Institute for Strategy and Business Economics

University of Zurich

Working Paper Series
ISSN 1660-1157

Working Paper No. 55

Entrepreneurial Signaling:

Success Factors for Innovative Start-Up

Uschi Backes-Gellner and Arndt Werner

March 2003

Published as: "Entrepreneurial Signaling via Education: A Success Factor for Innovative Start-Ups." *Small Business Economics*, 29(2007)1-2: 173-190. By Uschi Backes-Gellner and Arndt Werner.
Available at: http://dx.doi.org/10.1007/s11187-006-0016-9

Entrepreneurial Signaling: Success Factor for Innovative Start-Ups*

Uschi Backes-Gellner
Professor of Business and Personnel Economics,
University of Zurich, Switzerland,
backes-gellner@isu.unizh.ch

Arndt Werner
Institute for Small and Medium Size Enterprises,
Bonn, Germany,
werner@ifm-bonn.org

Zurich, Institute for Strategy and Business Economics, March 2003

Abstract: Innovative start-ups and their respective market partners are faced with severe problems of asymmetric information due to their lack of prior production history and reputation. We study whether entrepreneurial signaling can help solve these problems and thereby increase the potential success of innovative start-ups. We concentrate our analysis on the credit and labor market because they are crucial for the success of innovative start-ups and focus on the role of educational signals. We argue that entrepreneurs signal their quality to potential employees and creditors with certain characteristics of their educational history. According to our theoretical considerations we expect potential employees to use an entrepreneur's university degree as a quality signal when deciding whether to accept a job at an innovative start-up. And we expect banks to use a more precise indicator, namely the actual length of study in relation to a standard length, as a signal when deciding upon credits for an *innovative* founder. However, since asymmetric information problems and skill requirements are different for traditional start-ups we do not expect employees or banks to use the same signals for *traditional* start-ups. We empirically test our implications based on a dataset of more than 700 German start-ups collected in 1998/99. All implications are borne out in the data. So contrary to conventional wisdom, educational degrees and studying fast (not just studying) are even more important success factors for innovative than for traditional start-ups.

JEL Classification: M13, M5, D82, M21

---

* **Acknowledgements:** Financial support from the German Science Foundation under grant no. Ba 1832/1-1 is appreciated. For comments and discussions we are grateful to Edward P. Lazear, Alwine Mohnen and the participants of two German Science Foundation-workshops at Rauischholzhausen and Munich and the 2003 annual conferences of the German Association of Management and the German Association of Economics. The views expressed herein and all remaining errors are those of the authors.

Introduction*

Start-ups in general, and innovative start-ups in particular, are often seen as an important factor for economic growth and job creation (Dejardin, 2002; Acs and Audretsch, 1990; Storey and Tether, 1996; Kirchhoff, 1995; Birch, 1979; Brüderl, Preisendörfer, and Ziegler, 1998). However, innovative start-ups, compared to traditional start-ups, also pose unique problems and challenges (Audretsch, 2000). Because of the innovative character of their product or business process, no prior history of comparable cases exists. Outside financiers of an innovative start-up for example have no relevant data about production facilities, processes, or product markets to use as a benchmark to evaluate a proposed business plan. The value of an innovative project is therefore difficult to judge, even for the most experienced of creditors. In addition, asymmetric information between the founder of an innovative start-up and the creditor is likely to be extraordinarily large, resulting in well-known adverse selection problems and credit rationing (Stiglitz and Weiss, 1981). The founder, being better informed about potential wins, losses, and risks than the potential financier(s), has an incentive to exploit the asymmetric information to obtain credit conditions inadequate to compensate the financier for the risk taken (Oppenländer, 1998)[1]. Thus, it is no surprise that, as a

---

* Financial support from the German Science Foundation under grant no. Ba 1832/1-1 is appreciated. For comments and discussions we are grateful to Edward P. Lazear, Alwine Mohnen and the participants of two German Science Foundation-workshops at Rauischholzhausen and Munich. The views expressed herein and all remaining errors are those of the authors.

[1] Ravid and Spiegel (1997) argue further that a thorough screening of start-ups is unlikely to be cost effective because such firms are too small and complex, and there are no economies of scale. So banks do not use screening to solve the asymmetric informational problem but limit their risk by financing a

number of studies show, there is a higher default risk for innovative start-ups than for traditional start-ups (Audretsch, 1995; Hunsdiek and May-Stobl, 1986). Stakeholders find investment in an innovative start-up particularly risky, given the lack of history, reliable benchmarks, and prior reputation. Creditors concerned about adverse selection may ration credit[2], finance only a fraction of assets and operations, claim high collateral, or shorten the maturity of their loans (cf. Black, DeMeza, and Jeffreys, 1992; Binks and Ennew, 1996; Cressy, 1996a; Egeln, Licht, and Steil, 1997; Reynolds, 1997; Keuschnigg and Nielson, 2000). Employees may be reluctant to accept a job at such a company or to invest in company-specific knowledge. Suppliers may be hesitant to grant trade credits, and customers may be cautious about ordering products of possibly unacceptable quality or products that may not be delivered in due course. To summarize, innovative start-ups may present the highest growth potential, but they are also faced with the highest hurdles to realizing this potential. The founder can start and run his venture successfully only if he or she finds a way to overcome the initial problem of asymmetric information for all relevant markets.

---

smaller fraction of assets or shortening the maturity of loans. This makes raising the required capital more difficult or more expensive for the founder (see also Nooteboom, 1993; Chittenden, Hall, and Hutchinson, 1996).

[2] Astebro and Bernhardt (2003) explain when start-ups are credit constrainted and also point at the importance of human capital. However, their explanation focuses on the direct productivity effect of higher human capital whereas our explanation focuses on the signaling effect of human capital.

The focus of this study is on how innovative founders solve the problem of asymmetric information. We argue that where no reputation or prior business history exists, the founder's personal history is a key factor in overcoming this problem. Specifically, we expect the educational history of the founder to serve as a signal of the credibility of his or her venture. In Spence's (1973) signaling model workers signal unobservable productivity to an employer by acquiring an educational degree. We argue that, likewise, entrepreneurs signal unobservable entrepreneurial productivity to a bank, potential employee, or customer by the observable characteristics of their educational biography.

We concentrate our analysis on two crucial markets and their respective stakeholders: banks as the most important player on the market for financial capital, and employees as suppliers of labor. As for example Evans and Jovanovic (1989), Blanchflower and Oswald (1998), or Brüderl, Preisendörfer, and Ziegler (1996; 1998) show insufficient supply of start-up capital is the main reason why newly founded firms fail to grow or fail altogether. Moreover, empirical studies show that financial issues are even more crucial for innovative start-ups, which need more external capital than traditional start-ups (Albach, Hunsdiek, and Kokalji, 1986). According to Wippler (1998) and Werner, Backes-Gellner, and Kayser (2003), debt capital - not venture capital - is the most important source of external financial capital for innovative start-ups in Germany. If we look for evidence of the importance of the labor market, Egeln, Licht, and Steil (1997), as well as Audretsch (2000), emphasize that after acquisition of financial capital, successful hiring is the most important task for start-ups. Additionally, Backes-Gellner et al. (2000) show that labor shortage is a primary problem for small firms in general and

start-ups in particular, because both lack the opportunity to recruit or relocate personnel from an internal pool. Werner, Backes-Gellner, and Kayser (2003) provide evidence that labor shortage is worse for innovative start-ups than for traditional start-ups. According to Belfield (1999), the problems are typically most severe for highly qualified employees (with university education) because SMEs and start-ups are not able to communicate their quality as employers. This is particularly troublesome, first, because innovative start-ups need relatively more highly qualified employees than traditional enterprises or start-ups (Falk, 1999), and second, because there is a bigger labor market shortage for highly qualified employees than for less qualified employees (Backes-Gellner and Schmidtke, 2002). Therefore, our concentration on asymmetric information problems on capital and labor markets covers two key success factors for innovative start-ups, 1) reducing credit constraints, and 2) overcoming labor market shortages. Furthermore, we assume that, in principal, the results are transferable to other relevant markets for innovative start-ups.

