They need a wider resource base because in most cases they enter the market rather late due to the length of their product development cycles. Further, their products often are complex and difficult to explain to customers which makes a long-term sales process necessary. Therefore, a long-term perspective for NTBFs is needed.

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[1] See http://www.high-tech-gruenderfonds.de/

[2] See http://ec.europa.eu/enterprise/initiatives/cosme/index_en.htm

In this cumulative thesis, the author analyzes the development of NTBFs from the resource-based view taking three different perspectives into account: the internationalization of NTBFs, the determinants of business failures for NTBFs and the determinants for business model innovation in NTBFs.

2 Research gap

The lack of detailed knowledge in the development process of NTBFs was pointed out among others by Petty and Guber (2011). Previous studies mainly relied on data collected through personal interviews or survey (Bygrave, 2006). These methods have the disadvantage that the development over time can't be analyzed in-depth if data are missing. Further, Neergaard and Ulhoi (2006) declared that most studies used convenient accessible and readily available secondary data sets which may not be reliable enough to draw important conclusions. One of the most used data bases is VentureXpert - a commercial database covering 2,300 venture capital funds globally. Many studies have a similar research design and therefore similar findings because of the use the same data base as pointed out by different scholars (Dimov, & Muray, 2008; Milavo, & Fernhaber, 2009). Further, previous studies focus only on one or two determinants of development like human capital or financial base; holistic studies taking different areas of the development process into account are missing. A holistic research design would create the possibility to study the interaction of different areas and how they influence the development.

The research gap consists of the four following elements:

1. In-depth data of the development process are missing
2. A longitudinal research design is crucial to study the whole development process
3. A new data set is necessary to create new findings
4. A holistic view on the development of NTFBs will make it possible to study the interdependencies of the determinants for the development of NTBFs

This doctoral thesis contains publications which we performed to reduce that research gap. We conducted a longitudinal and holistic study on the development of venture-

capital backed NTBFs by collecting a new in-depth data set in Germany. We defined the term NTBF for legally independent high-technology companies which are not older than 10 years (Bürgel, 2000) and created the research project described in chapter 5.

3 Different themes on NTBF research

To identify the current themes on NTBF-research the author first performed a systematical literature review including articles published between 2004 and 2014. I examined the articles containing NTBF or synonymous phrases (e.g. high tech entrepreneurial firms, high tech startups or high tech entrepreneurship) in the title. I searched in the 12 journals listed as entrepreneurship journals by the 52nd edition of the Harzing Journal Quality List[3] and identified 63 articles having NTBFs as the main focus of the study. Six research themes were identified: (1) influence of the external environment on NTBFs, (2) incubation of NTBFs, (3) innovation within NTBFs, (4) internationalization of NTBFs, (5) networks of NTBFs, (6) and the resource-based view on NTBFs. Table 1 summarizes the different literature streams of NTBF research.

3.1 External environment

The research area environment of NTBFs deals with external factors influencing the creation, the survival and the development of NTBFs. This includes governmental policies and market conditions. For example, Koga (2005) analyzed the impact of governmental subsidies on the research financing of NTBFs. The role of clusters for the growth of NTBFs was studied by Main, Shapiro and Vining (2010). Bertoni, Colmbo and Grille (2013) analyzed the impact of the availability of venture capital on the growth of NTBFs (2011).

3.2 Incubation

The research area of the incubation of NTBFs deals with the effect of incubators on the creation and the success of NTBFs and how incubators should be designed for

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[3] http://www.harzing.com/jql.htm, accessed on December 7th, 2014

successful support of NTBF creations. E.g., the impact of the incubation on the entrepreneurs in NTBFs was in the focus of Cooper and John (2008). Colombo, Piva and Rentocchini (2011) studied the effects of incubation on academic and non-academic NTBFs. The different ways of the support for NTBFs on university-based incubators were outlined in the research of Kitagawa and Robertson (2012).

3.3 Innovation

In the research area of innovation in NTBFs it is examined how innovations are generated within NTBFs. Parida, Westerberg and Frishammar (2012) discussed for example the impact of open innovation on the overall innovation performance of NTBFs. The influence of the knowledge management on the innovation performance was in center of the study of Algere, Sgupta, and Lapiedra (2013). Oakey (2013) analyzed the relevance of open innovation in NTBFs in general.

3.4 Internationalization

The research area of the internationalization in NTBFs focuses on the internationalization process. Coeurderoy, Cowling, Licht, and Murray (2010) examined for example is the influence of the internationalization on the survival of the firms. Piva, Rossi-Lamastra and De Massis (2013) analyzed how the internationalization process differs between family-owned versus nonfamily NTBFs. The internationalization process of born-global NTBFs is the main topic of the study of Odorici and Presutti (2013).

3.5 Network

The research stream of the network within NTBFs explores how networks are built within and outside the NTBF and how this network building influences the development of a NTBF. Clarysse, Konackaert and Locket (2007) discussed the impact of integrating outside board members into the entrepreneurial network. The usage of the network for fundraising for NTBFs is in the research focus on Zhang and Wong (2008). Haeussler, Patzelt and Zahra (2012) analyzed the impact of strategic networks within NTBFs.

Theme	Sample Publications	Research focus
External Environment	Koga, 2005 Maine, Shapiro, & Vining, 2010 Bertoni, Colmbo, & Grille, 2013	The influence of the environment on the development of NTBFs
Incubation	Cooper, & John, 2008 Colombo, Piva, & Rentocchini, 2011 Kitagwa, & Robertson, 2012	The effect of incubation on the creation and the success of NTBFs
Innovation	Parida, Westerberg, & Frishammar, 2012 Algere, Sgupta, & Lapiedra 2013 Oakey, 2013	The innovation generation and process within NTBFs
Internationalization	Coeurderoy, Cowling, Licht, Murray 2010 Piva, Rossi-Lamastra, & De Massis, 2013 Odorici, & Presutti, 2013	The internationalization process of NTBFs
Networks	Clarysse, Konackaert, & Locket, 2007 Zhang, & Wong, 2008 Haeussler, Patzelt, & Zahra, 2012	Network building and the influence of networks for NTBFs
Resource-based view	Shrader, & Siegel, 2007 Brinckmann, Saloma, & Gemueden, 2011 Colombo, & Grilli, 2011	The impact of the resources on the development and success of NTBFs

Table 1: Thematic overview of the NTBF literature of the last 10 years

Source: Own illustration

3.6 The resource-based view

The research stream of the resource-based view deals with the influence of the resource base or changes in the resource on the development of a NTBF. Shrader and Siegel (2007) analyzed how the human capital of NTBFs influences the performance. Similarly, the impact of the financial management competence of the founding teams on the growth of NTBFs was analyzed by Brinckmann, Saloma and Gemueden (2011). In addition, Colombo and Grilli (2011) examined how the human capital and venture capital influence the growth of NTBFs.

4 The resource-based perspective

In this cumulative doctoral thesis I focused on the resource-based perspective on the development of NTBFs. NTBFs need different resources to grow and expand. Most important are human capital, financing and technology (Shrader, & Siegel, 2007; Revest, & Sapio, 2010).

NTBFs often need highly specialized employees to further develop their technology and bring it to the market. Therefore, previous studies showed that the industry-specific work experience is a crucial factor for a positive development of a NTBF (Colombo & Grilli, 2010). In addition, the general management competencies were shown as an important factor for receiving financing from external investors (Colombo & Grilli, 2005). A balanced management team is needed combining high technological skills with business and management skills to be successful. This enables NTBFs to develop excellent products, build and grow their business. Therefore, human resources are of crucial importance for NTBFs.

A significant amount of financing is needed to finish the product development and enter the market. This capital need is especially high for NTBFs as their product development is expensive and often highly-specialized and therefore employees with high salaries are needed (Colombo & Grilli, 2005). NTBFs most likely suffer from capital market imperfection (Bertoni, Colombo, Grilli, & Milano, 2005). The high expenses for the product development and the market entry cannot be covered by classical loans as the risk of loan failures is too high for credit institutes. Therefore,

NTBFs have to rely on the venture capital and private equity market to exchange company shares for money. This is a long process which can take several years. Therefore, NTBFs have to plan their financial resources carefully. That means that the financial resources are also very important for NTBFs.

The technology is the main asset of NTBFs. The technology has to be innovative in order to be competitive. To protect their intellectual property NTBFs often file for patents (Löfsten, & Lindelöf, 2005). This may restrain competitors to enter the market with the same or a similar product. However, NTBFs have to openly reveal their technology in order to file for the patent. This may facilitate the development of similar products not covered by the patent from competitors. Possibly, the progressiveness of the own technology is the biggest technological resource. Therefore, technology, its protection and advancement are a very important resource base of NTBFs.

