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David B. Audretsch, Werner Bönte and Prashanth Mahagaonkar

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David B. Audretsch, Max Planck Institute and CEPR
Werner Bönte, Max Planck Institute
Prashanth Mahagaonkar, Max Planck Institute

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Centre for Economic Policy Research
53–56 Gt Sutton St, London EC1V 0DG, UK
Tel: (44 20) 7183 8801, Fax: (44 20) 7183 8820
Email: cepr@cepr.org, Website: www.cepr.org

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ABSTRACT

Financial Signalling by Innovative Nascent Entrepreneurs

Innovative new ventures fail if they cannot attract resources needed to commercialise new ideas and inventions. Obtaining external resources is a central issue for nascent entrepreneurs - people who are in the process of starting new ventures. We argue in this paper that, a way to deal with this problem is to signal appropriability and feasibility of innovation to the financiers through patenting and prototyping activities, right in the early stages of the venture. We build a new dataset of over 900 nascent entrepreneurs with information on financing from conventional sources as well as business angels and venture capitalists. Our results suggest that patenting and prototyping increase the likelihood of obtaining external finance, especially equity. However, the most important determinant of debt is house ownership. This indicates that new start-ups need to protect their innovations and at the same time, should also prototype the intended product in order to obtain start-up finance. New ventures should therefore strategically use their innovativeness in order to obtain external finance.

JEL Classification: G14, G24, G32, L26, M13 and O34
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David B. Audretsch
Max-Planck Institute of Economic Entrepreneurship
Kahlaische Str. 10,
07745 Jena
GERMANY

Email: audretsch@econ.mpg.de

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Werner Bönte
Max-Planck Institute of Economic Entrepreneurship
Kahlaische Str. 10,
07745 Jena
GERMANY

Email: boente@econ.mpg.de

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Prashanth Mahagaonkar
Max-Planck Institute of Economic Entrepreneurship
Kahlaische Str. 10,
07745 Jena
GERMANY

Email: mahagaonkar@econ.mpg.de

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=169496

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Innovative new ventures fail if they cannot attract resources needed to commercialise new ideas and inventions. Obtaining external resources is a central issue for *nascent entrepreneurs* - people who are in the process of starting new ventures. They rarely have sufficient internal resources to finance their startup activities. One important problem is of information asymmetries between nascent entrepreneurs and external financiers. Although the U.S. venture capital industry has grown dramatically in the past thirty years, information asymmetries may still inhibit the commercialization of innovative ideas. In fact as Hsu (2004, p.1805) puts it, "particularly for entrepreneurs without an established reputation, convincing external resource providers such as venture capitalists (VCs) to provide financial capital may be challenging".

Information asymmetries are likely to be a severe problem, especially for innovative new ventures in the *earliest stage* of the startup process. Innovative nascent entrepreneurs developing their business concepts and operating businesses that do not yet generate revenues tend to possess assets which are knowledge-based and intangible. Consequently, the quality and value of the new venture cannot be directly observed.

Recently, the relevance of patents for access to external financial resources has been analyzed by Engel and Keilbach (2007). Using a dataset consisting of young German firms they found that those firms with a higher number of patent applications (size corrected) have a higher probability of obtaining venture capital. This result is in line with the findings reported by Hellman and Puri (2000). Their results suggest that innovators are more likely to obtain venture capital financing than are imitators.

However, patents provide only one signal. Gompers and Lerner (2001, p.35), for instance, warn that "Although more tangible than an idea, patents and trademarks themselves are not enough to enable a company to obtain financing from most lenders. A soft asset such as patent may have value only when it is combined with other assets, such as the entrepreneur's knowledge of a particular process or technology that the patent involves". In this paper, we argue that innovative nascent entrepreneurs can cope with the problem of asymmetric information by using patents and prototypes in order to signal the commercial potential of their innovative ideas to potential investors. While patents are a means to protect property rights and signal the entrepreneur's ability to appropriate the returns of an innovation (*appropriability*), prototypes signal the actual *feasibility* of the proposed project. For people who are in the process of starting a business or have

just started, prototypes may be the crucial link that actually provides additional value to patents as signals and thus make financing easier.

