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On regional innovator networks as hubs for innovative ventures

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Abstract

At least since Schumpeter published his work 'The Theory of Economic Development' (1912), a wide body of literature has focused on the evolutionary process behind firm growth and survival. Recently a growing interest is devoted to the variable 'location' as a critical factor, shaping firm performance. However, less attention has been paid to the region-specific characteristics that may play a relevant role in determining the growth and survival of a firm. Some works see university-based knowledge spillovers as one such factor (Audretsch and Lehmann 2005, Cassia et al. 2009). This paper extends this approach to the regional innovator network, promoting region-specific knowledge spillovers. Two data bases are applied. First, patent data delivers the innovator network for Thuringia. The second data base contains firm specific information on innovative ventures founded in Thuringia in the period between 1990 and 2006. The results show that the firm's individual probability to be innovative and connected to the innovator network positively influences the chances of this firm to survive.

Keywords: Innovation, Entrepreneurship, Networks, Inventor, Patents, Survival
JEL Codes: L26, D85, P25, O31

1. Introduction

Innovation can be defined as "a process that begins with an idea, proceeds with the development of an invention, and results in the introduction of a new product, process or service to the marketplace" (Edwards and Gordon 1984, p.1). Both, (i) the founding of a new firm and (ii) the survival of existing firms are substantially affected by this complex construct. As to (i), innovation is considered to be one of three important characteristics entailed by entrepreneurship (OECD 1998). This view stems from Schumpeter's (1912) suggestion that innovation is a creative *modus operandi* of an entrepreneur (Nijkamp 2009). Audretsch and Lehmann (2005, p. 1192) formulate the relationship as follows: "…entrepreneurship is an endogenous response to the potential for commercializing knowledge that has not been adequately commercialized by the incumbent firms". Thus, entrepreneurs discover an opportunity to exploit a new technology (Shane 2000) and implement this by founding a firm. As to (ii) by creating new variations, new innovative firms compete with incumbent firms, which force the latter to improve or change their production processes or product portfolios. Under these conditions, incumbent firms must be innovative if they are to survive (Brown and Eisenhardt 1997). Non-innovators will fall behind, while first movers respectively firms with an entrepreneurial orientation secure a position of competitive advantage (Lumpkin and Dess 1996, Pyka 1999).

Before World War II, and thus also in Schumpeter's theory, the linear model of innovation was the generally accepted one (Kline and Rosenberg 1986). In this model, events flow smoothly in a one-way street. First, one does research, after that follows development which is followed by production which itself is followed by marketing. Looking more closely on how new ideas are created and innovations come up, according to the definition of Edwards and Gordon (1984), a more complex process as compared to the linear model is going on. Kline and Rosenberg (1986) tried to formalize this complex process and proposed the 'chain-linked model' which entails five different paths of activity and considers feedbacks between the different stages of innovation. This model however does not recover, where feedbacks and information flows are coming from. Over the last decades the concept of collective invention and innovation, brought up by Allen (1983) and von Hippel (1987), has been developed which answers this question. This concept has been said to form the basis for the systemic view of innovative activities and the innovation process (Cantner 2000). Innovations are considered as new combinations that are brought to the market (Schumpeter 1912). Consequently, they require recombining different pieces of existing knowledge (Cantner and Meder 2007). These pieces of knowledge, necessary to successfully innovate, may not be in the immediate reach of an actor or firm but may rather lay outside (Cowan et al. 2006). Thus, access to external knowledge may be an important prerequisite for innovative success. At this point, collectivity comes into play. No single individual or firm can solve all problems (Ejermo and Karlsson 2006) since it does not hold all knowledge available in the world. Especially invention processes are based on the combination of various pieces of knowledge which are possessed by various economic actors. With this perspective in mind, we can argue that invention and innovation activities rely on processes of collective or social learning and exchange of knowledge between actors (Lundvall 1992, Doloreux and Parto 2005), whereas learning is the process whereby existing knowledge is selected and combined based upon a new perspective (Ejermo and Karlsson 2006). Consequently the creation of innovation requires knowledge spillover-producing interaction. These knowledge spillovers can happen deliberately, for example in the context of research collaborations, or involuntary and unintended.

In this research paper, the approach of the innovator network (IN) is used in order to explain if knowledge spillovers that are distributed via connections among inventors influence the success of a new venture if this venture has been founded by a person which is connected to this network. INs can be defined as networks that are built up by actors which cooperatively engage in the creation of new ideas and then economize the results (Cantner and Graf 2007). This economization can be realized within an existing firm or by the formation of a new venture. It is assumed that if a new venture is connected to a well-functioning IN, knowledge spillovers may result in new ideas, promoting firm's success.

Two data bases are used. First, patent data delivers the innovator network for Thuringia. The second data base contains information on innovative ventures founded in the period between 1990 and 2006, drawn from the register for commercial and private companies in Thuringia. Both data sources were merged by the names of inventors and founders.

The analysis is conducted in three steps. First survival analysis explains the relation between a firm's innovativeness and its survival. In a second step, the connection to the innovator network and its influence on a firm's innovativeness is analysed. In the third and last step the differences in chances to survive between innovative and connected firms as compared to innovative and non-connected firms are investigated.

The remainder of the paper will proceed as follows. Section 2 provides an overview on the mechanisms that are connecting innovator networks with entrepreneurial success and presents hypotheses based on these considerations. Section 3 is devoted to the description of the database and methods used. In section 4, results are presented and conclusions are provided. Section 5 discusses the paper's.