5 Corresponding research project

This doctoral thesis (dissertation) is embedded within the research project "Strategisches Risikomanagement in Frühphasenfonds" (English translation: "Strategic Management in early-stage financing"). This is a joint research project of the HHL Leipzig Graduate School of Management (HHL) and Technische Universität Dresden (TU Dresden) and was initiated by Prof. Dr. Andreas Pinkwart (HHL) and Prof. Dr. Michael Schefczyk (TU Dresden). The main goals of the research project are to get new findings in early-stage venture capital financing of NTBFs and to establish an active discussion in the literature. The research project focuses on the six following perspectives on early-stage funding: 1. Personal characteristics of the corresponding founders and investment managers, 2. Networks of the founders and investors and their usage within the development process, 3. The development of the technology within the process from founding to market entry, 4. Management support for the NTBFs by the VCFs, board members and external parties, 5. Risk management within the VCFs, and 6. Impact of internationalization on NTBFs.

As already outlined in chapter 2, there has been a lack of reliable data sets in the field of early-stage financing of NTBFs. Previous research was based on the same readily-available databases or on surveys. In-depth data was missing. Therefore, the focus of the research project was to build a new data-base with longitudinal data. To establish that data base HHL and TU Dresden worked together with nine venture capital funds in the technology field and analyzed their portfolio companies (PC). In this project we had access to anonymized data of the original deal documents which included the decision files (business plan, due diligence, investment committee paper) and the continuous reporting (qualitative and quantitative reporting, milestones, board meeting). This enabled us to analyze the whole process of the development of the PCs. In addition, we were able to collect data for multiple sets of variables to answer research questions in different fields.

We collected quantitative data (e.g. the financial figures and the years of working experience of the founders) and qualitative data (e.g. the assessment of the market risk in the monthly reporting or the competencies of the team). In addition, we conducted a survey with the investment manager to get information not available from the written data.

To be able to use quantitative methods for the qualitative data we encoded it using a code book. In this codebook we included anchor phrases to rate the qualitative quotes. We conducted investigator triangulation to ensure a high reliability of our data. All qualitative quotes were encoded by three research associates who were familiar within the field. To ensure the feasibility of our approach we conducted a pretest with eight NTBFs from three different VCFs. We refined our codebook multiple times until we reached high intercoder reliability. After our final coding round the Krippendorf's alpha for all our variables was 0.8 or higher which is an acceptable (Krippendorff, 2004). We therefore were able to perform quantitative methods on the data. In total, more than 10,000 qualitative quotes were encoded.

The data base currently consists of 128 PCs collected at 9 different VCFs. 42 per cent of the companies are in the field of information technology, 34 per cent in the field of life science, 14 per cent in the field of material science and 10 per cent are in other

industries. The average age of the companies is 5.1 years and the founder's team has on average 3 members. The PCs received on average already two financing rounds. The average investment sum was 700,000 Euros in the first round and 1,000,000 Euros in the second round. In our data set, 18 companies already experienced business failure; the rest is still on the market.

Our data base enabled us to create various scientific contributions; it was used for the empirical analysis for the three publications which are included in this thesis. Further, it led to various other scientific contributions which are outlined in chapter 7.

6 Scientific contribution for the doctoral thesis

The topic of the three publications used for my cumulative doctoral thesis is summarized in the following chapter. All articles use the resource-based view on the development of NTBFs in different research areas.

The first article discusses how the resource base impacts the internationalization behavior of German NTBFs. Some companies go international early, some internationalize only after a few years. We argued that the resource base is a substantial factor determining if a NTBF will internationalize or not.

In the second article, we analyze how the resource base impacts the survival of German NTBFs. We argued that a lack of sufficient resources can lead to early business failure. We further state that the different resources are necessary to fulfill the requirements within the development phases of the NTBF. To broaden our perspective we combined the resource-based view with the market view.

In the third article, we analyzed how the resource base impacts the business model innovation of NTBFs. The business model for NTBFs must often be tailored to fulfill the requirements of potential customers or to further grow the business. A sufficient resource base is necessary to be able to change the business model and buffer the transition phase.

The articles have the following titles:

Fist article: The Internationalization Behavior of German High-Tech Start-ups: An Empirical Analysis of Key Resources

Second article: Reasons for the failure of New Technology-Based Firms: A Longitudinal Empirical Study for Germany

Third article: The resource-based view for Business Model Innovation in New Technology-Based Firms: A quantitative empirical study.

The full versions of the papers are in the appendix. A short summary of each of the three articles is presented here:

6.1 First article

6.1.1 Introduction and motivation

The research area of international entrepreneurship as a subfield of internationalization research was introduced 20 years ago (Oviatt, & McDougall, 1994). Since, then various studies were conducted concerning this topic and international entrepreneurship became a well-established research field. However, NTBFs were not in the focus of current studies (Kriedrich, & Kraus, 2009). In different articles it's proposed that NTBFs should be analyzed separately as they differ in market entry strategies and speed of the internationalization process (Johnson 2004; Crick, & Spence 2005). Most previous research on international entrepreneurship was performed in the United States (Holtbrügge, & Enßlinger, 2005). US firms are more likely to go international quickly due to a different business culture (Johnson, 2004). Compared to the US and other European countries the internationalization rate of German NTBFs is rather low (Bürgel, Fier, Licht & Murray, 2000). This may be due to a lack in the sufficient resources for internationalization (Schmidt-Buchholz, 2001). We therefore analyzed how the resources base determines the internationalization behavior of German NTBFs.

6.1.2 Theoretical framework and methodology

We adopted the resource-based view on the determinants for the internationalization. This view states that internal conditions and recourses are the main drivers for

international activities. We therefore built on the framework of Rialp, Rialp & Knight (2005) which postulates that the internationalization strategy is influenced by the structural capital (technological, organizational, relational) and the human capital (entrepreneur-managers's/entrepreneurial team's characteristics, ties and roles). Using this framework we focused on the technological capital as an example of structural capital and the entrepreneurial team characteristics as an example of human capital. Further, we took the financing of new ventures into account. Schmidt-Buchholz (2001) showed that this may be an important determinant for an early internationalization.

We developed different hypothesis to test if resources within the three areas technology, financing and human capital, are related to internationalization. To test our hypothesis we used a subset of our sample we described in chapter 5. 47 of the 125 NTBFs that we examined, went already international. We used one-way analysis of variance (ANOVA) to test if the identified resource variables significantly differ between the German based only and the internationalized NTBFs.

6.1.3 Results and Discussion

We showed that the technological and the financial resources significantly differ between German based only and the internationalized NTBFs. The internationalized companies had a broader patent base and were able to obtain a higher investment sum from their VCFs. We state that the resource base has a significant influence on the internationalization of German NTBFs. There was no significant influence of the human capital on internationalization in our study. A reason for that would be that all the companies were financed by VCFs. To obtain a VC investment the entrepreneurial team NTBFs have to pass an extensive human capital due diligence process. Therefore, all the teams in our data set might be highly qualified.

6.1.4 Main scientific contribution

The main contribution of this article consists of two parts. The first part contains a separate analysis of the internationalization process of NTBFs. Previously, only few studies which solely focus on the internationalization process of NTBFs have been

published. The second part is the application of the resourced-based view on the internationalization process. We were able to show that the resource base is very important. A wider resource base would possibly lead to a higher internationalization rate.

6.1.5 Integration in the cumulative dissertation guidelines

The article was published in the Thunderbird International Business Review (Volume 56, Issue 1, pp. 43-53) on December 27th 2013. The Thunderbird International Business Review is rated as a "D" journal by the VHB-JOURQUAL 2.1 of March 29th, 2011 by the Verband der Hochschullehrer für Betriebswirtschaft e.V. (German Association for Business Research).[4]

The authors are Andreas Pinkwart and Dorian Proksch. The work-sharing between the authors can be found in the appendix.

6.2 Second article

6.2.1 Introduction and motivation

50 per cent of the new created ventures in Germany fail within the first five years (Schneck, & May-Strobl, 2013). While failure is an important part in a market economy (Albach, 1985; Pinkwart, 1992) it results in many negative aspects. The investors will lose their money and therefore the possibility to reinvest. It could come to a shortage of investment capital if too many new ventures fail. A failed new venture is not able to pay back their loans to credit institutes and their liabilities to suppliers so it can negatively impact the entire economy. While there is a wide stream of literature on the success of new ventures (Song, van der Bij, & Halman 2008) only few studies focus on the determinants of failure (Albach, & Pinkwart; 2003). In addition, longitudinal studies of the failure process are missing, because the time period from the first funding to the insolvency can be rather long. This might be especially important for NTBFs. They have long development cycles and enter the market rather late. We therefore conducted a longitudinal study analyzing the reason for failures for German NTBFs.