Moreover, previous studies have been restricted to analyzing how existing, incumbent firms are subject to financing constraints. Yet, it may be that financing constraints have the greatest impact on deterring potential entrepreneurs from even starting a new firm. Cassar (2004, p.279) states that for analyses of the financing of business start-ups "the ideal sample would consist of entrepreneurs in the process of starting a venture and tracking these entrepreneurs through the initial stages of business formation". In this paper we therefore shift the lens away from established, incumbent firms, to nascent entrepreneurs. We use a new dataset to address the point emphasised by Cassar (2004). Our sample consists of 906 individuals who are in the *process* of starting a new venture. Although we are unable to track these individuals, our dataset allows us to distinguish between nascent entrepreneurs that are planning to start a business and those in the very early start-up stage. In contrast to existing empirical studies our paper eliminates the problem of *survivorship bias* in the sample because we analyze ventures at birth. Moreover our sample enables us to identify if entrepreneurs possess patents and prototypes along with information on external sources of finance.

Hence, we contribute to the existing empirical literature on external finance of innovative new ventures by investigating the relevance of patents and prototype for the external finance of innovative nascent entrepreneurs[1].

We portray our arguments using a simple signalling model to show that having both patents and prototypes sends a stronger signal to investors than only having patents or prototypes. The empirical results support our arguments. The results suggest that nascent entrepreneurs that possess patents as well as prototypes have a higher probability of obtaining equity finance from business angels and venture capitalists. However we find that the signal matters to investors only if the nascent entrepreneurs are in the early stage of the startup rather than the planning stage. Bank finance, however, does not seem to value any of the signals and is based only on collateral.

In the following section we discuss the issue of financial constraints for innovative firms, followed by a detailed discussion of appropriablity and feasibility issues and their relation to financing constraints. We then use a similar signalling

[1]To the authors' best knowledge there is no empirical study dealing with the role of prototypes for financial signalling.

model as M. Spence (1973) to develop our hypotheses. Section II introduces the data used and provides some descriptive statistics; Section III presents empirical results and Section IV concludes.

1 Literature and Hypothesis Development

1.1 *Financial Constraints of Innovative Nascent Entrepreneurs*

Why are innovative nascent entrepreneurs financially constrained? This involves three main factors. The first factor is information asymmetries, which arise if the firm has better information about the returns occurring from their investment in intangible assets than do potential investors. Hence, "external finance may be expensive, if available at all, because of adverse selection and moral hazard problems" (Carpenter & Petersen, 2002, p.F56). It is likely that information asymmetries are higher for nascent entrepreneurs who do not have any established track record.

The second factor involves the fundamental uncertainty inherent in knowledge and new ideas. As Arrow (1962) pointed out, this uncertainty characterises the relationship between innovative efforts, or inputs into the innovation process, and their resulting outcomes. New knowledge is intrinsically uncertain in its potential economic value (Arrow, 1962). Thus, "the challenge to decision making is ignorance, the fact that nobody really knows anything" (O'Sullivan, 2006, p.257), or at least, anything for sure. So the degree of uncertainty inherent in the innovative process renders the decisions by potential investors to be based on subjective judgments which may or may not coincide with the assessment by the nascent entrepreneur. This implies that innovative activity may be burdened with difficulties in obtaining finance, even at the prevailing market interest rates. While this problem exists for all firms per se, one can argue that in the case of nascent entrepreneurs, potential investors tread their path extra carefully and many times abstain from investing in the seed stage itself. Moreover nascent entrepreneurs, due to inexperience, may not qualify for finance through the subjective judgments/heuristics commonly used by the investors.

The third factor, also pointed out by Arrow (1962), involves the propensity for knowledge to exhibit, at least partly, characteristics and properties of a public

good, i.e. it is non-excludable and non-rival in use. Thus, in order to fully appropriate investments in innovative activity, the associated intellectual property must be protected through some regime such as patents, copyrights or secrecy. If knowledge spills over to other firms, the benefits accruing from innovation cannot be fully appropriated by the innovating firm.

Taken together, uncertainty, knowledge asymmetries, and the potential nonexclusive nature of investments in intangible assets make it difficult to evaluate the expected value of an innovative firm, especially of an innovative nascent firm (Audretsch & Weigand, 2005).