2. Innovation, new ventures and the innovator network

In evolutionary economics the emergence and diffusion of innovation is seen as the most important driver of economic change (Pyka 1999). Economic change in this context means a selection process where firms having competitive advantages as compared to the rest of the industry over time gain market shares while the other firms lose. The resource based view of the firm sees the individual characteristics of a firm as most important resources to gain competitive advantages (Penrose 1959). One kind of individual characteristic is a firm's knowledge base which is an important prerequisite for innovation. Therefore, in general the ability of a firm to generate innovation is generally seen as a key driver for economic success of firms. This relation has been empirically proven by several authors. Jaffe (1986) was one of the first to empirically show that there is a systematic relationship between firms' patents, profits and market value to the technological position of firms' research programs. In a more recent study, Hall and Bagchi-Sen (2002) show for firms in the Canadian biotech industry that R&D intensity correlates with patent measures, while innovation measured in terms of new product introductions is associated with business performance. To mention one more, Steward Thornhill (2006) has shown that innovative firms are likely to enjoy revenue growth, irrespective of the industry in which they operate and that firm knowledge, industry dynamism and innovation interact in the way they influence firm performance. Based on this reasoning, the first hypothesis is formulated as follows:

> *Hypothesis 1 – Innovation and survival:*
> *Innovative firms have better chances to survive the selection process of the market than non-innovative ones.*

As it has been pointed out in the introduction, innovation requires a recombination of different pieces of already existing knowledge (Cantner and Meder 2007) which creates new knowledge. Since these pieces may not be in the immediate reach of a firm (Cowan et al. 2006), access to external knowledge may be an important prerequisite for innovative success. Therefore, the creation of innovation requires knowledge spillover-producing interaction.

Cassia et al. (2009), as well as Audretsch and Lehmann (2005), see university-based knowledge spillovers as the most important form of knowledge spillovers. They argue that knowledge from universities flows in the economic system and affects firms' propensity to create new market opportunities and introduce new ideas in the market. Cassia et al. (2009) as well as Audretsch and Lehmann (2005) have shown that a university's knowledge spillovers have a positive influence on firm's growth (measured as sales respectively as number of employees). Besides university-based knowledge spillovers, also spillovers from firm-researchers and employees of research institutes may play an important role since this knowledge may be more applied and ready for the market.

As stated above, knowledge spillovers are an important device for the generation of innovations and they are mainly transferred via personal contacts. In their seminal works, Breschi and Lissoni (2006) comprehensively elaborated this process. They argue that pure spillovers can only take place by trade-unrelated personal communication or through reverse engineering (Breschi and Lissoni 2006). However, when tacitness of knowledge plays a role, knowledge spillovers are not possible anymore without active participation of the inventor. As to the question why inventors should accept to pass information deliberately, Breschi and Lissoni (2006) find the answer in 'social obligations'. University researchers for example obey to the principles of open science and dedicate themselves to the production of public goods. Also corporate researchers may be willing to provide their colleagues with free advice as long as it happens reciprocally. Regarding tacitness as an important characteristic of newly generated knowledge, one could think of knowledge as a club good. Outsiders, defined as actors that are not connected to the social network of innovators, can be excluded from consuming the knowledge while insiders, defined as actors that are connected to the social network of innovators, profit from non-rivalry in the consumption of the shared knowledge.

Such a social network can be defined as innovator network (IN) that is built up by actors which cooperatively engage in the creation of new ideas and then economize the results in the market - either within an existing firm or by the formation of a new venture (Cantner and Graf 2007, Balconi et al. 2004). Innovative actors building the IN are employees of firms, of research institutes or of universities, students or self-employed persons who actively conduct research. These research oriented relationships indicate knowledge transfers and exchanges respectively knowledge spillovers which forms the basis for new ideas facilitated by the recombination of existing knowledge (Edwards and Gordon 1984). However, its not just their innovative effort which brings them together. Moreover, they get into contact by different means. They may of cause be partners in formal research cooperations between several firms. Additionally, they may be former colleagues, thus innovator mobility may play a role. It can also not be excluded that they may know each other from playing tennis in the same sports club, eating in the same restaurant or from bringing their little ones to the same nursery.

For a firm that employs an actor who is socially connected to the innovator network, the connection to the IN promotes the expansion of its knowledge base and its potential to innovate. Consequently an actor who is connected to the IN can provide an important prerequisite for the generation of innovations and therefore it may serve as an important facilitating device for long term firm survival of a firm (Thornhill 2006).

Hypotheses 2 and 3 are summing up these considerations:

> *Hypothesis 2 – Innovator network and innovative output:*
> *Firms that are connected to the innovator network are more innovative than non-connected ones.*

Hypothesis 3 - Innovator network and survival:
Innovative firms survive longer than non-innovative firms and this effect is driven by the connection to the innovator network.

In order to test hypotheses 1 to 3, a biographical firm database has been created which will be presented in the following section.

3. Database and variables

Database

The analysis in this paper aims at finding out whether the social connection to the innovator network influences firms' survival. To answer this question a biographical firm dataset has been constructed based upon two data bases. The first one is data on incorporations of enterprises in Thuringia which is based on the commercial register and the second one is patent data comprising all German patents applied for at the German Patent Office in the time period between 1993 and 2004.

Incorporations

Information on new ventures was collected by the Thuringian Founder Study[1]. The data base was drawn from the commercial register for commercial and private companies in Thuringia and contains information on the founders (date of birth, name, surname, academic title, address, gender) and on the firms (date of founding, date of closing, trade name, location, legal form, spin-off or not, industry). The survey population consists of 12505 founders whose 7016 companies were founded between 1990 and 2006 and are either active or have failed meanwhile. After cleaning the data (exclusion of firms founded before 1993 since the German reunification came with a phase of many management buyouts of former state combines, exclusion of firms where the founding date was missing, extraction of only those firms that are active in innovative industries following the classification of Grupp et al. (2000)) a population of 4568 companies is left for investigation.