In the section, “Entrepreneurial Signaling in Capital and Labor Markets,” we derive five hypotheses on entrepreneurial signaling based on an application of Spence’s (1973) theory of labor market signaling. In “Data, Measurement Issues, and Methodology,” we describe our data, a large sample of start-ups collected in 1999 in and around Cologne, Germany, and discuss measurement and methodological issues. Following this, we present the empirical results; and finally, we summarize and draw some tentative conclusions.

Entrepreneurial Signaling in Capital and Labor Markets – Theoretical Analysis

Start-ups in general, and innovative start-ups in particular, have no prior financial or internal labor market history, and hence, no reputation. For innovative product or business processes, there is no experience and no benchmark on which to build. Given this situation, we assume that a founder will most likely be better informed about the potential wins, losses, and risks of the innovative venture than outside stakeholders like financiers and employees, whom the founder nevertheless badly needs to run the start-up. Thus, we follow Lucas (1978) and Evans and Jovanovic (1989) in assuming that the entrepreneur knows his entrepreneurial ability *ex ante*, and market partners do not. Furthermore, it is reasonable to assume that the founder has an incentive to exploit asymmetric information to obtain better financial terms or labor contracts than he or she might if financiers or workers had full information. The consequence is obvious: faced with a typical adverse selection problem, neither banks nor employees will invest in an innovative start-up unless the informational asymmetries can be eliminated or at least substantially reduced.

Usually, there are a number of ways to cope with information asymmetries, i.e., reputation, relationship banking, screening, or the use of collateral and bonds (cf. Bester, 1985; Milde and Riley, 1988; Cressy, 1996b; Stiglitz and Weiss, 1983). However, most of these mechanisms are unsuitable, given the nature of innovative start-ups. There is no reputation, since the company is new. Screening is difficult because of the truly innovative nature of the venture, and sufficient collateral is often beyond the means of a typical founder. However, as introduced by Spence (1973), signaling is one more

way of dealing with information asymmetries. Signaling builds on the founder's past behavior in other activities, namely schooling, to allow conclusions to be drawn about future productivity in a new venture.

Surprisingly, the role of entrepreneurial signaling for start-up success has never been analyzed in depth, despite a very early hint by Lazear (1977) that signaling might be important not only for employees but also for the self-employed[3]. In this study, we apply Spence's original labor market signaling theory to entrepreneurial signaling for innovative start-ups in the capital and labor markets. We derive empirically testable implications regarding the relationship between the educational characteristics of the founder (of an innovative start-up) and 1) the problem of obtaining credit from banks and 2) recruiting qualified employees in highly competitive markets.

In Spence's labor market signaling model (1973), a worker signals his unobservable productivity to a potential employer by acquiring an educational degree, which, when specific conditions are met, credibly signals his or her quality. We assume that, in

---

[3] In the late 1970s, there was a discussion on how educational degrees of employees vs. the self-employed could be used to test the educational screening hypothesis (cf. Wolpin, 1977; Lazear, 1977, or more recently, Lofstrom, 2000). Wolpin argues that the self-employed should have lower levels of education if schooling is merely a screen. Lazear, on the other hand, argues that customers may use the credentials of the self-employed as a signal in assessing product quality. Unfortunately, this point was never picked up in entrepreneurship research. Signaling is sometimes mentioned, but none of the studies analyze in detail the impact of entrepreneurial signaling (Nooteboom, 1993; Brüderl, Preisendörfer, and Ziegler, 1996; Ripsas, 1997; Hinz, 1998; Leitinger and Strohbach, 2001).

principle, not only employees but also entrepreneurs signal their quality by their educational history. The start-up founder signals unobservable entrepreneurial quality to a bank and to potential employees by means of his or her educational biography, especially with respect to certain specific characteristics therein. Spence (1973) discusses two criteria that must be met for an educational degree to be a signal for the quality of an employee. First, the degree must be closely related to the type of productive capability employers are looking for in filling a particular job vacancy. Second, the cost to the employee of obtaining the degree must be negatively correlated with the individual's productivity. More precisely, the cost to the low-quality employee must be higher than the wage premium a future employer will pay. Therefore, the low-quality employee will not invest in a degree because the cost is higher than his or her future returns. Correspondingly, the cost to the high-quality employee must be lower than the wage premium, so he or she will invest in the degree because the cost of obtaining it is lower than his or her future wage premium. If the conditions of 1) productive capability, and 2) negative cost correlation both hold true, employers will pay the premium for the signal (degree)
because it guarantees a separating equilibrium. Following Spence's discussion, our study provides theoretical and empirical indications that particular aspects of innovative founders' educational histories meet the two conditions.

First, we analyze what kind of skill makes a founder more likely to be successful on innovative markets. As shown in a number of empirical studies innovative markets are characterized by rapid technological change, short product life cycles, and rather volatile

market conditions (Picot, Laub, and Schneider, 1989; Egeln, Licht, and Steil, 1997; McDermott and O'Connor, 2002). Founders who want to survive in such an environment must be able to work continuously and rapidly through a large amount of new market information, quickly and efficiently filter out what is important, and flexibly derive new solutions. Given this environment, a founder needs analytical and problem-solving skills, self-direction, and endurance (Lück and Böhmer, 1994; Konegen-Grenier and Mirna Kalka, 1994). Narrow occupational skills are quickly worthless in dynamic environments such as one finds in innovative start-ups. Further, the more innovative a product, business process, or market, the shorter the half-life of specific occupational skills (Heinzel, 1997). However, the ability to reason, analyze, communicate, and cross-check information is of enduring value, even for the most innovative founders. When we asked founders about the usefulness for their start-ups of a variety of skills acquired through their university education, the data they provided confirmed these findings[4]. Innovative founders find general analytical and problem-solving skills more helpful than traditional founders do. Conversely, traditional founders consider more specialized occupational skills, such as product knowledge, marketing skills, and finance tools to be more helpful (see Table 1)[5].

Table 1 around here

---

[4] For more information on our survey see the section on “Data, Measurement Issues, and Methodology.”

[5] Furthermore, Lazear (2002) shows that entrepreneurs in general need a broad set of skills to be successful.

Second, if general analytical and problem-solving skills are the most important skill requirements for a successful innovative founder, we have to analyze the kind of educational characteristics or history that guarantees these skills. We argue that general analytical and problem-solving skills are, in principle, those required for university study and are indispensable for obtaining a university degree. Furthermore, it is reasonable to assume that the more problem-solving and analytical skills a person possesses, the faster they finish their studies. Since in Germany the students have high discretion to spread out or shorten their time of studies, one can use the time they take to finish a university degree[6] as a more precise signal of the underlying capabilities of the individual than obtaining the degree itself[7]. Length of study should thus be given priority as a signal of quality, if the information is available. A number of studies support these assumptions. Berning (1982) analyzes whether certain work and study techniques of law students determine the time they take to complete their studies. He finds that slow students are less concentrated and able to work without interruption, suffer more often from self-motivation problems, and are less able to identify obstacles and find solutions to overcome them. Differences in length of study, then, are the result of systematic

---

[6] Consistent with this assumption are a number of empirical results showing a positive relation between a university education and the credit founders obtain. Brüderl, Preisendörfer, and Ziegler (1996) present some empirical evidence that higher education has a positive impact on the initial amount of capital raised by its founders. And Bates (1990) and Storey (1996) find a direct relationship between higher educational levels and the size of the bank credit a founder is able to obtain.