While problems with innovation are universal, one may therefore ask the question, "why consider nascent entrepreneurs?". In recent years, a number of empirical studies have investigated external financing of innovative firms. However, most of the these studies have been based on financing innovative activity in incumbent firms that already exist (Hall, 2002). While existing firms have at least some history, nascent entrepreneurs are people that have not even founded a new firm, and in some sense can be placed to the left of zero of the firm-age distribution and at zero for the firm size distribution. These conditions which are strongly associated with nascent entrepreneurship should exceed those for a new venture which is actually launched and a startup subsequently matures over its life cycle. Thus, nascent entrepreneurs would be expected to face financing constraints at least as great, but presumably even greater, than do new ventures.

1.2 *How Can Nascent Entrepreneurs Overcome Financial Constraints?*

One might argue that if appropriability of innovation can be ensured, it may help nascent entrepreneurs to overcome the financing problems. While this may be true, one cannot ignore the problem with the present systems of appropriability-namely patent, trademarks etc. While on the one hand, some degree of appropriability is being ensured, on the other hand valuable information is leaked in the process to unrelated parties, mostly competitors. Apart from this, the three previously mentioned problems with innovation still have to be addressed. Our aim in this paper is therefore to show that 'feasibility' serves as a useful signal on this aspect too. In order to do so we first deal with the present markets for knowledge and then discuss the usefulness of appropriability as a signal. We then suggest the reasons why feasibility is needed as a reinforcing mechanism to

appropriability.

Let us consider the problem of knowledge as a public good. The markets for knowledge create opportunities for increasing investment in innovation. From the policy perspective, the intellectual property system is encouraged mainly to ensure the appropriability of innovation and induce increases in investment further. Intellectual property(I.P) rights are the result of government intervention through which appropriability can be ensured from research and development and further investments can be encouraged (in the line of thought followed by Arrow (1962), Nelson (1959), and Levin et al. (1987)). As the European Commission [2] explains, " One direct means(to stop leakage of knowledge) is the strengthening of the appropriability conditions through an effective system of intellectual property rights". Entrepreneurs have to resort to private financing although public support is also in some cases. Most of the nascent entrepreneurs self-finance innovative activities and try to deploy protection mechanisms which per se ensure appropriability. The question remains as to whether appropriability mechanisms such as patents can serve as an reliable signal to external investors to obtain more investment.

Can patents serve as signals? From a law perspective, they do. Long (2002) shows that patents serve as a signal and patentees use patents for acquiring future benefits rather than only excluding others from accessing their intellectual property. The several reasons why patents can be used as signals are summarised by Long (2002). Patents are primarily information transfer mechanisms(Horstmann et al., 1985).In this manner they convey information about both the invention and the firm. In general, market actors believe patents are correlated with various desirable firm attributes.

Anton and Yao (2004) suggest that whether an innovation becomes patented depends on the amount of the information to be disclosed to the intellectual property markets leading to 'little patents and big secrets'. In this manner appropriability(by way of I.P) signals potential investors to anticipate the true value of an innovation.

While we address the problem of public good, patents seem to somehow be utilised as a channel through which the information asymmetry problem can also be addressed. The signal through patent acts in the mode of *information* and *characteristic* about the firm. Development of an invention from an idea

[2](*European Competitiveness Report 2006*, 2006, p.91)

and a concept to a patent indicates that the firm has prospective competent characteristics required in the market. The benefit to the investor when the firm fails to commercialise successfully generally includes rights and conditions which may sometimes also share royalties accruing from the patent along with other intellectual property monetary benefits. In this way investments in start-ups by entrepreneurs holding I.P and ion particular patents, may be considered partly secured, provided contracts are properly drawn. This view has been quite prevalent with venture capital and private equity investments.

Increasingly patent protection has been the main factor for VCs in making the decision of whether or not to invest (Hayes, 1999). As in the job market models, potential candidates observe the characteristic(degrees) potential employers value and try to obtain them beforehand to signal their productivity. Nascent entrepreneurs could also be considered to be attracted to patenting in order to signal commercializability of their ideas[3]. On the other hand, "Venture capitalists use client patents (or more likely, patent applications) as evidence that the company is well managed, is at a certain stage in development, and has defined and carved out a market niche"(Mark, 2001, p.14)