Innovator Network

Per definition, the innovator network comprises persons who cooperatively engage in the creation of new ideas and then economize the results (Cantner and Graf 2007). Both aspects have to be elaborated further. First, to be cooperatively engaged in the creation of new ideas does not necessarily mean being involved in active research cooperation. Rather it means that people may also be in the same sports club, meet each other in the same bars or restaurants, are former colleagues, have met on a conference/trade fair or take their little ones to the same nursery. The pivotal role in this respect comes to the fact that people are in contact. Also in a bar or in a sports club people talk about their jobs. Besides private information, they exchange information on what they are working on, what some colleagues of them are doing, what they have read about or what projects they are working on. This information must not be specifically related to innovative activities but at least these contacts lead to know-who respectively knowledge of who may be able to help you solving a certain problem. The underlying assumption of our approach is that a firm which is founded by one or more persons has access to the social capital of exactly these contacts they bring with. If it's not new influences for innovative activities, then this social capital at least helps to find an appropriate contact person for solving (also technical) problems. Of cause, it would also be

[1] Note that this data base was just the starting point for the Thuringian Founder Study Questionnaire. It is therefore not identical to the questionnaire data collected by the Thuringian Founder Study.

possible to find appropriate contact persons at the internet but face-to-face contacts and personal acquaintances are an important feature since members of social networks who personally know each other tend to exchange more information, help or advice (Breschi and Lissoni 2006). Measuring these kinds of relationships of cause is impossible. In order to picture the innovator network, at least in the form of linkages that arise from the participation in a common team of inventors, we use patent data. In the same line of thinking as Breschi and Lissoni (2006), we assume that inventors who worked together on the same patent know each other well enough to be willing to exchange information and to tolerate that this information may be passed on to somebody else than the receiver. Since those networks include members of various companies, circulation of knowledge across companies can be expected.

Second, there is the aspect of economization. This aspect restricts the network to those persons who develop new products or processes for their own firm or for their employer. They may be researchers, technologists or engineers whose aim is to create marketable ideas respectively innovations. Of cause, if we measure patent networks, we do not know whether these patents will end in a new product or process and there is no information available about how the invention has been pursued. However, since a patent application protects the knowledge from usage by other actors, it signals an intention to further use it for example in order to generate an innovation which per definition is the economization new ideas.

For this study, the inventor network of Thuringia has been constructed by including all patent applications to the German Patent Office between 1993 and 2004 on which at least one Thuringian inventor (the assignment was made by postal codes of inventors' address) was listed. The resulting data base contains information on 6,969 inventors (name, surname, address) and 5,381 patent applications (IPC-Code, name and address of the applicant, application date and year). The number of inventors results after checking raw data for misspelling of personal names. Using this data set, the one-mode affiliation network of inventors, where the connection is based upon co-inventions, could be constructed. The information resulting from an analysis of the network of inventors can be effectively combined with other sources of information (Balconi et al. 2004) - in this case with the firm database.

Combination of both

The combination of information gained from the innovator network with the firm database has been conducted by matching names of firm founders with names of inventors in the innovator network. It must be pointed out that this approach does not come without bias. However, the authors tried to check for addresses and birth dates in order to make the matches more accurate. If one or more founders of a firm are listed as inventor on a patent with an application date later than the date of firm founding, then in a first step, this firm was counted to be innovative. Sure, this assumes something that cannot observed, namely that the founder intends to economically exploit his invention within his own firm rather than selling licences or leaving the exploitation to the applicant.

If a firm is identified as being innovative in the sense of having patents, it must not necessarily be connected to the (regional) innovator network. Therefore , in a second step, an attribute dataset has been created, identifying inventors which at the same time have incorporated a firm. Subsequently network analysis has been applied in order to distinguish between connected and isolated inventor-founders. Of cause, if a firm was founded by more than one inventor-founder it is counted to be connected as soon as at least one founder is not isolated.

The information received from the analysis of the innovator network is used in order to create the core variables of the analysis. The variables will be presented in more detail in the following section.

Variables

Table 1 reports descriptive statistics for the data base created. Tables 6 and 7 in the appendix show the correlations of the variables on a significance level of 5%.

Table 1 Descriptive Statistics

	Variable	**Description**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
H1	*Innovative*	Binary variable, indicating whether the founders of the respective firm have applied for patents (1) or not (0).	4568	0.11	0.32	0	1
H2	*No.Patents*	Count variable, indicating the number of patents the founders of the respective firm have applied for.	4568	0.21	1.48	0	47
	Connected	Binary variable, measuring for those firms of founders who have applied for patents, whether they are connected to the innovator network or isolated from it.	516	0.37	0.48	0	1
	PatExperience	Count variable, indicating the number of patents the founders of the respective firm have applied for before the firm has been founded.	516	1.83	3.24	0	26
H3	*InnoConn*	Binary variable indicating that an innovative firm is connected to the network (1) or isolated from it (0).	516	0.37	0.48	0	1
	Prob(InnoConn)	Probability for a firm to be innovative and connected to the network at the same time, dependent on certain individual characteristics.	4494	0.04	0.12	0	0.97
Regional Differences	*ABG*	Dummy for Altenburg.	3508	0.03	0.18	0	1
	GGrz	Dummy for Gera/Greiz.	3508	0.07	0.26	0	1
	JShk	Dummy for Jena/Saale-Holzland-Kreis.	3508	0.12	0.33	0	1
	SOK	Dummy for Saale-Orla-Kreis.	3508	0.02	0.15	0	1
	SaalRud	Dummy for Saalfeld/Rudolstadt.	3508	0.04	0.21	0	1
	Central	Dummy for Central Thuringia (Sömmerda, Erfurt, Weimar, Weimarer Land, Ilm-Kreis, Gotha).	3508	0.33	0.47	0	1
	Sonne	Dummy for Sonneberg.	3508	0.03	0.18	0	1
	Schmalle	Dummy for Schmalkalden/Meiningen.	3508	0.14	0.35	0	1
	EAWak	Dummy for Eisenach/Wartburgkreis.	3508	0.08	0.26	0	1
	UHK	Dummy for Unstrut-Hainich-Kreis.	3508	0.03	0.17	0	1
	Eichs	Dummy for Eichsfeld.	3508	0.04	0.19	0	1
Controls	*ShareStudents*	Share of students in the whole population of the region the firm is located at.	3508	0.02	0.04	0	0.12
	Meanturb	Mean of industry turbulence in the time span of three years before the firm has been founded and the three years afterwards.	2900	3.96	6.64	-4.87	23.24
	Capcomp	Binary variable indicating whether the firm is a capital company (1) or a private company (0).	4568	0.93	0.26	0	1
	Academics	Number of founding-team members that is holding an academic degree.	4560	0.12	0.39	0	9
	Spinoff	Binary variable identifying academin spin-offs (1).	4568	0.02	0.15	0	1
	No.Founders	Team size. Number of persons that have founded the firm.	4560	1.39	0.77	0	16