[7] Jaeger and Page (1996), for example, show that signaling research based on years of schooling (i.e., without considering that many individuals did not even complete their degrees) is biased, which also shows that only the combination of a degree and the time of studies is a reliable indicator for productivity.

productivity differences.[8] Furthermore, Schaeper and Minks (1997) show not only a correlation between better grades and shorter length of study but also that extracurricular activities do not slow down good students.[9] Thus, it is reasonable to assume that, in Germany, for innovative entrepreneurs studying faster is a credible sign of being more productive. Also, acquiring a university degree within a given time meets Spence's second criterion (1973), i.e., the cost of obtaining a degree is higher for a person with fewer or lower level analytical and problem-solving skills, less endurance, and less ability for self-directed work. Empirical evidence for this negative relationship can be seen in the substantial failure rate at German universities, which in 2002 averaged about 25 percent across all fields and universities (IWD, 2002). In addition, there was a high variance in length of study within any given field. In management and economics, for example, the standard length of study in Germany, according to official study guidelines, is 4-1/2 years, but the average length of study is about 5-1/2 years. Only 14.5 percent manage to finish their studies within the standard time (Wissenschaftsrat, 2002). If we take a closer look at just one university, the variation in

---

[8] Similar results and conclusions are presented by Teichler, Buttgereit, and Holtkamp, 1984.

[9] Bankhofer and Hilbert (1995), who study the recruitment process of companies, found that 74 percent of the firms considered grades, and 69 percent considered length of study to be (very) important for hiring decisions. These results are consistent with a number of empirical studies on labor market entrants' wages. Schaeper and Minks (1997) analyze the wages of 11,300 labor market entrants with university degrees and find that students who study faster than average earn an additional 200 DM/month (approximately $100). In addition, Minks (1997) shows that students studying slower than average have higher unemployment spells after finishing their studies and are more often forced to accept less favorable jobs (like temporary work and freelance activities).

results is even more instructive (cf. Table 2). In 2001, the average length of study in management and economics at the University of Cologne was approximately 6-1/2 years (13 semesters). However, approximately 3 percent of the students were able to finish in fewer than 9 semesters, while 10 percent needed more than 16 semesters. Furthermore, the faster students (with lower than average length of study) are also the better ones (with better grades), which indicates that both grades and length of study can be used as reliable quality indicators.

Table 2 around here

Low-quality students, then, will obtain a degree only if they study longer than average, causing additional costs. Many decide to drop out because the cost of going on is too high in relation to the potential gains of a degree. Others may simply fail too many exams and be forced to drop out. A final group may need longer but still finishes their studies, meeting at least a minimum level of the required skills.[10] Thus, given the empirical evidence, it is reasonable to assume 1) that holding a university degree is a reliable indicator for a minimum level of the required skills, and 2) that a shorter length of study is a reliable indicator for a higher level of the required skills.

There is still another aspect to consider before concluding that a university degree and shorter length of study can function as a quality signal for innovative founders. They can

---

[10] These are the students that will be grouped together in the category “slow students with university degree” in our empirical analysis.

act as signals only if market partners can clearly and reliably observe the possession of a degree and the length of study. Here we must look at educational signals separately for the capital market and the labor market. Empirical studies show that commercial banks use a number of screening devices to evaluate a start-up, among which a detailed business plan is indispensable (Egger and Gronemeier, 1999; Evers, Krüger, and Reifner, 2000). A successful business plan provides detailed information about the educational (and labor market) history of the founder (e.g., a C.V. showing institutions, fields and dates of study, and degrees earned). Therefore, if banks consider a university degree and the length of study to be valuable information, they can easily get the information and use it for a credit decision. Since length of study can be assumed to be a more precise signal than just holding a degree, as argued earlier in this study, we predict that banks' credit decisions will be at least partly contingent upon length of study. Hence, we expect that innovative founders who studied faster for a given degree will have fewer problems acquiring credit than slower students do.

Unlike banks, potential employees usually have only limited information about the educational history of their future employer. In most cases, employees can easily discover whether a founder holds a university degree. In the simplest case, an employee can read the doorplate at the start-up office or search the telephone book. Also, with little or no effort, an employee can find out about an employer's educational background from one of the Chambers of Commerce. However, it is unlikely that an employee will find out the length of study. Therefore, we expect employees to use the existence of a

university degree as a signal for the unobservable quality and the potential success of the innovative founder, but not the length of study (since it is not available).[11]

In addition and in analogy to educational signals, we expect patents to be a credible signal for the unobservable quality of an innovative founder. Similarly, Amit, Glosten, and Muller (1990) and Schulz (1999) argue that prototypes are a valid quality signal for founders because more productive founders will develop prototypes at lower costs than less productive founders. Accordingly, we assume that the cost of acquiring a patent are negatively correlated with productivity. Since patent development is a highly innovative and complex task in itself, we assume that patents strongly reflect innovative capabilities, which in turn means that patents are particularly helpful for evaluating the capability of an innovative start-up founder. Since patents are readily observable by banks by means of the business plan, but not particularly by employees, we expect patents to function as a signal for banks.

To summarize our theoretical analysis, we assume that innovative founders are faced with problems of severe information asymmetries in the credit and the labor market. This

---

[11] Note that for a signaling equilibrium to exist it is not necessary that an innovative founder be aware that he is acquiring a signal when attending college (as argued in the traditional signaling model for employees). All a potential founder has to know is that by obtaining more education he or she will increase future profits. Nor do employees have to know anything about signaling. All that is necessary is that employees who are faced with the decision to accept a job in an innovative start-up believe that holding a university degree makes an innovative founder a more successful founder with better prospects for future work.

must be overcome for an innovative start-up to be successful. Since no business history, benchmark, or reputation exists, banks and employees alike will look for credible signals for the unobservable quality of the venture. Analogous with the original labor market signaling model (Spence, 1973), we argue that banks and employees will use the educational history of the founder as a signal for entrepreneurial quality. Since innovative start-ups mainly require general abilities such as analytical and problem-solving skills, endurance, and/or the ability for self-directed work (rather than typical occupational skills such as craft skills or knowledge of standard production processes), we predict that a university degree — regardless of field — will be an important entrepreneurial signal for potential employees. Likewise, creditors will use a university degree and particularly the length of study as a signal to decide whether to invest in an innovative start-up or not. Therefore, innovative founders with a university degree and a short length of study are expected to have less problems to acquire a sufficient amount of credits. For *non*-innovative start-ups, the asymmetric information and the skills required to run a start-up successfully are systematically different. So we do *not* expect the same signals to function for non-innovative start-ups. Hence, we should observe the following empirical patterns**,** which we will test in the next section.

A. Labor market shortages

1. Innovative founders with a university degree have fewer problems recruiting qualified employees than innovative founders without a university degree.
2. A university degree does *not* make a difference for the recruitment of *non*-innovative start-ups.

B. Credit market constraints

3. In the credit market, innovative founders with a shorter length of study have fewer problems obtaining the credit they need.

4. A shorter length of study makes no difference in the credit problems of non-innovative entrepreneurs.

5. Innovative founders holding a patent have fewer problems obtaining credits than innovative founders without patents.

Data, Measurement Issues, and Methodology

To test the implications on entrepreneurial signaling, we reuse a dataset of 790 start-ups in the Cologne area. The data were collected in 1998/99 in a project on regional determinants and effects of entrepreneurship and cover a representative sample of start-ups from 1992 to 1997.[12] Almost two thirds of the start-ups are from the service industry (62 percent); a quarter is in retailing, and 13 percent is in manufacturing. Eighty-seven percent of the firms are true start-ups; however, only 18 percent are innovative start-ups, and the rest are traditional start-ups. Average turnover in the first year was 728,000 Euros. The founders were predominantly male (79 percent), 36 years old on average, and often highly qualified (44 percent held a university degree and 7 percent a doctoral degree). For each start-up, we have a 6-page questionnaire with a broad spectrum of

[12] The data were collected with financial support of the German National Science Foundation (DFG) under project number STE 628/5-1, the German Founder Bank (Deutsche Ausgleichsbank, DtA) and the Cologne Savings Bank. We thank Petra Moog and Güldem Demirer for introducing us into their dataset.

questions on the founder and his or her personal background, the economic background of the start-up, it's financial situation, human resources issues, production technology, networks, and social capital. We have a broad set of variables that can be used to test our hypotheses, including the educational (and labor market) history of the founder, the sources and difficulties of getting start-up capital, and the problem of labor shortage (for more details on the Cologne Founder Study, see Backes-Gellner, Demirer, and Moog, 2000).