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[4]See http://vhbonline.org/uploads/media/Ranking_Gesamt_2.1.pdf

6.2.2 Theoretical framework and methodology

In most cases, there is not a single reason for failure but rather a combination of different factors. The factors were identified by previous studies and can be classified in the four areas technology, financing, management competencies and market (Schilling, 2002; Pleschak, Ossenkopf, & Wolf , 2002; Thornhill, & Amit, 2003; Carter, & van Auken, 2006). These four factors are a combination of the resource-based view taking the technological, financial and management resources into account and added to the market side. We examined whether the different factors may differ between the first two investment stages. Often the first stage is used to develop the product, the second stage to enter the market. Therefore, we created a set of propositions of the factors for failure in four areas of different stages.

We used the data set that we described in chapter 5 to test a subset of our propositions. We used logit regression to test the proposition. Thereby, we used the binary variable business failure as the dependent variable. We created three models: the first model took into account only cases from the first investment stage, the second model only cases from the second investment stage and a third model using all of our cases.

6.2.3 Results and Discussion

We showed that the four areas technology, financing, management competencies and market are important factors for the failure of NTBF as described in previous studies. Further, we were able to prove that the factors significantly differ between the first two investment stages. The technology was not significant in the first stage but in the second stage. In addition, the connotation of the variables differ in the financial and human resource variables throughout the stages, the market variables stayed the same. We found that different financial stages should be analyzed separately when looking at business failure.

6.2.4 Main scientific contribution

This main contribution of this article consists of two parts. In the first part a set of propositions for reason of failures in the different development stages of NTBFs are described. We argue that they reasons of failure differ in each financial stage and therefore created different propositions for each stage. The second part describes the empirical test of a subset of the propositions. We could prove that the reasons for failure of NTBFs differ throughout different stages. Further studies on business failures should take this into account.

6.2.5 Integration in the cumulative dissertation guidelines

This article was accepted for publishing in "Credit and Capital Markets" on November 28th, 2014 as indicated by one of the chief editors. The Credit und Capital is rated as a "C" journal with a high impact factor by the VHB-JOURQUAL 2.1 of March 29th, 2011 by the Verband der Hochschullehrer für Betriebswirtschaft e.V. (German Association for Business Research).[5]

The authors are Andreas Pinkwart, Dorian Proksch, Michael Schefczyk, Torsten Fiegler and Cornelia Ernst. The work-sharing between the authors can be found in the appendix.

6.3 Third article

6.3.1 Introduction and motivation

NTBFs often create business model innovation in the early development stages. Reasons for that may be that the business model was not sufficiently tailored to the market needs (Teece, 2010) or that the NTBFs need to adapt their business model to further grow. An important question is how these business model enable innovations. The lack of research in the area was pointed out in literature (Chesbrough, 2010; Schneider, & Spieth, 2013). In addition, quantitative studies are missing; most scholars focus on qualitative and conceptual studies (Zott, Amit, & Massa, 2011). We tried to

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[5]See http://vhbonline.org/uploads/media/Ranking_Gesamt_2.1.pdf

close this research gap by conducting an empirical study focusing on the resources which might enable business model innovation for German NTBFs.

6.3.2. Theoretical framework and methodology

The resource-based view was identified as one of the six main research streams for business model innovation of new ventures (George, & Bock, 2011). Further, the acquiring of key resources is stated to be one of the main factors influencing a business model (Garnsey, Lorenzoni, & Ferriani, 2008). Hence, a change in the business model often needs sufficient resources. We therefore focus on the resource based view in this study.

Analyzing the literature we identified five main drivers for business model innovation in NTBFs looking at the resource perspective. They consist of the financial strength (Sosna, Trevinyo-Rodríguez, & Velamuri, 2011; Aspara, Hietanen, & Tikkanen, 2011), the technological strength (Calia, Guerrini, & Moura, 2007; Sood, & Tellis, 2011), the management competencies (Chesbrough, 2007), the management support (Robson and Bennett 2000) and the network strength (Joseba, & Castello, 2010).

We tested whether these five areas influence the business model innovation of the companies. Therefore, we used a subset of the data set that we described in chapter 5. To measure business model innovation we used the nine areas of the business model canvas by Osterwalder (2004). We used qualitative data to identify whether changes happened within the areas of business model innovation. As business model innovation itself and the five enabling areas could not be measured directly we used a structural equation modeling approach. We created a partial least squares (PLS) model as this is the first choice for explorative models (Henseler, Ringle, & Sinkovics, 2009).

6.3.3 Results and Discussion

We found that the four areas technological strength, management competencies, management support and the network strength have a significant impact on the business model innovation. The financial strength has no impact. This shows that the resources are an important factor for the business model innovation. Further, we created a scale by measuring the business model innovation by the elements of the

business model canvas. Our scale proved to be valid indicated by the Cronbach's alpha, the composite reliability, the AVE and a high factor loading of each of the nine items.

6.3.4 Main scientific contribution

The main contribution of this article consists of two parts. The first part is presenting the results of our quantitative empirical study regarding the main drivers of business model innovation in NTBFs. Previous work in this research streams mainly relied on qualitative work. The second part is creating a scale for the measurement of the degree of business model innovation. Only few approaches are described in the literature until now.

6.3.5 Integration in the cumulative dissertation guidelines

An extended abstract of this paper was accepted and presented on the „Wissenschaftstagung 2014"of the Erich-Gutenberg-Arbeitsgemeinschaft Köln e.V. in Nuremberg. It passed an anonymous, double-blind review process. The full paper was submitted to the review process of the "Journal of Business Economics". Only papers which were accepted for the "Wissenschaftstagung 2014" were allowed to submit their full paper. The Journal of Business Economics is rated as a "B" journal by the VHB-JOURQUAL 2.1 of March 29th, 2011by the Verband der Hochschullehrer für Betriebswirtschaft e.V. (German Association for Business Research).[6]

Dorian Proksch is the sole author of the paper.

6.4 Use of different research methods

Within the thesis a variety of research methods were applied. First, a qualitative approach was used; we conducted a content analysis with more than 10,000 pages of original documents of the VCFs. We used a code book with anchor phrases to encode the qualitative data to quantitative data. Conducting a pre-test for this approach ensured a high feasibility. We used investigator triangulation with multiple encoding

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[6]See http://vhbonline.org/uploads/media/Ranking_Gesamt_2.1.pdf

rounds to ensure a high reliability of our data. The multiple encoding led to a refinement of our codebook. Therefore, three research associates were involved who were familiar with the topic. As an intercoder reliability measure Krippendorff's alpha was taken. We reached a Krippendorff's alpha value of 0.8 or above which is regarded to be acceptable (Krippendorff, 2004).

Further, the author used three different quantitative research methods in this cumulative thesis. In the first paper, we used one-way analysis of variance (ANOVA). We identified factors which significantly differ in international versus domestic NTBFs.

In the second paper, we used logit regression analysis. We identified the factors which lead to a higher probability of insolvency for NTBFs. Logit regression is applicable for models with a binary dependent variable.

In the third paper, we used PLS as a structural equation modeling approach. This was necessary because the business model innovation could not be measured directly but instead was defined by the nine different parts of the business model canvas. PLS is the first choice for explorative models (Henseler, Ringle, & Sinkovics, 2009).

In summary, a new independent data base was created to examine the development of NTBFs from the resource perspective. We found that the resource base impacts the internationalization decision and innovations of the business model. An insufficient resource-base can lead to business failure. Therefore, the resource-based view is of crucially importance for the development of NTBFs and may possibly be used to answer further request questions in this research area.

7 Further academic and practical contributions

Within the project the author presented his research at various national and international academic conferences as well as on events for practitioners. These are listed in the following.

7.1 Scientific presentations

Pinkwart, A.; Proksch, D. (2013): The Internationalization Process of German High-Tech SMEs - An Empirical Analysis, 8th European Conference on Innovation and Entrepreneurship ECIE 2013, Brussels (Belgium), September 2013

Pinkwart, A.; Proksch, D. (2013): The impact of internationalization on the success of German new technology-based firms, G-Forum 2013, Koblenz (Germany), November 2013

Pinkwart, A.; Proksch, D. (2013): Strategisches Risikomanagement in Frühphasenfonds – Zwischenergebnisse, Bonner akademischer Sommer, Bonn (Germany), Mai 2014

Pinkwart, A.; Proksch, D. (2013): Internationalization of German High-Tech SMEs: Overcoming the Main Barriers, ICSB 2014 World Conference, Dublin (Ireland), June 2014

Proksch, D. (2014): Main drivers for early Business Model Innovation in New Technology-Based Firms: A longitudinal empirical study, Scientific Conference on "Business Model Innovation and Transformation" of the Erich Gutenberg-Arbeitsgemeinschaft Köln e.V., Nuremberg (Germany), September 2014

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10 Declaration of authorship

I hereby declare that I have written this thesis without any help from others and without the use of documents and aids other than those stated above.