Dependent variables

The *Survival* of a firm is its life span from the year of founding on up to the year of closing in the case the firm failed. Since firms are only observable here until the year 2006, for those firms that lived longer, failure cannot be observed after 2006. The Cox-proportional hazards model which will be described in more detail in chapter 4, accounts for this truncation problem of survival data.

The variable *No.Patents* counts the number of patents the firm's founder(s) applied for during the life span of the firm. This number ranges between 0 and 47 while the majority of firms (4267 out of 4568) count a zero.

InnoConn is a binary variable indicating whether the founders of innovative firms are connected to the innovator network (InnoConn=1; 192 out of 516 firms with innovative founders either before or after founding the firm) or whether they are isolated notes of the net (InnoConn=0; 324 out of 516 firms with innovative founders either before or after founding the firm). As argued above, the analysis in this paper assumes for young and small firms, that social scientific capital of the founders can be directly translated into social scientific capital of the firm. Since social relations usually do not break up from one year to the other, also the connection of the founder(s) to the network in the years before firm founding as part of the scientific social capital of the firm has been encountered.

Control for regional differences

Of cause the regions differ in regards to their economic environment, the structure of the regional network and other factors which cannot be analysed within this paper. However, in order to cope with this problem and to control for pure regional differences, dummies for the 12 travel to work areas of Thuringia as defined by Granato and Farhauer (2007) have been included.

Independent variables

The variable *Innovative* is a binary variable, which measures whether the founders of the firm have applied for patents (Innovative=1; 516 out of 4568) or not (Innovative=0; 4052 out of 4568) before and after the firm has been founded. This indicated whether one can consider the firm to be innovative or not.

Connected is a binary variable indicating whether the founders of a firm are connected to the innovator network (*Connected*=1; 192 out of 516 innovative firms) or whether they are isolated notes of the net (*Connected* =0; 324 out of 516 innovative firms). As has been argued above, the authors assume for young and small firms, that social scientific capital of the founders can be directly translated into social scientific capital of the firm. Since social relations usually do not break up from one year to the other, also the connection of the founder(s) to the network in the years before firm founding as part of the scientific social capital of the firm has been encountered.

*PatExperienc*e is a count variable, indicating how many patents the founders of a respective firm have applied for before founding it. For the 516 innovative firms in the sample, this variable ranges between 0 and 26. For 213 firms, one finds a 0 which means that they have no patenting experience. The founder(s) of the other 303 firms bring along experience in patenting.

Prob(InnoConn) measures the probability of a firm to be connected to the innovator network and at the same time to be innovative (which means that the founders have applied for patents before or after the firms has been founded). This variable becomes zero for all firms that have no connection to innovative activities that might be measurable through patent information. For all the other firms where the founders have shown patenting activities, even before the firm has been founded, it takes a value between 0 and 1.

Control Variables

In order to control for regional differences, dummies for the 12 Thuringian travel-to-work areas as defined by Granato and Farhauer (2007) were created. Figure 1 in the appendix illustrates these areas.

The probability to be an innovative firm might differ dependent on whether a region is a so called student-region or not. Therefore, the variable *ShareStudents* measures the share of students in a travel-to-work area compared to the whole population in this area.

The firms in the sample are active in different industrial sectors and of cause the sector plays an important role to for the survivability of a firm. Since this paper is analyzing young firms, it is not only controled for sectors but to also for the economic environment/stage of the sector they are active in. For this purpose, data from the IAB (Institut für Arbeitsmarkt- und Berufsforschung) has been used, which contains the number of firm founding and closing for each industry (Nace 2-digit level) for the years 1976 to 2010. Based on this data, the variable named *Meanturb* has been constructed, which is measuring the turbulence in the sector the firm is active in for a time span of six years, three years before the firm has been founded and three years afterwards. The turbulence is measured as number of firm founding in a certain sector in the specific years minus the number of firm close downs in the same sector in the same years. From this value, the mean over the six years around the firm founding is estimated and used for analysis.

The variable *Capcomp* (1 of it is a capital company, 0 otherwise) controls whether the firm is a private company.

Academics measures the number of team member that is holding an academic degree.

Spinoff measures whether the firm is an academic spin-off, which means a spin-off from a university or research institute (*Spinoff*=1) or not.

No.Founders measures the founding team's size.