Dependent Variables

First, we must specify the two dependent variables, one to measure a founder's problems on the labor market and one to measure problems on the credit market. Unfortunately, we do not have hard facts on labor shortage. However, we do have a variable specifying what percentage of employees must be classified as overloaded with work in general. We assume that work overload among employees is highly correlated with job vacancies and recruiting problems because incumbent incumbent employees must take over the workload of vacant positions. Thus, the percentage of employees that is classified as overloaded with work can be used as an indicator for recruitment problems.

For credit market problems, we chose a similar solution. We do not have hard facts on credit conditions, such as interest rates, collateral, or maturity of loans, but we do have a more implicit indicator that should reflect all these aspects simultaneously. Respondents were asked whether they found it problematic to obtain the credit they initially needed for their start-up. They had to answer on a 5-point scale from 1 = very problematic to 5 = not

at all problematic. We assume that the more unfavorable the hard facts, the poorer the subjective evaluation because less favourable credit conditions make it more difficult for a founder to obtain a certain amount of money. Binks and Ennew (1996) similarly argue that a subjective classification is a useful proxy for credit constraints because individual difficulties in obtaining credit correspond with unfavorable credit conditions. Furthermore, one can argue that a subjective indicator has the advantage of capturing various kinds of constraints in one indicator. Egeln, Licht, and Steil (1997) show that there is a strong correlation between a firm's self-classification of credit problems and the (objective) classification made by Creditreform, Germany's largest credit-rating agency.

Independent Variables

In accordance with our theoretical considerations, we need three major *explanatory* variables, namely university degree, length of study, and patents. The first variable is operationalized as follows. Based on a question on the personal educational history of the founder, we built three educational degree levels that are relevant to our hypotheses. First, we have founders who hold a doctoral degree as their highest university degree. Second, we have founders who hold a standard university degree, such as a Diploma or Magister Artium. And third, we have founders who never received a university degree, including those who never started higher education and those who are dropouts. Our dummy variables are DD for doctoral degree and UD for university degree (the reference group consists of the founders with no university degree). Our second independent variable, the length of study, is not easy to measure, given the German university system with all its discretion and heterogeneity. Respondents were asked how many years it took them to finish their degree, which gives us numbers for

length of study. However, we cannot compare these numbers across different types of universities. For example, finishing a degree in a typical research university in six years might be fast, whereas finishing a degree in six years in a university of applied sciences might be slow in comparison to what is standard within that particular type of university. Therefore, we use a standard number of years per type of university as a benchmark to evaluate the individual length of study. Since official study guidelines rarely coincide with reality, we decided not to use the standard years given in study guidelines. Instead, we use the average number of years that students actually take to finish their degrees in a given university type. However, because of data restrictions, we are only able to clearly distinguish different university types for the Cologne student population (which is 81.3 percent of the sample), but not for students studying at universities outside Cologne. Therefore, we selected only Cologne students and built two groups of students: Cologne students studying faster than average (FASTUD) and Cologne students studying slower than average (SLOWUD).Our reference group are founders without a university degree. Our third independent variable, patents, is a dummy variable. PATENT = 1 if a founder holds a patent, and zero if he or she does not hold a patent.

Finally, we must separate innovative from non-innovative start-ups. This is daunting, given the difficulty of clearly defining “innovativeness” and additional data restrictions (Acs and Gifford, 1996). In general, a variety of indicators can be and are used to measure a firm’s innovative activity. These are R&D expenditure of a company, number of patents a company holds, average R&D-intensity in an industry, or various subjective measures of innovation (cf. Acs and Audretsch, 1990; Brüderl, Preisendörfer, and

Ziegler, 1996; Nerlinger, 1998). In our dataset, we have information on patents, R&D expenditures on a firm and industry level, venture capital backing, and collaboration with external research facilities. Table 3, which shows how these different measures are interrelated, is used to identify a reliable indicator to separate innovative from non-innovative start-ups.[13]

Table 3 around here

Comparing the correlation between our five innovation measures, we see that they are all positively correlated. If we further look at the level of significance, we see that only the number of patents and R&D intensity on an industry level are closely interrelated to all other indicators. On a firm level, collaboration with external research facilities, venture capital backing, and R&D expenditure perform slightly worse, in the sense that they correlate with a smaller number of indicators. Therefore, to grasp most of the information with one indicator (and thus avoid too many missing values) we should use either number of patents or R&D intensity on an industry level. Since number of patents is available for only a very small number of firms in our dataset, we decided to use R&D intensity on an industry level to distinguish innovative from non-innovative founders in order to keep missing values low. R&D intensity correlates significantly with all other innovation indicators and is available for all start-ups in the sample (a similar classification is used by Nerlinger, 1998 and Almus and Nerlinger, 1999).

---

[13] The magnitude of the correlations is similar to that in Brüderl, Preisendörfer, and Ziegler (1996), who introduced this method to identify the best indicator for a start-up's success.

On top of the variables that result from our theoretical considerations, we use a number of standard control variables, which are specified in Table 4.

Table 4 around here

Methodology

Since our dependent variable percentage of overloaded workers is left censored at zero and right censored at 1, we use a Tobit model to test our labor market implications. To test our credit market implications, we use an ordered probit model, because the dependent variable “credit problems” is ordinal, which makes OLS regression inappropriate.

Empirical Results

A. Labor market signaling of innovative entrepreneurs

First, we estimate the effects of entrepreneurial signals on recruiting problems of innovative start-ups. Table 5 displays the results of Tobit estimations with percentage of overloaded workers as dependent variable.

Table 5 around here

In a first model, we use a specification that includes only the vector of control variables that was described in Table 4 and the dummy variable for innovative vs. non-innovative founders. In a second model, we use the two university education dummies and patents

as additional variables. And in a third model, we also include interactions between doctoral degree and innovative start-up; university degree and innovative start-up; and patent and innovative start-up. With the interaction term, we allow the educational signals to differ for innovative and non-innovative start-ups because, in accordance with our theoretical considerations, we expect entrepreneurial signaling with educational degrees to be important for innovative founders only. If we look at the estimation results, we find that all our hypotheses on entrepreneurial signaling on the labor market are borne out in the data.

First, we find that the goodness of fit increases from model 1 to model 2, indicating that university degrees and patents indeed matter for the recruiting problems of start-ups. However, in the two models where innovative and non-innovative founders are not separated, DD, UD, and PATENT have no significant effect on the percentage of overloaded workers. So if we do not distinguish between innovative and non-innovative founders, educational degrees obviously do not have a significant effect on recruiting problems. This changes once we look at model 3, where we added the interaction terms. The goodness of fit increases again, indicating that the interactions are important. The coefficient UD*INNOVSU represents the effect of a university degree for innovative start-ups only. The coefficient is negative and highly significant, meaning that innovative founders with a university degree have significantly lower percentages of overloaded workers than innovative founders without a university degree. This is consistent with hypothesis 1. At the same time, UD by itself is not significant, which is consistent with hypothesis 2. University degrees function as entrepreneurial signals on the labor market,

but only for innovative start-ups. As expected in hypothesis 5, patents do not have an impact on the labor market. Somewhat surprisingly, doctoral degrees have no significant effect independent of the model we use. This might be due to a small number of cases and great heterogeneity or because most of the hidden information is already captured by the first university degree. As to our control variables, we find that faster growing start-ups (FASTGR) and growth-targeted start-ups (with plans for future investments, GROSU) - all else being equal - have significantly more problems recruiting the required number of qualified employees, which is consisten with previous empirical evidence on labor shortages of start-ups. All other control variables also bear no surprises.[14]

B. Credit market signaling of innovative entrepreneurs

To test our credit market hypotheses, we use ordered probit estimations with a subjective measure for credit problems as the dependent variable. The lower the indicator, the more problems the founder experienced; the higher the indicator, the easier it was to obtain the required credit. Table 6 displays the results for four different models.