If patenting seems to be a good signal, a crucial element still remains. If patents are actually used in order to convey information to uninformed potential investors, then at the same time valuable information is also being leaked out to competitors. Bhattacharya and Ritter (n.d.) call this the 'feedback effect equilibrium'. Anton and Yao (2002)take a similar view. Both these papers then suggest either partial disclosure or strategic disclosure as a remedy. These models inherently assume that the firm is confronted with only one way of information disclosure and that is not without leakage problems. It would be therefore worthwhile to have a deeper look at this assumption. There are mainly two reasons why informed agents always find alternatives to safeguard their secrets (while informing potential investors). Firstly, the learning effect, where agents learn about leakage problems and try to find alternatives. The second reason is that when informed agents realise that the same kind of signal is being used by many, they search for other, more unique signals that they can send to stand out. Therefore, when such 'signal search' happens we can assume that in the process always new signals are emerging. In what follows we show that patenting is accompanied by

[3]Hall and Ziedonis (2001) find in their interviews with industry representatives that "stronger patent rights are especially critical to (the) firms in attracting venture capital funds and securing proprietary rights in niche product markets"

a different signal for the informed agent to benefit from signalling.

How to address the problem of fundamental uncertainty? While appropriability indicates the *characteristics* and *information* about the agent, feasibility of the project particularly acts as a signal for the *ability* of the agent. One indicator of feasibility is the development of a prototype. What is ability in the eyes of an investor? Broadly we can think of manufacturing ability, ability to ensure a sound pricing and costing strategy. This would mean a big step ahead of the business plan. Every principal seeks to find such agents that would signal future plans and profitability as accurately as possible. Even though advanced planning techniques exist to provide accurate numeric forecasts, the ability of a prototype to signal success or failure of the start-up is even higher. Mitigating information asymmetries and the quality of a signal remains a crucial step in reducing financing constraints. A stronger signal that can substantially reduce information asymmetry is the development of a prototype.

Prototyping is a crucial step in the commercialization process. In some cases prototyping makes patenting easier, and in some cases it serves as a crucial link to the patent and final realization of the finished marketable product. When an agent possesses a prototype, she can clearly determine the processes required for large-scale production, the resources needed and the best suppliers can be charted out. Hence production plans can be strengthened. Once the production plans are clearly defined, the costs and the pricing strategy can be accurately approximated by the agent. Business plan projections become much accurate, and therefore having a prototype serves as a signal to decrease information asymmetry (it also reduces the uncertainty inherent in the project).

Prototyping also increases the scope and scale of appropriability by enabling the agent to benefit from subsequent intellectual property rights, such as design rights (on the prototype and production designs), copyrights and trademarks etc. Therefore, the expected benefit from investing in a start-up having prototypes tends to be high for investors, thus increasing the probability of the agent to obtain external finance. An interesting experiment at the Cranfield Institute of Technology (Hilal & Soltan, 1992) found the following advantages with the prototyping approach as compared to the non-prototyping (structured development approach).

1. The prototyping approach was found to be more robust to sudden and major changes (such as absence of an expert due to illness)

2. it provides a 'superior environment for knowledge elicitation, where a domain expert is available, through the mechanism of allowing the expert to criticise working models of the final system'

3. Prototyping approach allows for greater flexibility in project planning

4. 'Testing' can be done throughout the project while in the non-prototyping approach it is left until the very end

Feasibility via prototyping can also signal higher ability and therefore a higher likelihood of obtaining external funding, mainly from investors who want to be part of the start-up process and be involved at every stage. This tends to be most relevant in the case of nascent entrepreneurs confronting the most severe credit rationing, as well as information asymmetry problems. A nascent entrepreneur who can signal both appropriability and feasibility therefore has an advantage in terms of obtaining external finance. In this way the problems of information asymmetry, fundamental uncertainty and public good nature of knowledge can be significantly decreased. This feature may not be as straightforward as it seems and may be affected by the sector (in some sectors patenting is not the first priority) and risk taking attitude of the investor, even though the signals are strong and reduce the extent of information asymmetries. Such a case would happen mainly when the entrepreneur serves as the link between the idea and an actual start-up.

1.3 *Appropriability and Feasibility as Signals to Investors*

In this section we adopt a simple A. M. Spence (1973) type model to portray our arguments that appropriability and feasibility can serve as signals and present our hypotheses. We assume that informed agents are trying to signal uninformed agents about the commercializability of their innovative ideas. Since what is inherent is their commercializability types of ideas can be distinguished in the following manner. *Types*: Commercializable ideas are denoted by type-high-h, and non-commercializable ideas as type-low-l.