4. Method

Innovation and survival

In order to analyze the role an innovator network plays for the survivability of a young and innovative firm, the analysis in this paper proceeds in three steps. The first step is to identify the relation between innovativeness and survival of a firm. Since in this first step success is measured in terms of survival, Cox's proportional hazards model (1972) is applied. It has been widely recognized that survival as an outcome variable does not come without bias. The problem arises due to non-complete measurements on all 'members' or entities of a random sample (Kaplan and Meier 1958). For example in medical follow-up studies, contact to some of the individuals will be lost before their death and others will die due to other reasons. Similarly the observation of the lifetime may be ended at a certain point in time, due to the need to get out a report within a reasonable time. In many applications, and this holds also for our investigation, survival may be a subject to right censoring and left truncation (Tsai et al. 1987). Right-censored cases are study objects whose failure event is not observed. The term "right-censored" implies that the event of interest is to the right of our data point (Kaplan and Meier 1958). In other words, if the units were to keep on operating, the failure would occur at some time after our data point. Truncation is a source of bias in survival analysis, in which certain objects are ignored and not sampled (Tsai et al. 1987). Left-truncation occurs when some subjects are registered at a delayed time. The present database contains firms founded at several points in time. Thus, there is a problem with left-truncation. Also, the event of interest (closure) is not observed for some of our observations, thus the data is right-censored. Cox proportional hazards model (1972) is used since it gives a valid estimate of the survival rate for data sets including right-censored and left truncated cases.

Innovator network and innovative output
After having identified the relation between innovativeness and survival, the analysis is in a second step devoted to the relation between the connection to the innovator network and innovativeness. This means that it is asked whether in the group of innovative firms those with connection to the innovator network are more successful in innovating than the isolated ones. Since the number of patents applied for as our outcome variable is highly skewed to the left with a high number of zeros, negative binomial regression as proposed by Greene (2003) as well as Cameron and Trivedi (1998) is applied.

Innovator network and survival
The third step of the analysis aims at bringing together the first two steps. The authors want to see whether the combination of being innovative and connected to the network influences firm survival. In order to do this, first the factors that explain this aforementioned combination are analysed. This means that special characteristics are regressed on the binary variable *InnoConn*. Since the outcome variable is binary, logistic regression is applied. The individual coefficient of this regression (the fitted value), reveals for each firm that is at least innovative, the probability to be innovative and connected at the same time based on certain characteristics. This value is stored and in the next step and used as explanatory variable for the survivability of the firm in a cox regression.

5. Empirical Results

Innovation and survival

Table 2 shows the results for the first step of analysis which is devoted to hypothesis 1 stating that innovative firms have better chances to survive the selection process of the market than non-innovative ones. As to the controls, being a capital company (*Capcom*) reduces the exit hazard whereas being in an industry with higher market turbulences (*Meanturb*) increases the hazard rate.

Models 1-3 differ in the inclusion of regional control variables. Considering all three models, we find that the coefficient for the dummy variable *Innovative* ranges between 0.64 and 0.76 on a 1-10% significance level. This means that innovative firms have a risk to die in the upcoming period which is only about 70% of the risk for non-innovative firms. Therefore, hypothesis 1 cannot be rejected.

Table 2 Cox proportional hazards model

– regression on the influence of innovativeness on the hazard of a firm to be closed in the next period

Method	Cox regression - Breslow Method for ties					
Dep. Var.	survival					
Population	all firms					
	model 1		model 2		model 3	
Innovative	0.7568	*	0.7015	**	0.6433	***
	(-1.66)		(-2.09)		(-2.59)	
ABG					6.0795	***
					(4.53)	
GGrz					5.3627	***
					(4.59)	
JShk			1.4725	***	4.7279	***
			(2.85)		(4.39)	
SOK					4.7730	***
					(3.60)	
SaalRud					6.2421	***
					(4.79)	
Central			0.4627	***	1.4790	
			(-5.61)		(1.10)	
Sonne					3.1264	***
					(2.76)	
Schmalle					4.1954	***
					(4.06)	
EAWak					0.5847	
					(-1.02)	
UHK					1.3157	
					(0.49)	
Eichs					1.0088	
					(0.02)	
Capcomp	0.7404	*	0.7105	**	0.7113	**
	(-1.75)		(-1.98)		(-1.97)	
Meanturb	1.0351	***	1.0387	***	1.0340	***
	(5.00)		(5.52)		(4.77)	
No. of Obs.	2199		2199		2199	
No. Of Failures	367		367		367	
Prob>Chi2	0.000		0.000		0.000	

Robust z statistics in parentheses

*significant at 10%, **significant at 5%, ***significant at 1%

Innovator Network and innovative output

The second step of analysis is devoted to the second hypothesis which is assuming that innovative firms that are connected to the innovator network show a higher innovation output than isolated ones. The causality, however, appears to remain unclear. It might be the case that firms apply for more patents since they are connected to the innovator network. But it might as well be that the highly innovative firms are connected since they have more patents. The authors do not claim to have an answer to this point here. The models just aim at revealing the connection in the data. The question which direction is the correct one remains unsolved. Table 3 shows the results of the negative binomial regression on the number of patents a firm applied for in four models which differ with respect to the inclusion of control variables.