Table 6 around here

---

[14] Furthermore, we control for take-over start-ups (TAKEOSU) because we expect these firms to experience less trouble attracting new labor because of their reputation. The negative sign of the coefficient backs the assumption of reputational effects.

In the first model, we start again with a specification including the vector of control variables only; and in the second model, we add our first set of explanatory variables, i.e., the university degree dummies and the interaction terms with innovative start-ups. In the third model, we add length of study and the respective interaction term (but only for innovative founders) to see whether banks indeed use the more precise signal for their credit decisions (cf. hypotheses 3 and 4). In the fourth model, we add patents and the respective interaction term to test hypothesis 5. Overall, we find that our hypotheses on entrepreneurial signaling in the credit market are borne out.

If we compare models 1 and 2 with model 3, we see, as expected, that banks use the more precise indicator—length of study—as opposed to the pure existence of a university degree. None of the university degree variables or the respective interaction terms is significant in model 2. Adding the length of studies and the respective interaction terms in model 3 increases the goodness of fit substantially. FASTUD and SLOWUD alone have no significant effect on our subjective credit problem indicator, indicating that the length of study makes no difference in the credit problems of non-innovative founders which is consistent with hypothesis 4. But as we expected in hypothesis 3, FASTUD*INNOVSU is significantly positive. So for innovative founders, studying faster than average makes it easier to obtain credits, but not for non-innovative founders. This supports our hypothesis that for traditional start-ups, banks can build on their experience and use traditional benchmarks to evaluate the quality of a business plan, so they do not need educational signals to evaluate an unobservable quality. However, for innovative start-ups, banks cannot build on experience and prior

information or reputation, so they must use educational signals. In doing so, they prefer more precise signals, i.e., length of study, rather than less precise signals, i.e., the university degree itself. In model 4, we also add patents and the respective interaction term (PATENT*INNOVSU) and find again that patents are used as signals, but only for innovative founders. If an innovative founder holds a patent, it is significantly easier for them to obtain credit. Furthermore, being among the faster students makes it still easier. So banks obviously use multiple signals for their credit decisions if available; however, they do not take just any element of the educational history as a credible signal. Instead, they carefully select the most precise indicators that are available. These results are consistent with our entrepreneurial signaling explanation. Faced with severe asymmetric information for innovative founders, banks use signals to evaluate the quality of the founder and decide on his or her credit conditions.

Furthermore, we find that innovative founders experience more problems obtaining credit than non-innovative founders because of higher capital requirements for innovative start-ups. Higher equity rates (EQR) make it easier to obtain credit (with diminishing effects (EQR(SQR)) because a higher rate of private equity indicates a higher personal commitment of the founder and reduces the bank's risk, consistent with literature on optimal financial structure (e.g., Harris and Raviv, 1991; Böhm, 1999; Huyghebaert and Van de Gucht, 2002). Also, job experience (JOBEXP) and previous founding experience (FOUNDEXP), both typically included in the business plan and therefore easily observable by banks, also reduce problems significantly. The reduction of problems is most likely the result of a combination of human capital and signaling

effects. The more job experience a founder has, the more productive they will be in handling all kinds of business affairs, increasing the likelihood that a business will be run successfully. In addition, if a founder has already started another business in the past, he or she has gathered a lot of start-up–related knowledge. Therefore, they are of course more productive when starting another new business. The rest of the control variables, again, bear no surprises.

Conclusion

This paper studies the role of entrepreneurial signaling in the credit and labor markets of innovative start-ups. For innovative start-ups, compared to traditional start-ups, there is no prior history on similar production or business processes; their *ex ante* default risk is higher than for traditional enterprises; and there is no reputation due to company history or prior ties. As a result, innovative start-ups, and their respective market partners are faced with severe asymmetric information problems. We focus on whether and what kind of entrepreneurial signaling can help solve or substantially reduce these information problems and thereby increase the potential success of innovative start-ups. We concentrate our analysis on credit and labor market problems because it has been shown that they are crucial for the success of start-ups. As in the standard labor market-signaling model developed by Spence (1973), we focus on educational signals and assume that not only employees but also entrepreneurs credibly signal their quality with certain characteristics of their educational history. However, as Spence shows, educational characteristics must meet certain conditions to become a valid and credible signal. Therefore, we first analyze what kinds of capabilities are particularly required to

run an innovative start-up and what kind of educational career requires these same capabilities (first condition). In a second step, we study what aspect of an educational career guarantees a sufficiently negative correlation between the cost of acquiring the signal and the quality of the innovative founder so as to guarantee a separating equilibrium (second condition). Finally, we analyze what kind of information is available to which market partner (at what cost). We conclude that potential employees will use a university degree as a quality signal if they have to decide whether to accept a job at an innovative start-up, and banks will use a more precise indicator, namely the length of study, as a credible signal when deciding upon credit for an innovative founder. Additionally, banks will use the patents a founder holds as a signal for the quality of his or her innovative start-up. Furthermore, since asymmetric information and skill requirements are different for traditional start-ups, we do not expect employees or banks to use the same signals when deciding upon a job or credit in a traditional start-up. We test these assertions using a dataset of more than 700 start-ups in and around Cologne collected in 1998/99. Consistent with what we expected, we find that innovative—and only innovative—founders holding a university degree have a lower percentage of overloaded workers, indicating that they have fewer problems attracting enough qualified employees. Also consistent with our assertions, we find that innovative—and only innovative—founders experience fewer problems obtaining the credit they initially need to start their venture if they finished their university degree in less than a standard number of years. Furthermore, if an innovative founder holds a patent, it also makes it easier for them to obtain credit. Since holding a patent does not reduce credit problems for traditional start-ups, we presume that in our case patents are not a matter of property

rights and market protection, but more a signal for the founder's overall entrepreneurial capabilities, particularly in an innovative environment.

To conclude, we show that entrepreneurial signaling is obviously a powerful instrument in overcoming typical problems of asymmetric information for innovative start-ups, which has so far hardly been studied. The dearth of studies is mostly due to a lack of adequate data. We present a unique database covering not only a wide variety of variables on the newly founded enterprises but also on the founder and his or her educational, labor market, and personal history. The database allows us for the first time to study empirically the effects of entrepreneurial signaling. One of our main results is that a university degree and length of study are important signals, particularly for innovative founders. Therefore, contrary to what popular discussion might suggest, finishing an education with a degree is necessary especially for innovative founders. During the boom years of the new market, many students in Germany (and elsewhere) considered it a waste of time to finish their studies and work for a degree. New innovative businesses did not seem to require or honor traditional education, and students dropped out en masse, many of them with the aim of becoming one of the new stars on the glamorous innovative start-up-horizon. However, our empirical results indicate that traditional educational patterns and values, such as finishing an education and meeting a time target, are even more important for innovative markets than for traditional markets, where other credible quality indicators might be available.

References

Acs, Z. J. and D. B. Audretsch, 1990, *Innovation and Small Firms*, Cambridge: MIT Press.

Acs, Z. J. and S. Gifford, 1996, 'Innovation of Entrepreneurial Firms', *Small Business Economics,* 8, 203-218.

Albach, H., D. Hunsdiek and L. Kokalj, 1986, *Finanzierung mit Risikokapital,* Stuttgart: Poeschel.

Almus, M. and E. A. Nerlinger, 1999, 'Growth of new Technology-Based Firms: Which Factors Matter?' *Small Business Economics,* 13, 141-154.

Amit, R., Glosten, L. and E. Muller, 1990, 'Does Venture Capital Foster the most Promising Firms?' *California Management Review*, 32, 102-111.

Astebro, T., I. Bernhardt, 2003, 'The Winner's Curse of Human Capital'. Forthcoming *Small Business Economics,* SSRN Working Paper No. 383002, March 2003.

Audretsch, D. B., 2000, Entrepreneurship in Germany, in D. L. Sexton and H. Landstrom, H. (eds.), *The Blackwell Handbook of Entrepreneurship*. Oxford, UK: Blackwell Publishing, 107-127.