Furthermore, I have mentioned all used sources and have cited them correctly according to the citation rules defined by the HHL Style Guide.

Moreover, I confirm that the paper at hand was not submitted in this or similar form at another examination office, nor has it been published before.

With my signature I explicitly approve that HHL will use an internet-based plagiarism detector which screens electronic text files and looks for similar pieces on open-access websites as well as similarities in work previously submitted.

Leipzig, December 15, 2014

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Dorian Proksch

11 Appendix

The three articles of the dissertations are following. The original formatting of the articles based on the specific journal guidelines as well as the page numbering was kept.

First article

The Internationalization Behavior of German High-Tech Start-ups: An Empirical Analysis of Key Resources

Andreas Pinkwart, Dorian Proksch

Abstract

Although there were a lot of new studies about the phenomenon of internationalization in the past several years, the field of newly founded technology-based firms (NTBFs) internationalization was less considered in literature. We contributed in filling this research gap using a longitudinal study to discover the determinants of internationalization in Germany. Our sample was based on 116 venture capital-financed NTBFs; 44 of them went international. Given the high dependence on exports of the German economy, the internationalization behavior of its NTBFs is of great importance for the future macroeconomic development of the country. In comparison, there are still very few empirical studies on the key determinants and initial drivers for the rapid internationalization of German start-ups. We showed that technological and financial factors are positively related to going global. The characteristics of the human capital, however, have no significance for going international in our sample.

Second article

Reasons for the Failure of New Technology-Based Firms: A Longitudinal Empirical Study for Germany

Andreas Pinkwart, Dorian Proksch, Michael Schefczyk, Torsten Fiegler, Cornelia Ernst

Abstract

We analyzed the determinants for the business failure of German New Technology-Based Firms (NTBF) in different financial stages. This included a literature review and creation of a set of propositions for the determinants within the individual stages. On the basis of an empirical and longitudinal dataset including data of 82 NTBFs, we tested a subset of our assumptions. With this, we could prove that the technology, the market, the financing and the management competencies comprise important factors as identified in previous studies. Further, we proved that the factors differ in each investment stage as shown by the significance and the connotation of the correlations. The area of technology was not significant in the first investment stage but in the second. While the determinants proved to be the same in the market area, the connotations of the variables differ in the financial and human resource variables. We showed that the different financial states should be analyzed separately when determining factors of business failure.

Third article

The resource-based View for Business Model Innovation in New Technology-Based Firms:

A quantitative empirical study

Dorian Proksch

Abstract
The enablers for business model innovation are not thoroughly analyzed in literature. We try to fill this research gap by conducting an empirical study with new technology-based firms (NTBFs) in Germany. We therefore developed a measurement scale for business model innovation on basis of qualitative data derived from the company reporting. Using PLS as a structural equation modeling approach we found that the technological strength, the management competencies, the management support and the strength of the network impact the chance of a business model innovation to be generated by a NTBF. This is especially the case in later development stages of the companies. The financial strength of the NTBFs has no impact on the business model innovation. Our findings establish the bases for further quantitative work in the area of business model innovation.

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Keywords   Business Model Innovation, High-Tech Startups, Venture Capital, Longitudinal Study

JEL Classification   L260, M13, O31

1. Introduction

New Technology-Based Firms (NTBFs) develop an innovative product or service and test it on the market. Often, the product or service is not fitted to the customer needs at first or the wrong customer group is addressed. Therefore, NTBFs often need to change their business model multiple times until they are successful (Teece 2010) as prominent examples like Google Inc., Paypal Inc. or Alibaba Group Holding Limited showed. The open question is what is facilitating these changes. The research gap in the enablers of business model innovation was among other pointed out by Chesbrough (2010) and Schneider and Spieth (2013). Further, the current business model research is mostly based on qualitative studies and of more conceptual nature (Zott et al. 2011). Previous research in the field of NTBFs was often based on personal interviews or readily available secondary data set (Bygrave 2006). Therefore, creating new empirical studies became necessary. We conducted a quantitative study to analyze the enablers for business model innovation in NTBFs collecting original data from venture capital companies.

2. Theoretical Framework

To establish a common understanding about the term business model and business model innovation we first describe which definitions we use in this article. Further, we describe the research stream we focus on and then come to our hypothesis.

2.1 Important definitions

There are various different definitions of business model and the community of researchers didn't agree on a single one. Zott et al. (2011) summarized the most used definition. In our study, we will refer to the definition of Teece (2010): "A business model articulates the logic, the data and other evidence that support a value proposition for the customer, and a viable structure of revenues and costs for the enterprise delivering that value". We chose these definition because it emphasizes that a business model not only consists of the value proposition but also includes a perspective on the costs. Similarly, different definitions of business model innovation exist. We particularly focus on two definitions. Casadesus-Masanell and Zhu (2013) describe business model innovation as: "The search for new logics of the firm and new ways to create and capture value for its stakeholders. It focuses primarily on finding new ways to generate revenues and define value propositions for customers, suppliers, and partners." This definition focuses more on a change of the value side of a business model. In this study we want to take a broader view and also take the definition by Mitchel and Coles (2004) into account which describes business model innovation as: "Any successful change in any element that enhances an on-going performance in delivering benefits." This definition is much broader and for example also includes a change in the marketing channels to reach a new customer segment.

2.2 The resource based view on business model innovation

George and Bock (2011) conducted an intensive literature review on the impact of business models research on entrepreneurship research and identified six research streams which are also relevant for new venture science. One of the research streams is the resource based view which we focused on in the current work. Various authors concluded that acquiring and allocating resources are one of the main factors of a business model (Hamel 1999; Garnsey et al. 2008). Hence, to change the business model the NTBF has to build a sufficient resource base. We try to analyze which resource base can drive business model innovation. Therefore, we look on different kinds of resources.

2.3 The drivers of business model innovation of NTBFs

Current studies mostly focus on the enablers and drivers of business model innovation in established firms. One factor discussed in literature is the financial resource base. Corporate crises and a shortage of firm resources can trigger a business model innovation (Sánchez and Ricart 2007; Sosna et al. 2011; Aspara et al. 2011). The companies even might be forced to change their business model in order to survive. Having enough financial resources is one of the biggest challenges of NTBFs (Song et. al, 2008). That's why this factor might be even stronger for NTBF. We postulate that having a sufficient financial bases act as a prerequisite for realizing the business model in NTBF:

H1: Financial strength is an enabler for business model innovation in NTBFs.

Another factor is the area of technology. Desylllas and Sako (2013) identified the IP situation as an important enabler. Companies are more likely to innovate their business model if their IP is protected. However, for other companies the time to market is more important that filing for a patent. In this case, waiting until a patent is granted actually hinders the innovation process (von Hippel 2007). Also an advancement of technology can enable business model innovation (Calia et al. 2007; Sood and Tellis 2011). A new technology can make it for example possible to address new customer groups. Further, the advancements in information technology enable to further improve existing business models or to create new ones (Kagermann et al. 2010; Wu et al. 2013). The technology is the main asset of a NTBF. That's why a NTBF might first concentrate on making it ready to market before it will consider working on or changing their business model. We tested if the technological strength is an enabler for business model innovation:

H2: Technological strength is an enabler for business model innovation in NTBFs.

In addition, the human capital as measured by the management competencies can be an important factor. Business model innovation requires involvement of the top leadership (Chesbrough 2007). Especially, good leadership skills might be necessary to enforce the new model in the company. A change in business model always will bring new risks and employees might therefore try to resist the change. Therefore, an active engagement with the employees might be needed to overcome obstacles, especially the liabilities of smallness and newness. Also, other stake holders like investors must be convinced of the advantages of the business model innovation. That's why we assume that the management competencies, especially in the area of leadership, decision making and organization have an influence on the business model innovation:

H3: Management competencies are an enabler for business model innovation in NTBFs.

Further, the management support might have an influence of the decision to go through a business model innovation. The advisory board and external advisors will encourage or discourage the company to do so (Robson and Bennett 2000). Also, they might bring in their experience and ideas to adjust the business model to new market needs. The management of a NTBF is often supported by external stakeholder like the investors or consultants. Strong external support of the management may give new perspectives and help NTBFs to innovate its business model which leads to our forth hypothesis:

H4: Management support is an enabler for business model innovation in NTBFs.