Table 3 Negative binomial regression

-the influence of being connected to the innovator network on the number of patents an innovative firm applies for

Method	Negative binomial regression							
Dep. Var.	*No.Patents*							
Population	all firms							
	model 1		model 2		model 3		model 4	
Connected	0.5164	***	0.5013	***	0.5543	***	0.5955	***
	(3.23)		(3.16)		(3.15)		(3.31)	
PatExperience			0.0434	**	0.0377	*	0.0302	
			(2.09)		(1.81)		(1.45)	
ABG							2.6978	**
							(2.25)	
GGrz							0.8015	
							(1.52)	
JShk					6.2492		-24.3060	*
					(1.55)		(-1.89)	
SOK							2.1660	
							(1.63)	
SaalRud							2.6545	**
							(2.32)	
Central					-0.1042		1.7021	**
					(-0.53)		(2.13)	
Sonne							2.8368	**
							(2.41)	
Schmalle							2.9570	***
							(2.90)	
EAWak							1.5311	**
							(2.01)	
UHK							2.2234	*
							(1.78)	
Eichs							omitted	
Academics	0.4409	***	0.4130	***	0.4576	***	0.4617	***
	(3.48)		(3.27)		(3.54)		(3.54)	
Spinoff	-0.1214		-0.2315		-0.1827		-0.1730	
	(-0.47)		(-0.88)		(-0.68)		(-0.66)	
No.Founders	0.1024		0.1115		0.0978		0.0900	
	(1.05)		(1.15)		(1.01)		(0.93)	
ShareStudents	1.0681		1.6061		-51.9694		225.9738	*
	(0.71)		(1.06)		(-1.51)		(1.94)	
Constant	-0.0089		-0.1106		0.0695		-2.7225	**
	(-0.05)		(-0.59)		(0.32)		(-2.43)	
No. of Obs.	442		442		442		442	
Pseudo R2	0.0266		0.0295		0.0312		0.0412	

Robust z statistics in parentheses
*significant at 10%, **significant at 5%, ***significant at 1%

Over all models, the relationship between the connection to the innovator network and the number of patents a firm applies for is significant and positive. Interpreting model 4, one can say that, all the other variables considered being constant, being connected to the innovator network goes hand in hand with a higher difference in the logs of the patent count. Therefore, hypothesis 2 cannot be rejected and it can be assumed that the innovator network has a positive influence on the degree of innovativeness in the group of innovative firms. As to the controls, having a higher share of academics (*Academics*) in the founding team increases the number of patents.

Innovator network and survival

In order to test hypothesis 3, the authors start by calculating the individual probability of a firm to be innovative and connected to the innovator network at the same time (*Prob(InnoConn)*). Table 4 shows the logistic regression for this.

Table 4 Logistic regression

– Variables that are determining the probability for a firm to be innovative and connected to the innovator network at the same time

Method	Logistic regression	
Dep. Var.	*InnoConn*	
Population	all firms	
	model 1	
PatExperience	0.1560	***
	(4.19)	
Academics	0.5708	***
	(3.04)	
Spinoff	0.8551	**
	(2.42)	
No.Founders	0.1113	
	(0.8)	
ShareStudents	-7.2862	***
	(-3.11)	
Constant	-1.1191	***
	(-4.20)	
No. of Obs.	442	
Pseudo R2	0.0851	

Robust z statistics in parentheses
*significant at 10%,
**significant at 5%,
***significant at 1%

The probability to be connected and innovative, which can only be calculated if the firm is indeed innovative and connected, depends on the firm’s experience in patenting (*PatExperience*), the number of academics in the team (*Academics*) , whether the firm is a spin-off (*Spinoff*) and the share of students among the whole population in the region (*ShareStudents*). For all firms where, *InnoConn* is 0, the authors set *Prob(InnoConn)* to 0 which means that not the fitted but the real value is used in order to explain whether the connection to the innovator network is positively linked to the survivability of firms. Cox proportional hazards model is applied to explain survival with the probability to be connected to the innovator network and innovative as well as some control variables. Table 5 shows the results.

Table 5 Cox proportional hazards model

– influence of the probability to be innovative and connected to the innovator network on the hazard of a firm to be closed in the next period

Method	Cox regression - Breslow Method for ties					
Dep. Var.	survival					
Population	all firms					
	model 1		model 2		model 3	
Prob(InnoConn)	0.4851	*	0.4784	*	0.3796	**
	(-1.68)		(-1.65)		(-2.14)	
ABG					6.0375	***
					(4.51)	
GGrz					5.3268	***
					(4.57)	
JShk			1.4329	***	4.5649	***
			(2.67)		(4.30)	
SOK					4.7659	***
					(3.60)	
SaalRud					6.1765	***
					(4.76)	
Central			0.4646	***	1.4817	
			(-5.58)		(1.11)	
Sonne					3.1189	***
					(2.76)	
Schmalle					4.1853	***
					(4.05)	
EAWak					0.5820	
					(-1.03)	
UHK					1.3085	
					(0.48)	
Eichs					1.0124	
					(0.02)	
Capcomp	0.7402	*	0.7098	**	0.7105	**
	(-1.75)		(-1.99)		(-1.98)	
Meanturb	1.0351	***	1.0390	***	1.0343	***
	(5.00)		(5.56)		(4.81)	
No. of Obs.	2199		2199		2199	
No. Of Failures	367		367		367	
Prob>Chi2	0.000		0.000		0.000	

Robust z statistics in parentheses

*significant at 10%, **significant at 5%, ***significant at 1%

Again, models 1-3 differ simply in the inclusion of control variables. Looking at the main variable of interest, *Prob(InnoConn)*, one can see that a high probability to be innovative and connected to the innovator network reduces the hazard ratio to about 48%.

Therefore, hypothesis 3 cannot be rejected and it can be assumed that the connection to the innovator network plays an important role in the explanation of differences in the survival of firms. As to the controls for *Capcom* and *Meanturb* the coefficients show up to be equivalent to the ones in table 2.