Audretsch, D. B., 1995, *Innovation and Industry Evolution*, Cambridge: MIT Press.

Backes-Gellner, U., G. Demirer and P. Moog, 2000, 'Hochschulinduzierte Gründungen im Kontext der Gründungsforschung: Grenzen und Lösungsmöglichkeiten einer empirischen Analyse', in D. Bögenhold (eds.), *Kleine und Mittlere Unternehmen im Strukturwandel,* Frankfurt am Main: Peter Lang Verlag, 123-140.

Backes-Gellner, U., W. Freund, R. Kay and P. Kranzusch, 2000, *Wettbewerbsfaktor Fachkräfte - Rekrutierungschancen und -probleme von kleinen und mittleren Unternehmen*, Wiesbaden: Dt. Univ.-Verl.

Backes-Gellner, U. and C. Schmidtke, 2002, 'Inter-Firm Differences in Job Vacancy Rates and Employer Signaling', Working Paper, University of Cologne.

Bates, T., 1990, 'Entrepreneur Human Capital Inputs and Small Business Longevity', *Review of Economics and Statistics,* 72, 551-559.

Belfield, C. R., 1999, 'The Behaviour of Graduates in the SME Labour Market: Evidence and Perceptions', *Small Business Economics,* 12, 249-259.

Bester, H. (1985), 'Screening vs. Rationing Credit Markets', *The American Economic Review,* 75, 850-855.

Binks, M. R. and C. T. Ennew, 1996, 'Growing Firms and the Credit Constraint', *Small Business Economics,* 8, 17-25.

Birch, D. L., 1979, *The Job Generation Process*, Cambridge: M.I.T. Program on Neighbourhood and Regional Change.

Black, J., D. De Meza and D. Jeffreys, 1992, House Prices, the Supply of Collateral and the Enterprise Economy, Discussion Paper in Economics Nr. 92/08, University of Exeter.

Blanchflower, D. G. and A. J. Oswald, 1998, 'What makes an Entrepreneur?' *Journal of Labor Economics*, 16, 26-60.

BMWi, 2001, 'Das Einmaleins der Gründungsförderung - Die Basisprogramme für Existenzgründer und junge Unternehmen', *GründerZeiten* Nr. 7/8.

Böhm, A., 1999, *Geschäftsbeziehung zwischen Bank und Gründer*, Köln, Josef Eul Verlag.

Brüderl, J., P. Preisendörfer and R. Ziegler, 1996, '*Der Erfolg neugegründeter Unternehmen - Eine empirische Studie zu den Chancen und Risiken von Unternehmensgründungen*', Berlin: Duncker & Humblot.

Brüderl, J., P. Preisendörfer and R. Ziegler, 1998, Fast Growing Businesses – Empirical Evidence from a German Study, Working Paper, University of Mannheim.

Casson, M. C., 1982, *The Entrepreneur - An Economic Theory*, Oxford, UK: Martin Robertson and Co. Ltd.

Chittenden, F., G. Hall and P. Hutchinson, 1996, 'Small Firm Growth, Access to Capital Markets and Financial Structure: Review of Issues and Empirical Investigation', *Small Business Economics*, 8, 59-67.

Cressy, R., 1996a, 'Are Business Startups Debt-Rationed?', *The Economic Journal,* 106, 1253-1270.

Cressy, R., 1996b, 'Commitment Lending under Asymmetric Information: Theory and Tests on U.K. Startup Data', *Small Business Economics*, 8, 397-408.

Dejardin, M., 2002, 'Firm Demography, Innovation, and Regional Growth', Working Paper, University of Namur, Belgium.

Diamond, D. W., 1989, 'Reputation Acquisition in Debt Markets', *Journal of Political Economy*, 97, 828-862.

Dunn, T. and D. Holtz-Eakin, 2000, 'Financial Capital, Human Capital and the Transition to Self-Employment: Evidence from Intergenerational Links', *Journal of Labor Economics,* 18, 287-305.

Egeln, J., G. Licht and F. Steil, 1997, 'Firm Foundations and the Role of Financial Constraints', *Small Business Economics*, 9, 137-150.

Egger, U. P and P. Gronemeier, 1999, *Existenzgründung*, Wiesbaden: Gabler Verlag.

Evans, D. S. and B. Jovanovic, 1989, ‘An Estimated Model of Entrepreneurship Choice under Liquidity Constrains‘, *Journal of Political Economy*, 97, 808-828.

Evans, D. S. and L. S. Leighton, 1989, ‘Some Empirical Aspects of Entrepreneurship‘, *American Economic Review*, 79, 519-535.

Evers, J., U. Krüger and U. Reifner, 2000, *Beratungsqualität in Finanzdienstleistungen*, Baden-Baden: Nomos Verlag.

Falk, M., 1999, ‘Technological Innovations and the Expected Demand for Skilled Labour at the Firm Level‘, Discussion Paper No. 99-59, Centre of European Economic Research.

Harris, M. and A. Raviv, 1991, ‘The Theory of Capital Structure‘, *Journal of Finance*, 46, 297-355.

Heinzel, M., 1997, *Anforderungen deutscher Unternehmen an betriebswirtschaftliche Hochschulabsolventen: Zur Marktorientierung von Hochschulen.* Wiesbaden: Dt. Univ.-Verl.

Hinz, T., 1998, *Betriebsgründungen in Ostdeutschland*. Berlin: Sigma.

Hunsdiek, D. and E. May-Strobl, 1986, *Entwicklungslinien und -risiken neugegründeter Unternehmen*, Stuttgart: Poeschel.

Huyghebaert, N. and L. M. Van de Gucht, 2002, ‘The Determinants of Financial Structure: New Insights from Business Start-ups‘. Working Paper. Katholieke Universiteit Leuven, Belgium.

Informationsdienst des Instituts der deutschen Wirtschaft (IWD), 2002, ‘Studienabbrecher- Die Puste ausgegangen‘, IWD, 49, 2.

Jaeger, D. A. and M. E. Page, 1996, ‘Degrees Matter: New Evidence on Sheepskin Effects in the Returns to Education‘. *The Review of Economics and Statistics*, 78, 733-739.

Keuschnigg, C. and S. B. Nielsen, 2000, ‘Tax Policy, Venture Capital and Entrepreneurship‘, NBER Working Paper Series 7976, Cambridge, MA.

Kirchhoff, B. A., 1995, *Entrepreneurship and Dynamic Capitalism - The Economics of Business Firm Foundation and Growth*, Westport, CT: Praeger Publishing Co.

Konegen-Grenier, C. and A. Mirna Kalka, 1994, ‘Wege zur Vermittlung von Schlüsselqualifikationen, Ergebnisse der Diskussion‘, in C. Konegen-Grenierand W. Schlaffke (eds.), *Praxisbezug und soziale Kompetenz: Hochschule und Wirtschaft im Dialog*. Köln: Institut der Deutschen Wirtschaft, 109-116.

Laub, U., 1989, *Zur Bewertung innovativer Unternehmensgründungen im institutionellen Zusammenhang – Eine empirisch gestützte Analyse*‘, München: VVW.

Lazear, E. P., 1977, ‘Academic Achievement and Job Performance: Note‘, *American Economic Review*, 67, 252-254.

Lazear, E.P., 2002, ‘Entrepreneurship‘, NBER Working Paper 9109, Cambridge, Ma.

Leitinger, R. and H. Strohbach, 2001, ‘Informationsasymmetrien bei der Finanzierung von KMUs und deren Lösungsmöglichkeiten‘, in H. Klandt, K. Nathusius, J. Mugler and H. Heil. (eds.), *Gründungsforschungsforum – Dokumentation des 4. G-Forums*, Köln: Josef Eul Verlag, 335-359.

Lofstrom, M., 2000, ‘A Comparison of the Human Capital and Signaling Models: The Case of the Self-Employed and the Increase in the Schooling Premium in the 1980´s‘, Discussion Paper 160, Institute for the Study of Labor, Bonn.