Lastly, the networks of a company can increase the likelihood of business model innovation. A strong network can make it easier to implement the change in the business model because important partners and suppliers might already be available. Further, a business model innovation might also be triggered by a supplier which comes up with an innovation on its product itself. Joseba and Castello (2010) find collaborative networks to be a significant factor for business model innovation. NTBFs might not have established strong networks yet because of their liability of newness. However, the network can also hinder a possible innovation (Sydow, 2003). The supplier might resist change and therefore makes it more difficult for the NTBF to innovate. A strong network can be an advantage and lead to further development of the current business model:

H5: Network strength is an enabler for business model innovation in NTBFs

3. Methodology

3.1 Sample
We collected qualitative and quantitative data of 73 venture capital-financed NTBFs at nine different venture capital funds in Germany. We therefore had direct access to the original deal documents of the venture capital companies including the business plans, the investment committee papers, the monthly reporting and the annual statements of the NTBFs and the venture capital companies. This enabled us to do in-depth content analysis. To test the feasibility of our approach we conducted a pre-test with nine NTBFs at three different venture capital funds. To further enhance our data we conducted a survey with the corresponding investment managers which supervised the investment. That allowed us to add the data we could extract from our content analysis. For this

study, we included only NTBFs for which we both had the qualitative data and the responses from the survey with the investment managers.

Only high-tech companies are included in our data set coming from the following industries: IT and automation, life science, material science, energy and telecommunication. The average age of the NTBFs is 4.7 years and they have on average successfully completed two investment rounds.

3.2 Measures and Variables

The degree of business model innovation and the different areas of enablers can't be measured directly. We therefore had to use proxy variables. We used partial least squares (PLS) as a structural equation modeling approach to build and test our model. PLS is the first choice for explorative models (Ainudding et al 2007; Henseler et al. 2009) and our models and scales are new. In addition, PLS yields more accurate results with limited sample size (Fornell and Bookstein 1982). PLS is compared with covariance based methods also applicable for sample sizes smaller than 100 (Haenlein M, Kaplan, 2004). Further, the indicators do not have to follow normal distribution (Hulland 1999) which enabled us to include more indicators which otherwise would have to be omitted.

We used a reflective measurement model for the outer constructs of the enablers for business model innovation, the control variables and the construct business model innovation. Further, we used a reflective measurement model for the inner construct. Reflective measurement models are well researched and have defined reliability test criteria (Roy et al., 2012). In addition, our indicator variables are strongly correlated within a construct which approves the choice of a reflective model. The basic structure of our model is show in figure 1.
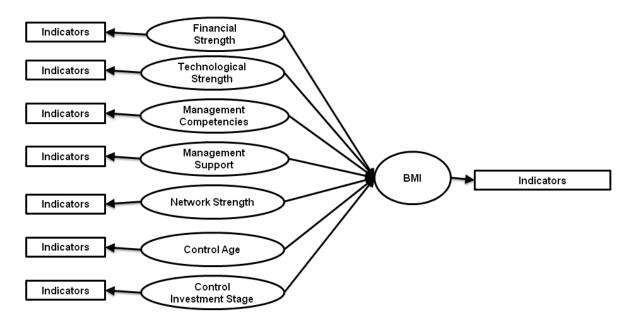

Figure 1: Structure of our PLS model

3.2.1 Dependent variables

There is no established scale for measuring the degree of business model innovation in literature. Most current studies rely on qualitative data and case studies (see e.g. Richter 2013; Simmons et al. 2013; Wu 2013). Due to the lack of scales for measuring business model innovation we establish a construct to do so. We therefore measure if changes happened in one of the parts of the business model. There are various articles which describe the different parts of the business model (see e.g. Bonaccorsi et al. 2006; Brousseau and Penard 2006). Zott et al. (2011) summarized them so we refer to this study for an overview about the different concepts of classifying the parts of a business model. The most cited concept is the business model canvas by Osterwalder (2004). He clusters the business model in nine different parts separating the business model into the efficiency and the value side. These parts are easy to measure and describe the business model in great detail. Compared to other

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approaches in literature this model was built on the most practical relevance and therefore is easier to measure than abstract constructs. That's why we chose the model by Osterwalder (2004).

We measured the changes in the different parts of a business model qualitatively using content analysis. We therefore looked at the investment committee documents and the monthly reporting. We did a pre-test with 10 NTBFs and created a code book with anchor phrases to assess changes in the different parts. On bases of the code book we coded all cases. To ensure a high reliability of our approach we used investigator triangulation with two researchers and measured the intercoder reliability. We used multiple encoding rounds until we had high values for the important intercoder reliability measures for all our items (Hruschka et al., 2004). We reached a Krippendorff's alpha of above 0.9 which can be interpreted as an acceptable value (Krippendorff, 2004). Further, we calculated the values for Scott's Pi which is higher than 0.9 and can be interpreted as excellent (Lombard et al. 2002). Also the Chohen's Kappa is larger than 0.81 for all of our variables which can be interpreted as nearly perfect (Landis and Koch 1977).

In the following the different parts are described. The anchor phrases were mostly in Germany and were translated into English. You can find the original wording in Appendix A1. The company and product names were removed to ensure anonymity. The company which is referred to in the anchor phrases was called company XYZ.

1. Key Partners

The key partners include the suppliers and cooperation of the company. We measured if a change in the key partners occurred. That could be either a new key partner or the removal or substitution of a key partner. In the qualitative data we found a few times the substitution of a key partner to minimize dependencies as our anchor phrase shows:

> *By establishing a professional sales architecture the dependencies with company XYZ [external sales provider] should be loosened.*

2. Key Activities

The key activities include the product development, sales, market and the acquiring of new financing. To be able to do more research activities to improve their product several companies filed for research grants as our anchor phrase shows. That enables the companies to shift their activities more to research and development. We measured if a shift of activities occurred.

> *Our application for research funding of the EU was approved. The project includes doing research based on breast cancer products of the product pipeline of company XYZ.*

3. Key Resources

The key resources for NTBFs are the intellectual properties, the human capital and the financials. Several NTBFs tried to acquire public research funds to broaden their resource bases as our anchor phrase shows. We measured if a substantial change in the key resources occurred.

> *The company XYZ received a research grant of the amount of 355k Euros of the BMBF [Federal Ministry of Education and Research].*

4. Cost Structure

The cost structure describes how the costs are divided between fixed and variable costs. In several companies we saw a change in cost structure by for example outsourcing an activity to a supplier as shown by our anchor phrase. We measured if the cost structure substantial changed.

> *The product ABC is not produced anymore by the company itself but by a supplier (supplier DEF) which also delivers self produced instruments to company GHI.*

5. Value Proposition

The value proposition describes which customer problems are solved and in what way. In several cases in our data set, we saw a transition from a producing company to a service company and vice versa as our anchor phrase indicates. We measured if a change in the value proposition occurred.

> *The XYZ AG transitioned from a software consulting company for financial markets to a leading provider for intelligent e-trading solutions for market participants.*

6. Customer Relationship

The customer relationship describes in what way and how frequent the contact to customers happen. In our data set, many of the NTBFs rely on external service providers to handle the sales activities so they can focus on the product development. However, some of the companies changed their strategies as the anchor phrase showed. We measured if a change took place.

> *Our business plan is largely based on direct sales. We are changing this strategy and are now going to use an indirect sales strategy through solution providers.*

7. Customer Channels

The channels to reach customer can greatly vary between the companies. As many NTBFs are research focused they try to reach their customers on science or trade fairs and later change to direct sales. We measures if the customer channels changed as shown in our anchor phrase.

> *Sales with focusing on wholesales were not successful; change of strategy in the end of 2007. Since 2008 the sales focus are premium vendors and direct marketing on events.*

8. Customer Segment

The customer segments describe which customers are targeted by the company. An example of a change of customer segments is indicated by our anchor phrase. The company focuses on large players instead of small companies like before. We measured if the customer segment was changed.

> *Future focus on multipliers and big aid agencies because small organizations generate neither few or no revenue.*

9. Revenue Streams

Different revenue models like subscription or licensing fees exist as well as different pricing models like pay per transaction or pay per model. We measured if at least one revenue stream was changed as our anchor phrase indicted:

> *For the stabilization of the cash flow the company replaced the model of selling software licenses to renting it and reached some successes after the implementation.*

3.2.2 Independent variables

We measured different items for the areas financial strength, technology, management competencies, management support, network strength. The items are described in the following.