6. Discussion and conclusions

The aim of this paper was to show for young firms in innovative industries in how far the connection to the innovator network or in other words, the amount of scientific social capital the firm can make use of, is a hub for its chances to survive the economic selection process.
In a first step, the authors looked at the factors that are influencing innovativeness and find the connection to the innovator network to be one of the main ones. However also experience in patenting positively influences whether the founders of the respective firm go on with their patenting activities. Additionally the number of founders with academic background positively influence tendency of a firm to apply for patents.
In the next step, the authors looked at the connection between innovativeness, the innovator network and the survivability of firms. The theoretical framework suggested that this relation is positive and that an innovative firm which is connected to the innovator network has more success in gaining competitive advantages through innovation and therefore has better chances to survive. An analysis of 4568 companies in the German state Thuringia indicates that the probability of a firm to be innovative and connected to the innovator network at the same time is positively related to its probability to survive.

Besides the connection to the innovator network, three other factors turn out to be influential for the viability of a young company. First, it was found that capital companies have a reduced hazard ratio as compared to private companies.
Secondly, the mean turbulence of the industry the firm is active in for the time span three years before and three years after firm founding is negatively related to the hazard ratio. A high value of turbulence indicates a recently growing sector where there are more company founding's than closings. According to Gort and Klepper's (1982) theory on the diffusion of product innovations (Industry Life Cycle), this industry is in phase II which is the interval from the take-off point of the net entry until the net entry starts to decline drastically. This explains the negative connection which we find for the survival of firms. If a firm is founded in phase II it has to go through phase IV which is a phase of shake out where the net entry becomes negative and where many firms are closed until the market stabilizes. The probability that a firm does not survive this stage is quite high which goes in line with what has been found in the present data.
Third, the authors also find that survival differs regionally. With respect to firm's survival and success, location has been identified as one among many critical factors (Heckmann and Schnabel 2005, Storey 1994). However, locations differ with respect to their organizations like universities, research institutes, firms or public agencies, as well as with respect to institutional factors like norms and regulations, a qualified labour force or business taxes. Besides these, but related, an important locational factor is the regional innovation system as defined by Cooke et al. (1997). The network of innovators can be seen as one core element of such an innovation system. However, it may not be irrelevant to which IN a firm is connected. On these terms, various researches have shown that innovative activities are spatially not evenly spread but a rather regionally bounded phenomenon (Asheim and Isaksen 2002). Already by this unequal distribution innovative performance differs among regional innovation systems (e.g. Porter 1990, Jaffe et al. 1993). Moreover, regions differ with respect to the success of their respective firms or with respect to founding rates (e.g. Storey 1994). The success of incumbent firms as well as their founding rate is driven by innovation (Nijkamp 2009, Audretsch and Lehmann 2005, Brown and Eisenhardt 1997, Lumpkin and Dess 1996) which in turn is driven by the IN. If regions differ with respect to innovative and firm performance, this may be due to different characteristics of the respective regional innovator networks (RINs). Among those characteristics may be network properties like a

high degree of connectedness, a high centrality of single actors or the existence of structural holes. Additionally, one might expect differences occurring due to the characteristics of the knowledge that is flowing in the network. Some regions are highly specialized, thus concentrated on a small number of industries. In these regions, the knowledge flowing through the RIN will also be very specialized and therefore the knowledge bases of the network-actors will have a high degree of overlap. Other regions are more diverse with respect to industries. Consequently, the knowledge flowing through the network is rather diverse and the actors' knowledge bases show a low degree of overlap. These considerations leave lots of space for further research on the connection between network characteristics and firm's success.

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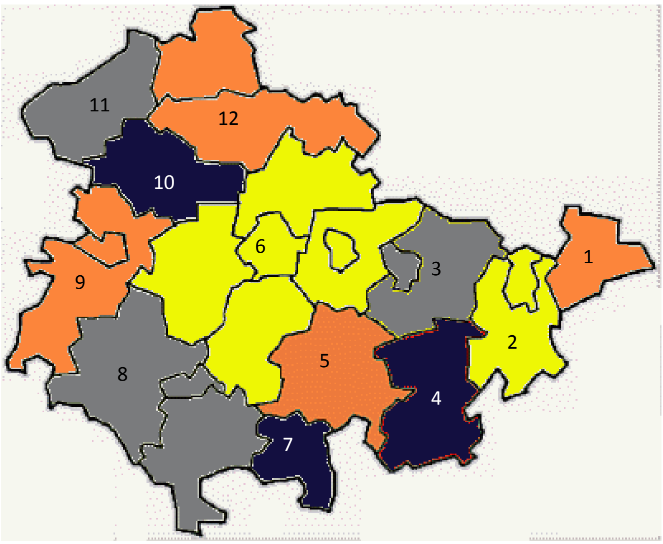
Appendix

Figure 1 Thuringia and its Travel-to-work areas



TTWA$_i$ **(i=1,…,12)**	**Travel-to-work areas**
1	Altenburger Land
2	Gera/Greiz
3	Jena/Saale-Holzland-Kreis
4	Saale-Orla-Kreis
5	Saalfeld-Rudolstadt
6	Central Thuringia
7	Sonneberg
8	Schmalkalden-Meiningen/Suhl/Hildburghausen
9	Eisenach/Wartburgkreis
10	Unstrut-Hainich-Kreis
11	Eichsfeld
12	Nordhausen/Kyffhäuser-Kreis

Table 6 Correlations – full sample (2199 Observations; Estimations in Table 2 and 5)