Lucas, R. E., 1978, ‘On the Size Distribution of Business Firms‘, *Bell Journal of Economics*, 9, 508-523.

Lück, W. and A. Böhmer, 1994, ‘Entrepreneurship als wissenschaftliche Disziplin in den USA‘, *Zeitschrift für betriebswirtschaftliche Forschung*, 46, 403-421.

McDermott, C. M. and G. C. O’Connor, 2002, ‘Managing Radical Innovation: An Overview of Emergent Strategy Issues‘, *Journal of Product Innovation Management*, 19, 424-438.

Milde, H. and J. G. Riley, 1988, ‘Signalling in Credit Markets‘, *Quarterly Journal of Eonomics*, 102.

Nathusius, K., 2001, ‘Zur Theorie der Gründungsfinanzierung‘, in K. Nathusius, H. Klandt and D. Seibt (eds.), *Beiträge zur Unternehmensgründung*, Köln 2001: Josef Eul Verlag, 1-153.

Nerlinger, E., 1998, *Standorte und Entwicklung junger innovativer Unternehmen*: *Empirische Ergebnisse für West-Deutschland*, Baden-Baden: Nomos Verlag.

Nooteboom, B., 1993, ‘Firm Size Effects on Transaction Costs‘, *Small Business Economics,* 5, 283-295.

Oppenländer, K. H., 1998, ‘Problems in Assisting New Businesses Start-Ups in Germany‘, in K. H. Oppenländer (eds.), *The Limits of Government - On Policy Competence and Economic Growth, Papers from the Sixth Conference of the International Schumpeter Society*, Stockholm, 253-269.

Picot, A., U.-D. Laub and D. Schneider, 1989, ‘*Innovative Unternehmensgründung: Eine ökonomisch-empirische Analyse*‘, Berlin: Springer Verlag.

Ravid, S. and M. Spiegel, 1997, ‘Optimal Financing Contracts for a Start-up with Unlimited Operating Discretion‘, *Journal of Financial and Quantitative Analysis,* 32, 269-286.

Reynolds, P. D., 1997, ‘New and Small Firms in Expanding Markets‘, *Small Business Economics,* 9, 74-84.

Riley, J. G., 2001, ‘Silver Signals: Twenty-Five Years of Screening and Signaling‘, *Journal of Economic Literature*, 39, 432-478.

Ripsas, S., 1997, *Entrepreneurship als ökonomischer Prozess - Perspektiven zur Förderung unternehmerischen Handelns*, Wiesbaden: Dt. Univ.-Verl.

Schaeper, H. and K. H. Minks, 1997, *Studiendauer - eine empirische Analyse ihrer Determinanten und Auswirkungen auf den Berufseintritt*, Hannover: HIS Kurzinformation.

Schulz, E., 1999, *Die Finanzierung von Existenzgründungen - Eine informationsökonomische Analyse*, Frankfurt am Main: Peter Lang Verlag.

Spence, M., 1973, 'Job Market Signaling', *Quarterly Journal of Economics*, 87, 355-374.

Spremann, K., 1990, *Investition und Finanzierung*, München: Oldenbourg.

Stiglitz, J. and A. Weiss, A., 1981, 'Credit Rationing in Markets with Imperfect Information'. *American Economic Review,* 71, 393-410.

Stiglitz, J. and A. Weiss, 1983, 'Incentive Effects of Terminations: Applications to the Credit and Labour Markets', *American Economic Review*, 73, 912-927.

Storey, D. J., 1994, 'New Firm Growth and Bank Financing', *Small Business Economics,* 6, 139-150.

Storey, D.J. and B. Tether, 1996, *Review of the Empirical Knowledge and an Assessment of Statistical Data on the Economic Importance of new Technology Based Firms*, Country Report for Great Britain, Coventry.

Teichler, U., M. Buttgereit and R. Holtkamp, 1984, *Hochschulzertifikate in der betrieblichen Einstellungspraxis. Studien zu Bildung und Wissenschaft*, Bad Honnef: Bundesministerium für Bildung und Wissenschaft.

Werner, A., U. Backes-Gellner and G. Kayser G., 2003, 'Zum Einfluss von Bildungssignalen auf innovative Unternehmensgründungen: Eine theoretische und empirische Analyse', in M. Fritsch and M. Niese (eds.), *Gründungsprozess und Gründungserfolg - Interdisziplinäre Beiträge zum Entrepreneurship Research* (forthcoming).

Wippler, I., 1998, *Innovative Unternehmensgründungen in Deutschland und den USA*, Wiesbaden: Gabler Verlag.

Wissenschaftsrat, 2002, Empfehlungen zur Stärkung wirtschaftswissenschaftlicher Forschung an Hochschulen. Saarbrücken, 15. November 2002, Drs. 5455-02.

Wolpin, K. I., 1977, 'Education and Screening', *The American Economic Review,* 67, 949-958.

TABLE I
Usefulness of different kinds of skills and knowledge for start-ups

	Mean value
Were the following skills and subjects you acquired during your university education helpful for your start-up? (1 = not at all helpful; 5 = very helpful)	
analytical and general problem solving skills	
Innovative start-ups	4.21
Traditional start-ups	4.10
product-specific knowledge	
Innovative start-ups	3.73
Traditional start-ups	3.87
knowledge on taxation	
Innovative start-ups	3.28
Traditional start-ups	3.63
marketing-specific knowledge	
Innovative start-ups	2.97
Traditional start-ups	3.50
labor law and labor relations-specific knowledge	
Innovative start-ups	2.77
Traditional start-ups	3.17
finance-tools	
Innovative start-ups	2.89
Traditional start-ups	3.21

[a] Note: Data are from the Cologne Founder Study (CFS).

TABLE II

Length of study and average grades in diplomas in management and economics at the University of Cologne (fall 2001)

length of study	N	percentage	average grade[b]
less than 4.5 years	9	3.3	2.00
4.5 years	12	4.0	2.40
5 years	56	18.6	2.53
5.5 years	25	8.0	2.59
6 years	84	27.6	2.75
6.5 years	18	6.0	2.90
7 years	37	12.3	2.93
7.5 years	7	2.3	2.90
8 years	22	7.3	2.99
more than 8 years	30	10.0	3.14
Average: 6.9 years	Total: 300 Students		Average grade: 2.88

[a] Note: data from Official Exam Report, Faculty of Business, Economics and Social Sciences, University of Cologne (Cologne, 06.05.2002).

[b] lower grade numbers indicate better diplomas (best grade = 1.0; worst grade = 5.0).

TABLE III
Correlation Matrix of Various Innovation Indicators

	Patents	R&D intensity on firm level	Venture capital backing	Collaboration with research facilities	R&D-intensity in industry
Patents		0.097**	0.069*	0.148***	0.094***
R&D investments on firm level			-0.007	0.147**	0.137***
Venture capital				0.012	0.093**
alliances with research facilities					0.097**

[a] Note: Data are from Cologne Founder Study (CFS).
[b] *** Significant on the 1 percent level; ** Significant on the 5 percent level; * Significant on the 10 percent level

TABLE IV
Definitions of variables and descriptive statistics (790 observations)