Determining the financial strength of a NTBF is difficult. Revenue and profit might not be good indicators because most NTBFs need several years until they will become profitable (Bertoni et al. 2005). Therefore, we focus on indicators which measure the survival of NTBFs. If a NTBF lacks sufficient financial resources it has to declare bankruptcy. We took the liquidity risk as the first item. If the NTBF faced liquidity problems it would probably focus on acquiring additional funding instead of focusing on changing the business model. Similarly, we took the risk of not getting new investors into account. If the NTBFs have difficulties in finding new investors they will likely focus on this activity and not focus on business model innovation. Further, we took

bankruptcy into account. Possibly, the NTBF wouldn't focus on business model innovation when it's facing becoming bankrupt. On contrary, a NTBF might try to change the business model quickly to prevent bankruptcy. An indicator, for a negative financial development is the depreciation of the NTBFs in the books of the venture capital fund. If the investment managers don't believe anymore in the success of a NTBF they will lower the evaluation in their books and depreciate the difference of the old and the new value. The last value we take into account is the evaluation of the NTBF. A high evaluation accounts for a strong belief in the success of the company by the venture capital company. Also, a high evaluation is an indicator of a high investment of the investors.

The technology is often the most important asset of a NTBF. We first measured the technology feasibility. This describes if the technology is working as the founders of the NTBF planned. This might be a prerequisite to be able to focus on innovating the business model. In contrary, if the technology doesn't work as expected it could be a driver to change the business model according to the technology or to shift the business model from a technology provider to a service provider. Further, we measure the degree of the development of the technology. If the technology matured it might enable the NTBF to explore new areas of applications for it and enhance their business model. Similarly, we measured if technological milestones are reached. If this is the case it might enable the NTBF to explore new areas of application. Further, we look at the IP protection. A strong IP protection may secure the core business of the NTBF and enables it to further expand in other directions.

The management competencies might have a significant role in changing the business model. We therefore measured the hard and the soft skills as assessed by the investment mangers supervising the teams. For the hard skills we measured the business and the technological skills of the founding teams. To change or innovate the business model the team must understand and be able to evaluate the business processes in their company and in addition have sufficient technological knowledge to evaluate if their product and service could be tailored to a new business model. In addition, soft skills are needed to successfully implement the business model change within the company. We therefore measured bargaining and conflict managing skills. Possibly, not all employees are content with a business model change because it might imply more risks. Therefore, good bargaining skills and a sensitive way to deal with conflicts might be helpful. Further, decision making skills and leadership skills might also be helpful to carry through the business model change. Therefore, organizational skills might also be an advantage. The last item we measured are social skills. Good social skills might help to successfully implement the business model innovation without unsettling others in the company.

The management support may have a significant influence on the decision to change the business model or not. The investors, the advisory board and external advisors often directly support the NTBF and consult them in important decisions. We measured the degree of support for sales and marketing activities and for the technological development. These both activities are strongly related to the business models and if the investors are involved within these they are more likely to be also involved in the decision process. In addition, we measure the support in strategic decisions. That is the area which influences most changes in business models. We further measure the degree of the involvement of the advisory board and of external advisors.

The strength of the network may impact the decision to change a business model. If a NTBF has a strong network of investors it may attract the financing needed for a business model change more easily. In addition, a strong supplier network might make it easier to build new products or services. Further, a strong international network can possibly make it easier to enforce a new business model.

3.2.3 Control variables
We controlled our model for age and investment stage. Companies might be more likely to change their business model when they are older and have more experience on the market. In addition, the investment stage could be an important factor. Companies might be more likely to change their business model in a later stage because the NTBFs often enter the market in the first stage and can only assess in the second investment stage that their product or service is not accepted by the market and might then change their business model. In addition, the might use business model innovation as a growth strategy. Tesla Motors Inc. for example let everybody freely use their patents to motivate more companies to invest in the necessary infrastructure for electric cars.

The descriptive statistics of all our variables can be found in appendix A2.

4. Results

4.1 Model results

The resulting path model is shown in table 1. The financial strength is not significant in our model. The absolute value of the loading of the construct is below 0.1 and the t-statistics show that the construct is not significant at a 90 per cent level. Therefore, we have to reject H1. Looking at the technological strength we find it highly significant indicated by the t-statistics and the high factor loading. The loading of the construct is negative which means a NTBF with a high technological strength is less like to change the business model. We can accept H2. Management competencies is the strongest construct in our model. It has the highest loading and is significant by the t-statistics. Further, the effect size is the highest which means that this construct explains best the variance of our model. The loading of the management competencies is negative. That means that highly skilled management team is less likely to change their business model. We can accept H3. The management support has a strong construct loading and is significant as indicated by the t-test. We therefore can accept H4. In addition, the loading of the network strength is also high and the t-statistics indicates significance. The loading of the network strength is negative. We therefore can accept H5. Further, the control variable age is not significant indicated by a low factor loading and no significance in the t-statistics. However, the investment stage is significant and has an effect in our model.

In the following we look at the indicator variables of the single constructs. The indicator loadings and t-statistics are shown in table 2. Looking at the construct financial strength we found the liquidity risk and the risk of not founding new investors significant. The items bankruptcy, depreciation and evaluation have no effect on the construct. Only the feasibility of the technology was significant in the construct technology strength, the development of the technology, the reaching of milestones and the IP protection were not relevant. In contrary, all items except of the technological competencies were significant in the construct management competencies. Looking at the construct management support we found sales support, strategic support and technological support to be significant. The advisory board and the external advisors had no significance. The supplier network was significant for the network strength construct. The other two items, investors network and international network, were not significant.

Construct	Loadings	t-Statistics	Cronbach's alpha	Composite reliability	AVE	f²	q²
Financial Strength	-0.062	0.862	0.6720	0.8555	0.7481	0,0029	0,0160
Technological Strength	-0.337	5.362***	1	1	1	0,1026	0,0391
Management Competencies	-0.368	6.852***	0.8924	0.9142	0.6073	0,1686	0,0612
Management Support	0.28	4.256***	0.6809	0.7484	0.5167	0,1144	0,0259
Network Strength	-0.213	3.284***	1	1	1	0,0513	-0,0005
Control Age	-0.020	0.288	1	1	1	0,0000	0,0120
Control Investment Stage	0.209	3.673***	1	1	1	0,0557	-0,0201
Business Model Innovation	-	-	0.9072	0.9249	0.5822	-	-

Tables 1: Reliability measures of our PLS model

Significance of * 90 % level, ** 95 % level, *** 99 % level

When we look at the construct business model innovation all variables are significant and have a high factor loading. While factor loadings of 0.4 and above are acceptable for exploratory studies our lowest factor loading is 0.6 (Hair et al. 2013). This shows the validity of our approach of measuring the business model by using the different parts of the business model canvas.

4.2 Reliability measures

Assessing the right reliability measures for a PLS model was subject to a long discussion in literature. In 2013, Hair et al. came up with a framework on which reliability measures to use for which aspects for a PLS model. He therefore suggested a separate analyzes for the structural and for the measurement model. We followed this recommendation and describe the reliability measures for both models in the following. We included the reliability measures Hair et al. (2013) proposed.

4.2.1 Reliability of the structural model

Our overall model has a R^2 value of 0.322. This is an acceptable value for an explorative study (Huber et al. 2007; Nitzl 2010). The Q^2 value is 0.1303. A positive Q^2 value indicates a predictive relevance of the model (Henseler et al. 2009). The effect size of the construct management competencies is above 0.15 which indicates a moderate effect (Hair et al. 2013). The constructs technological strength, management support, network strength and investment stage have an effect size above 0.02 which indicates a weak effect (Hair et al. 2013). The effect size of financial strength and the control variable age shows no effect on the overall construct which is not surprising as these construct are not significant as indicated by the t-statistics. The predictive relevance for technological strength, management competencies, management support indicates a weak predictive relevance (Hair et al. 2013). The financial strength and the control variable age show no predictive relevance. This is not surprising considering the low loading of both factors (below 0.01). However, the construct network strength and the control variable investment stage have no predictive relevance. We chose to include the constructs in the model because of the positive loadings, t-statistics and effect size and the explorative design of our study.