		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
1	*Innovative*	1.0000															
2	*Prob(InnoConn)*	0.9094*	1.0000														
3	*ABG*	-0.0097	-0.0158	1.0000													
4	*GGrz*	-0.0225	-0.0188	-0.0503*	1.0000												
5	*JShk*	0.1256*	0.0457*	-0.0680*	-0.1047*	1.0000											
6	*SOK*	-0.0263	-0.0288	-0.0285	-0.0438*	-0.0593*	1.0000										
7	*SaalRud*	0.0348*	0.0350*	-0.0390*	-0.0600*	-0.0812*	-0.0340*	1.0000									
8	*Central*	-0.0069	0.0387*	-0.1268*	-0.1952*	-0.2639*	-0.1105*	-0.1513*	1.0000								
9	*Sonne*	0.0025	0.0050	-0.0333*	-0.0512*	-0.0693*	-0.0290	-0.0397*	-0.1292*	1.0000							
10	*Schmalle*	-0.0332*	-0.0283	-0.0726*	-0.1117*	-0.1511*	-0.0633*	-0.0866*	-0.2817*	-0.0739*	1.0000						
11	*EAWak*	-0.0309	-0.0380*	-0.0518*	-0.0797*	-0.1078*	-0.0451*	-0.0618*	-0.2009*	-0.0527*	-0.1150*	1.0000					
12	*UHK*	-0.0229	-0.0206	-0.0322	-0.0496*	-0.0671*	-0.0281	-0.0384*	-0.1250*	-0.0328	-0.0716*	-0.0511*	1.0000				
13	*Eichs*	-0.0372*	-0.0260	-0.0352*	-0.0541*	-0.0732*	-0.0307	-0.0420*	-0.1365*	-0.0358*	-0.0781*	-0.0557*	-0.0347*	1.0000			
14	*ShareStudents*	0.1250*	0.0457*	-0.0813*	-0.0748*	0.9978*	-0.0709*	-0.0971*	-0.2613*	-0.0828*	-0.1703*	-0.0993*	-0.0802*	-0.0876*	1.0000		
15	*Meanturb*	-0.0645*	-0.0732*	0.0432*	0.0566*	-0.0056	0.0022	-0.0385	0.0728*	0.0193	-0.0504*	-0.0691*	-0.0431*	-0.0478*	-0.0024	1.0000	
16	*Capcomp*	0.0195	0.0129	0.0027	0.0058	0.0281	-0.0050	-0.0183	0.0122	-0.0183	-0.0074	-0.0051	0.0130	-0.0386*	0.0292	0.0454*	1.0000

Table 7 Correlations Sub sample (442 Observations; Estimations in Table 3 and 4))

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*
1 *No.Patents*	1.0000																		
2 *Connected*	0.1920*	1.0000																	
3 *PatExperience*	0.1457*	0.2275*	1.0000																
4 *InnoConn*	0.1920*	1.0000*	0.2275*	1.0000															
5 *ABG*	-0.0096	0.0174	-0.0465	0.0174	1.0000														
6 *GGrz*	-0.0193	0.0780	-0.0208	0.0780	-0.0503*	1.0000													
7 *JShk*	0.0540*	-0.1194*	-0.0240	-0.1194*	-0.0680*	-0.1047*	1.0000												
8 *SOK*	-0.0187	-0.0892	-0.0386	-0.0892	-0.0285	-0.0438*	-0.0593*	1.0000											
9 *SaalRud*	0.0059	-0.0629	0.0034	-0.0629	-0.0390*	-0.0600*	-0.0812*	-0.0340*	1.0000										
10 *Central*	0.0220	0.3816*	0.0854	0.3816*	-0.1268*	-0.1952*	-0.2639*	-0.1105*	-0.1513*	1.0000									
11 *Sonne*	-0.0024	-0.0648	0.0347	-0.0648	-0.0333*	-0.0512*	-0.0693*	-0.0290	-0.0397*	-0.1292*	1.0000								
12 *Schmalle*	0.0000	-0.1599*	-0.0510	-0.1599*	-0.0726*	-0.1117*	-0.1511*	-0.0633*	-0.0866*	-0.2817*	-0.0739*	1.0000							
13 *EAWak*	-0.0250	-0.0579	-0.0517	-0.0579	-0.0518*	-0.0797*	-0.1078*	-0.0451*	-0.0618*	-0.2009*	-0.0527*	-0.1150*	1.0000						
14 *UHK*	-0.0192	-0.1097*	-0.0208	-0.1097*	-0.0322	-0.0496*	-0.0671*	-0.0281	-0.0384*	-0.1250*	-0.0328	-0.0716*	-0.0511*	1.0000					
15 *Eichs*	-0.0279	-0.0328	0.0751	-0.0328	-0.0352*	-0.0541*	-0.0732*	-0.0307	-0.0420*	-0.1365*	-0.0358*	-0.0781*	-0.0557*	-0.0347*	1.0000				
16 *ShareStudents*	0.0533*	-0.1166*	-0.0240	-0.1166*	-0.0813*	-0.0748*	0.9978*	-0.0709*	-0.0971*	-0.2613*	-0.0828*	-0.1703*	-0.0993*	-0.0802*	-0.0876*	1.0000			
17 *Academics*	0.1793*	0.1290*	0.1008*	0.1290*	-0.0350*	-0.0174	0.1590*	-0.0432*	-0.0433*	0.0451*	-0.0154	-0.0522*	-0.0593*	-0.0207	-0.0172	0.1603*	1.0000		
18 *Spinoff*	0.0559*	0.1000*	0.0575	0.1000*	-0.0106	-0.0402*	0.0842*	-0.0266	-0.0364*	0.0814*	-0.0310	-0.0174	-0.0483*	-0.0301	-0.0328	0.0841*	0.0722*	1.0000	
19 *No.Founders*	0.0841*	0.0620	0.0427	0.0620	0.0141	-0.0086	0.1168*	-0.0078	-0.0254	0.0209	-0.0305	-0.0339*	-0.0345*	-0.0408*	-0.0274	0.1175*	0.3006*	0.0934*	1.0000