	Dependent variables	Mean	(Std. Dev.)
LS	Labor shortage: percentage of employees overloaded with work	24.12	(31.01)
CC	Credit constraints: subjective evaluation of problems obtaining initial credits 1 = very problematic, 5 = not problematic at all	2.82	(1.46)
	Independent variables		
	Educational Degrees		
DD	Doctoral Degree: Yes = 1, No = 0	0.073	(0.261)
UD	University Degree (Diploma, Magister Artium and other first degrees as highest educational degree): Yes = 1, No = 0	0.446	(0.497)
	Reference group: Founders without any university degree		
	Length of Study		
FASTUD	Fast University Degree (students with university degree and less than average number of years to finish studies) Yes = 1, No = 0	0.103	(0.304)
SLOWUD	Slow University Degree (students with university degree and more than average number of years to finish studies) Yes = 1, No = 0	0.129	(0.336)
	Reference group: no university degree		
	Patents		
PATENT	Patent held by founder: Yes = 1, No = 0	0.041	(0.199)
	Innovative start-ups		
INNOVSU	Innovative start-up classified by industry (OECD list) Yes = 1, No = 0	0.18	(0.38)
	Control Variables		
EQR	Equity ratio: equity capital to total capital in percent	0.643	(0.402)
DEBTC	Debt capital: total amount (in 100,000€.)	0.575	(2.593)
PROFSU	Profitable start-up (the start-up has made profits in the first year): Yes = 1, No = 0	0.52	(0.50)
LNTURNO	LN Turnover in the first year: total amount in 100.000 €)	7.28	(66.79)
FASTGR	Fast growers (start-up growing faster than average): Yes = 1, No = 0	0.375	(0.485)
GROSU	Growth oriented start-ups (founder is planning to enlarge investments in the near future): Yes = 1, No = 0	0.594	(0.492)
TAKEOSU	Take-over start-up (new firm was started by taking over an existing firm) Yes = 1, No = 0	0.133	(0.349)
JOBEXP	Job experience: Prior job experience in the start-up industry in years	6.61	(7.54)
FOUNDEXP	Founding experience (founder had prior founding experience): Yes = 1, No = 0	0.234	(0.423
HSD	High school degree (founder holds a high-school degree): Yes = 1, No = 0	0.701	(0.459)
PQUAL	Product quality comparative advantage (subjective evaluation of the product quality as being a competitive advantage): Great advantage = 1, Great disadvantage = 5	2.327	(1.011)
PPRICE	Product price competitiveness (subjective evaluation of the product price as being a competitive advantage): Great advantage = 1, Great disadvantage = 5	1.761	(0.893)

SECONDJ	Second Job (founder has an additional second job as an employee): Yes = 1 No = 0	0.178	(0.383)
FAGE	Founders' age in years	36.16	(8.92)
MALE	Male founder: Yes = 1, No = 0	0.791	(0.406)
SUAGE	Start-ups' age in years (Min = 0, Max = 6)	2.65	(1.77)
MARRIED	Married: Yes = 1, No = 0	0.527	(0.499)
CHILD	Children (founder has children): yes = 1, No = 0	0.490	(0.500)
MANUF	Manufacturing: Yes = 1, No = 0	0.127	(0.333)
TRADE	Trade: Yes = 1, No = 0	0.25	(0.434)
SERVICES	Services: Yes = 1, No = 0	0.623	(0.485)
	Reference group: manufacturing		

[a] Note: Data are from Cologne Founder Study (CFS).

TABLE V
Tobit regression results: Entrepreneurial signaling and labor market constraints

	Model 1	Model 2	Model 3
Independent variables:	Coeff. (t-value)	Coeff. (t-value)	Coeff. (t-value)
INNOVSU	9.546 (1.07)	10.449 (1.17)	36.927 (2.71)***
DD[a]		10.976 (0.75)	19.032 (1.25)
UD[a]		-0.122 (-0.01)	11.846 (1.18)
PATENT		17.463 (1.00)	20.711 (1.11)
DD * INNOVSU			-25.224 (-0.58)
UD * INNOVSU			-45.757 (-2.53)**
PATENT * INNOVSU			-11.037 (-0.24)
PROFSU	-3.383 (-0.48)	-3.079 (-0.44)	-1.176 (-0.17)
LNTURNO	2.523 (1.33)	2.533 (1.34)	1.625 (0.87)
FASTGR	14.913 (1.95)*	15.272 (1.97)**	14.510 (1.90)*
GROSU	20.504 (2.64)***	19.071 (2.43)**	15.954 (1.98)**
TAKEOSU	-17.208 (-1.76)*	-16.051 (-1.63)	-12.843 (-1.32)
HSD	12.629 (1.56)	11.772 (1.18)	8.033 (0.80)
FAGE	0.966 (1.53)	0.611 (1.31)	0.592 (1.29)
MALE	7.982 (0.82)	7.663 (0.79)	6.833 (0.72)
SUAGE	4.108 (1.61)	3.784 (1.45)	3.331 (1.30)
CONST	-92.776 (-2.89)***	-90.523 (-2.79)***	-77.625 (-2.42)**
Number of observations	168	168	168
LR-Chi²	30.02***	31.76***	38.53***
R²-Pseudo	0.026	0.0275	0.0334

[a] Note: Data are from Cologne Founder Study (CFS)
[b] Reference group: no college/no university degree
[c] All regressions include dummies indicating economic sectors (manufacturing, trade, services)
[d] *** Significant on the 1 percent level; ** Significant on the 5 percent level; * Significant on the 10 percent level

TABLE VI
Ordered Probit regression results: Entrepreneurial signaling and credit market constraints

	Model 1	Model 2	Model 3	Model 4
Independent variable:	Coef. (z-value)	Coef. (z-value)	Coef. (z-value)	Coef. (z-value)
INNOVSU	-0.501 (-2.12)**	-0.680 (-1.97)**	-0.727 (-2.07)**	-0.710 (-2.03)**
DD[a]		0.257 (0.71)	0.351 (0.96)	0.311 (0.85)
UD[a]		0.134 (0.49)		
FASTUD[a]			0.234 (0.70)	0.199 (0.59)
SLOWUD[a]			0.197 (0.61)	0.130 (0.40)
PATENT				0.601 (1.11)
DD * INNOVSU		0.226 (0.33)	0.269 (0.39)	0.237 (0.34)
UD * INNOVSU		0.334 (0.68)		
FASTUD * INNOVSU			1.529 (2.28)**	1.549 (2.31)**
SLOWUD * INNOVSU			-0.372 (-0.63)	-0.941 (-1.47)
PATENT * INNOVSU				1.792 (1.68)*
EQR	1.549 (1.24)	1.651 (1.31)	2.059 (1.61)	2.134 (1.66)*
EQR(SQR)	-1.543 (-1.41)	-1.599 (-1.45)	-1.889 (-1.69)*	-2.056 (-1.82)*
DEBTC	5.6e-08 (0.37)	4.5e-08 (0.28)	4.3e-08 (0.26)	-2.7e-07 (-1.30)
JOBEXP	0.019 (1.32)	0.023 (1.51)	0.026 (1.71)*	0.031 (1.99)**
FOUNDEXP	0.218 (1.02)	0.257 (1.18)	0.328 (1.49)	0.421 (1.89)*
PQUAL	-0.108 (-1.04)	-0.099 (-0.95)	-0.099 (-0.94)	-0.114 (-1.08)
PPRICE	0.119 (1.37)	0.105 (1.18)	0.117 (1.30)	0.120 (1.31)
TAKEOSU	-0.010 (-0.03)	-0.033 (-0.10)	0.074 (0.23)	0.261 (0.80)
HSD	0.012 (0.06)	-0.118 (-0.46)	-0.227 (-0.87)	-0.085 (-0.32)
SECONDJ	-0.089 (-0.35)	-0.105 (-0.41)	-0.186 (-0.71)	-0.263 (-0.98)
FAGE	0.001 (0.04)	-0.004 (-0.28)	-0.003 (-0.18)	-0.010 (-0.66)
MALE	-0.259 (-0.94)	-0.281 (-1.02)	-0.310 (-1.12)	-0.309 (-1.11)
MARRIED	0.332 (1.52)	0.317 (1.37)	0.317 (1.37)	0.331 (1.43)
CHILD	-0.328 (-1.35)	-0.308 (-1.24)	-0.299 (-1.20)	-0.279 (-1.12)
Number of obs.	170	170	170	170
LR-Chi²	33.11*	34.65*	43.45**	50.40**
R²-Pseudo	0.062	0.065	0.081	0.094

[a] Note: Data are from Cologne Founder Study (CFS)
[b] Reference: no college/no university degree
[c] All regressions include dummies indicating economic sectors (manufacturing, trade, services) and founding year (1992-1997)
[d] *** Significant on the 1 percent level; ** Significant on the 5 percent level; * Significant on the 10 percent level