4.2.2 Reliability of the measurement model

We stepwise removed the indicators which had a standardized indicator loading below 0.4 until our final model included only indicators with an standardized indicator loading above these value (see table 2). A loading of 0.4 is acceptable for exploratory studies (Henseler et al. 2009, Hair et al. 2013). All our included indicators are significant on a 99.9 per cent level determined by the t-statistics. To check the internal consistency reliability we used Cronbach's alpha and the composite reliability. The cronbach's alpha is above 0.6 for all our constructs (see table 1) which is acceptable for exploratory studies (Nunnally and Bernstein, 1994). The composite reliability is above 0.7 for all our constructs (see table 1) which is a good value (Henseler et al. 2009, Hair et al. 2013). The convergent validity was measured by the AVE which is widely accepted in literature (Fornell and Larcker 1981; Hair et al. 2013). All our constructs exceeded 0.5 (see table 1) which is an excellent value. To check for the discriminant validity we used both the Fornell-Larcker criterion results and the cross loadings (Fornell and Larcker 1981). The square root of the AVE of a construct should exceed all the latent variable correlations of the construct for the Fornell-Larcker criteria to be fulfilled. Testing the crossloading each variable should load highest for the corresponding construct. Both tests showed the validity as it can be seen in Appendix A3.

Item	Loadings	t-Statistics	Item	Loadings	t-Statistics
Financial Strength			**Network Strength**		
Liquidity Risk	0.912	4.830***	Supplier networks	1	-
New Investors	0.815	3.863***	**Control**		
Technology			Age	1.000	-
Feasibility	1.000	-	Investment Stage	1.000	-
Management Competencies			**Business Model**		
Business Skills	0.683	11.269***	Key Partners	0.654	10.196***
Bargaining Skills	0.816	20.974***	Key Activities	0.807	19.506***
Conflict handling Skills	0.822	16.066***	Key Resources	0.677	11.054***
Decisions Skills	0.782	12.422***	Cost Structure	0.884	42.282***
Leadership Skills	0.911	26.627***	Value Proposition	0.863	32.341***
Organizational Skills	0.812	17.243***	Customer Relationship	0.809	20.656***
Social Skills	0.585	4.915***	Channels	0.618	9.000***
Management Support			Customer Segment	0.638	9.288***
Sales Support	0.958	23.363***	Revenue Stream	0.856	32.405***

Strategic Support	0.617	4.028***			
Technological Support	0.502	2.542***			

Table 2: Loadings and t-statistics of the items
Significance of * 90 % level, ** 95 % level, *** 99 % level

5. Discussion

Measuring the degree of the business model innovation is a challenging task as no measures are provided in literature. Therefore, we tried to describe this construct by using the different parts of the business model canvas as proxy variables for business model innovation. We thereby collected qualitative data and codified it to a quantitative scale using a code book and investigator triangulation. To ensure a high reliability of our approach we used intercoder reliability measures which are widely accepted in the literature. Our model showed each item of the business model canvas to be linked to business model innovation as verified by the t-statistics and the indicator loading. The Cronbach's alpha and the composite reliability being both above 0.9 assure the validity of this approach. However, that's the first time this scale is used and it should be validated in further empirical studies.

Looking at the main drivers of business model innovation we could show that the technological strength, the management competencies, the management support and the network strength significantly influence the likelihood of a business model innovation. Taking the technological strength into account we found a negative effect. That means that a business model innovation could be triggered when there are difficulties with realizing a product out of the technology. Then, the NTBF has to come up with a new business model like for example shifting to a consultant service in the corresponding area. Looking at the indicator items only the technological feasibility was relevant describing that the technology worked as planned. The three items development, milestone reaching and IP protection were not relevant. An explanation could be that it does only have an effect if the technology worked but not if the development process took longer. If the last was the case the NTBF would rather focus on further developing the product instead of changing their business model. The IP protection might not be relevant because it only indicates that an idea works which not necessarily mean that the product based on a patent might work as well. However, we only found one variable to be significant in the construct of technology. For non-explorative studies, each construct should have at least three variables (Hair et al. 2013).

The management competencies have a negative effect on business model innovation. That means that experienced teams are less likely to change the business model in the beginning of the development of a NTBF. A reason for that could be that a highly skilled team is better able to establish a working business model right from the beginning and will only change it later to for example implement a new growth strategy. On the other hand, a less skilled team might have to make more adjustments to the business model until it will be successful. Looking at the indicator items we found seven of our eight items to be significant. Only, technological skills were not significant. A reason for that could be that the technological skills are high in all our NTBFs. This assumption is backed up by the highest average rating among all skills (4.493) and the lowest standard derivation of 0.710.

The management support has a positive effect on business model innovation. If the investors actively supported the NTBF in questions of strategy, technology development and sales it would be more likely to adjust their business model. An explanation for that could be that the NTBFs implement the advice of the experienced investors and with their help continuously improve their business model. However, it could also mean that the investors only would actively support a NTBF if the development wasn't going well. If this is the case it might also often be necessary to change the business model. Looking at the indicator items we found all items influenced by the investor themselves, sales support, strategic support and technological support as significant. The advisors board and external advisors were not significant.

Further, the network strength has a negative effect on the chances of business model innovation in a NTBF indicated by the supplier network. That means if the NTBF had strong dependencies with suppliers it would be less likely to change their business model. Possibly, they don't have alternatives for some parts of their value

chain which could make it difficult to change their business model. Looking at the items, only supplier dependencies were significant, the network of investors and the international network have no influence. A reason for that could be that in the first stages of the development of the NTBF only a small number of investors are needed and having more investors is no advantage. In addition, most NTBFs first try to enter the domestic or European market so that the broader international network will only become relevant.

The financial strength has no significant effect. A reason for that can be that we only included venture-capital financed companies in our data set and these companies all successfully acquired investors. Therefore, there is no lack of sufficient resources. Looking at the items liquidity risk and the possibility to acquire new investors were significant. Bankruptcy, depreciation and the company evaluation had no significant effect. A reason for that could be that NTBFs which failed early didn't have the chance to change their business model although some would try. The evaluation might not have an effect because the evaluation is often made based on the old business model and the change of it will take place after acquiring the new financial resources based on the old evaluation.

6. Limitations, Implications and Outlook

6.1 Limitations
As most empirical studies our research is subjected to several limitations. We will describe them in the following.

First, we focused on the enablers of business model innovation based on the resources of a company in our study. Therefore, we didn't take outside events like external crisis or a negative market development into account which may enable or hinder business model innovation.

Second, our sample size is rather small. Therefore, our study has an explorative character and the results should be verified with a bigger data set.

Third, our control variable investment stage was significant. That means that a business model innovation is more likely to take place in a later investment round. Therefore, we propose conducting a longitudinal study analyzing the factors for business model innovation separately in each investment rounds.

Fourth, we focus on German NTBFs. It's unclear if the results can be generalized to other countries. Similar studies in other European countries, Asia and North America would help to uncover possible similarities and differences in other countries.

6.2 Implications
We made a suggestion how to measure the business model innovation in companies and successfully tested our approach with empirical data. This might be of great help for future studies and enable them to use quantitative models. That can enhance this qualitative dominated stream of research.

We were able to identify the enablers of business model innovation for NTBFs and to empirical verify them. This might help researchers and practitioners to better understand how and why business model innovation happens in new ventures. We showed that there is no single enabler for a business model innovation but it is initiated by different factors. The interaction of the management team, the technology, the network and the support of the investors will make business model innovation more likely.

If the management team wants to change the business model it should take the other resources into account from the beginning. It should further tailor their technology to the new needs and involve the investors early on. This way, the chances of a successful business model innovation would be higher.

An investor supervising a NTBF he invested in could also take the resource perspective into account early when the NTBF is discussing a business model innovation. He can assist the team in providing network contacts and discuss the technological changes with the NTBF.

7. Appendix

A1. The original text phrase for assessing changes in the business model
In the following, the original German text phrases are shown which we used as a base for encoding the qualitative data for each of the parts of the business model canvas. The data was derived from the investment committee papers and the monthly reporting of the companies. Some of the documents were original in English. That's why not all phrases have a German expression.

1. Key Partners

Durch den Ausbau einer professionellen Vertriebsstruktur soll zudem die Abhängigkeit von dem Unternehmen XYZ [externes Vertriebsunternehme] reduziert werden.

2. Key Activities

Unser Forschungsförderungsantrag bei der EU wurde positiv bewertet. Das Projekt umfasst die Erforschung von Firma XYZ-Pipeline-Produkten bei Brustkrebs

3. Key Resources

Die Firma XYZ hat einen Zuwendungsbescheid in Höhe von 355 T€ vom BMBF [Bundesministerium für Bildung und Forschung] erhalten.

4. Cost Structure

Produkt ABC wird nicht mehr von der Firma XYZ selbst gebaut, sondern von einem Lieferanten (Lieferant DEF), der u.a. auch die Firma GHI mit selbst entwickelten Instrumenten beliefert.

5. Value Proposition

Die XYZ hat sich seit 1999 von einem Softwareberatungsunternehmen für Finanzmärkte zu einem der führenden deutschen Anbieter von intelligenten Handelslösungen (e-trading solutions) für Marktteilnehmer entwickelt

6. Customer Relationship

Our business plan is largely based on direct sales. We are changing this strategy and are now going to use an indirect sales strategy through solution providers.

7. Customer Channels

Vertrieb in 2007 Konzentration auf Großhandel, nicht erfolgreich; Strategieänderung Ende 2007. Seit 2008 erfolgte der Aufbau des Vertriebs über Premiumhändler und in der Direktvermarktung bei Großveranstaltungen.

8. Customer Segment

Zukünftiger Fokus auf Multiplikatoren und große Hilfsorganisationen, da kleine Organisationen teils keine oder kaum Umsätze generieren

9. Revenue Streams

Für eine stärkere Verstetigung des Cashflows hat das Unternehmen mit der Umstellung vom Kauf der Softwarelizenzen hin zu deren Vermietung begonnen und sieht sich durch erste Erfolge bestätigt.

A2. Descriptive data of our dependent and independent variables

Item	Mean	Std. Dev.	Scale	Data source
Financial Strength				
Liquidity Risk	3.528	1.210	Metric	Survey with investment managers
New Investors	2.819	1.378	Metric	Survey with investment managers
Bankruptcy	0.127	0.355	Binary	Annual statement of the VC company
Depreciation	1.014	1.863	Metric	Annual statement of the VC company
Evaluation	3,528 k	1,210 k	Metric	Term sheet
Technology				
Feasibility	2.803	1.410	Metric	Survey with investment managers
Development	3.918	0.968	Metric	Survey with investment managers
Milestone Reaching	3,534	1,107	Metric	Survey with investment managers
IP Protection	0.471	0.503	Binary	Business plan, reporting
Management Competencies				
Business Skills	3.452	0.972	Metric	Survey with investment managers
Technological Skills	4.493	0.710	Metric	Survey with investment managers
Bargaining Skills	3.534	0.929	Metric	Survey with investment managers
Conflict Handling Skills	3.219	1.109	Metric	Survey with investment managers
Decisions Skills	3.740	0.834	Metric	Survey with investment managers
Leadership Skills	3.507	1.120	Metric	Survey with investment managers
Organizational Skills	3.753	0.910	Metric	Survey with investment managers
Social Skills	3.712	1.020	Metric	Survey with investment managers
Management Support				
Sales Support	2.775	0.913	Metric	Survey with investment managers
Strategic Support	3.822	0.714	Metric	Survey with investment managers
Technological Support	2.319	1.098	Metric	Survey with investment managers
Advisory board	3.356	1.032		
External advisors	3.5211	0.988	Metric	Survey with investment managers
Network Strength				
Supplier network	3.041	1.028	Metric	Survey with investment managers
Investors network	4,125	1,087	Metric	Survey with investment managers
International network	3,639	0,924	Metric	Survey with investment managers
Control				
Age	4.723	2.080	Metric	Business plan
Investment Stage	1.800	0.844	Metric	Investment committee papers
Business Model Innovation				
Key Partners	0.096	0.296	Binary	Investment committee papers, reporting
Key Activities	0.205	0.407	Binary	Investment committee papers, reporting
Key Resources	0.178	0.385	Binary	Investment committee papers, reporting
Cost Structure	0.205	0.407	Binary	Investment committee papers, reporting
Value Proposition	0.233	0.426	Binary	Investment committee papers, reporting
Customer Relationship	0.123	0.331	Binary	Investment committee papers, reporting
Customer Channels	0.082	0.277	Binary	Investment committee papers, reporting
Customer Segment	0.151	0.360	Binary	Investment committee papers, reporting
Revenue Stream	0.205	0.407	Binary	Investment committee papers, reporting

Table 3: Descriptive statistics of our items

A3. Results of discriminant validity tests

In table 4, the cross loadings of each variable in our PLS model are given. Each item must load highest on its corresponding construct so that the discriminant validity test is passed. This is true for our model. The highest cross loading for each item is marked in bold.

	Financial Strength	Technological Strength	Management Competencies	Management Support	Network Strength	Age	Investment Stage	Business Model Innovation
Financial Strength								
Liquidity Risk	**0.9122**	0.4528	-0.307	-0.17	0.0317	0.128	0.1155	-0.1267
New Investors	**0.8149**	0.3336	-0.1574	-0.1991	0.112	0.1502	0.1662	-0.0896
Technology								
Feasibility	0.4626	**1**	-0.2054	-0.0587	0.2816	0.0058	0.2198	-0.2005
Management Competencies								
Business Skills	-0.2873	-0.1182	**0.6827**	0.1385	0.0417	-0.38	0.0038	-0.1919
Bargaining Skills	-0.1108	-0.1112	**0.8163**	-0.0937	-0.0436	0.0177	0.0796	-0.271
Conflict solving Skills	-0.3361	-0.2198	**0.8218**	0.0684	0.0961	-0.1693	-0.0791	-0.2415
Decisions Skills	-0.1334	-0.2069	**0.7824**	-0.0518	0.1821	-0.0371	0.0229	-0.144
Leadership Skills	-0.2574	-0.2157	**0.9109**	0.0204	0.0492	-0.108	-0.1647	-0.2316
Organizational Skills	-0.2333	-0.1372	**0.812**	0.004	-0.033	-0.1123	-0.1243	-0.2436
Social Skills	-0.154	-0.1379	**0.5847**	0.0268	0.1636	-0.1334	-0.2106	-0.0648
Management Support								
Sales Support	-0.2113	-0.083	-0.0168	**0.9578**	0.426	-0.0985	-0.2234	0.3362
Strategic Support	-0.1109	0.0236	0.0842	**0.6171**	-0.0629	-0.2865	-0.4431	0.119
Technological Support	0.0459	0.1371	0.1775	**0.5019**	0.1901	-0.2914	-0.1609	0.0113
Network Strength								
External Advisors	0.0745	0.2816	0.0537	0.3437	**1**	0.0462	0.0214	0.1943
Control								
Age	0.1574	0.0058	-0.158	-0.1758	0.0462	**1**	0.3643	0.0626
Investment Stage	0.1565	0.2198	-0.0681	-0.3233	0.0214	0.3643	**1**	0.0562
Business Model								
Key Partners	-0.0616	-0.2298	-0.2507	0.1518	0.0939	0.115	-0.0345	**0.6536**
Key Activities	-0.1571	-0.1732	-0.1759	0.2503	0.2107	0.0512	-0.0423	**0.8068**
Key Resources	0.0447	-0.2367	-0.2414	0.2274	0.072	0.0787	0.0184	**0.6772**
Cost Structure	-0.1266	-0.2652	-0.1724	0.3021	0.1417	0.0298	0.0781	**0.8842**
Value Proposition	-0.1045	-0.0273	-0.2914	0.2564	0.2709	0.0747	0.0974	**0.8626**
Customer Relationship	-0.1221	-0.1914	-0.1461	0.2218	0.0384	0.0289	0.0929	**0.8091**
Customer Channels	0.001	0.0148	-0.2065	0.2748	0.1546	-0.0365	0.0123	**0.6181**
Customer Segment	-0.1042	-0.103	-0.1758	0.1671	0.1572	0.0173	-0.0856	**0.6385**
Revenue Stream	-0.2066	-0.1295	-0.231	0.3002	0.1791	0.0478	0.1648	**0.8562**

Table 4: Crossloadings for the model constructs

In table 5, the latent variable correlations are shown. We inserted the square root of the AVE (the original AVE values can be found in table y) in the diagonal. The Fornell-Lacker criterion states that the square root of the AVE of a construct should be higher than all values below and left in the latent variable correlation table in order to pass the discriminant validity test. This is true for all our constructs.

	Financial Strength	Technological Strength	Management Competencies	Management Support	Network Strength	Age	Investment Stage	Business Model Innovation
Financial Strength	**0.7481**							
Technological Strength	0.4626	**1**						
Management Competencies	-0.281	-0.2054	**0.6073**					
Management Support	-0.2088	-0.0587	0.0159	**0.5167**				
Network Strength	0.0745	0.2816	0.3437	0.0537	**1**			
Control Age	0.1574	0.0058	-0.158	-0.1758	0.0462	**1**		
Control Investment Stage	0.1565	0.2198	-0.0681	-0.3233	0.0214	0.3643	**1**	
Business Model Innovation	-0.1277	-0.2005	-0.2761	0.3175	0.1943	0.0626	0.0562	**0.5822**

Table 5: Fornell-Lacker criterion results

8. Acknowledgements

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