1.3.1 *The Basic Model*

The game first begins by nature determining the type of idea. Investors hold a common prior, μ_0. This is the probability of the type being type-h and reflects the prior belief of investors regarding the fraction of type-h ideas in the market. Individuals owning the ideas choose to appropriate the benefits of innovation by choosing different appropriability mechanisms(patent, prototype or both). Investors observe the extent of appropriability(denoted by e) and update their beliefs regarding the type of each idea. Each investor then decides which idea she is willing to consider as a potential investment.

Appropriability and feasibility are costly. Legal costs, other direct monetary costs, opportunity costs etc. have to be borne by the nascent entrepreneurs[4]. These costs are generally high and have to be financed using own money. As is intuitive, these costs increase with the number of appropriability and feasibility mechanisms utilised. The cost of these mechanisms to an extent of effort e for a type-h idea is given by

$$C_h(e) = \frac{1}{2}\theta e^2; 0 < \theta < 1 \tag{1}$$

and the cost of type-l is given by $C_l(e) = \frac{1}{2}e^2$.

Since different mechanisms are possible and are of different value to the firm, we consider these under a continuum with a ranking such that having a patent and also a prototype is ranked highest against having only a prototype, only a patent or nothing. It can therefore be observed that costs increase with the rank assigned. Precisely, C increases with an increase in e(also the single crossing and spence-mirrlees condition).

Value of Ideas to Investors: Investors are assumed to be unable to perceive the true value of an idea. Investment in an idea therefore depends on its commercializability. Since commercializability itself cannot be perfectly estimated, investors would therefore prefer those ideas that signal strong 'credentials', in this case - strong appropriability and feasibility. The value of the idea is therefore assumed to be $v_t(e) = \alpha_t + \beta_t e, where$

- $v_h = \alpha_h \geq v_l = \alpha_l$
- $\partial v_h/\partial e = \beta_h \geq \partial v_l/\partial e = \beta_l, \forall e \geq 0$

[4]If in case we think of secrecy as an alternative, the entrepreneur has to bear the cost of keeping the ideas secret

This shows how each investor would value ideas where t is the type and e is the extent of appropriability and feasibility(A&F).The first point implies that investors attach an intrinsically higher value to a type-h idea and secondly, valuation of an idea increases linearly with the extent of A&F, with the rate of increase being slightly higher for type-h idea. For purpose of simplicity we assume $\alpha_l = \beta_l = 0$ which means that the value for a type-l idea is set to zero, by the investor.

1.3.2 *Equilibrium Analysis*

We will now analyze the equilibrium of this signalling model and will show that the probability of obtaining external finance increases with the strength of the signal. [5]

Complete information : Assume that the type of idea is common knowledge. This means type-h ideas will be believed as type-h with probability 1 and as type-l with zero probability. The optimal extent of A&F by entrepreneurs would be

$$\begin{aligned} e^*_{h\to 1} &= argmax_e[v_h(e) - C_h(e)] \\ e^*_{l\to 0} &= argmax_e[v_l(e) - C_l(e)] \\ \Rightarrow e^*_{h\to 1} = \beta/\theta \;\text{ and }\; e^*_{l\to 0} &= 0, \;\text{ with }\; e^*_{h\to 1} > e^*_{l\to 0} \end{aligned} \tag{2}$$

Thus, the best response of entrepreneurs with type-h ideas would be always to choose higher level of A&F.

Asymmetric Information (AI) : In the case of asymmetric information, a separating equilibrium can be derived. Generally two cases of envy and non-envy need to be defined. Here we discuss only the non-envy case where the owners of type-l ideas have no incentive to falsely signal their idea being type-h. A separating equilibrium involves the choice of a strictly higher extent of A&F by entrepreneurs having type-h ideas, than of type-l ideas. A minimum level of A&F

[5] As with the usual signalling models, multiple equilibria are possible and generally several refinements exist to pin-point to one. For simplicity, we do not discuss the refinements and suggest that the intuitive criterion would suffice since it is possible that entrepreneurs may still deviate from the pooling equilibrium, even if she is not sure of beliefs of other players. Intuitive criteria helps keep the most efficient outcome: low types are indifferent between acquiring appropriability/feasibility and acquiring nothing. See (Cho & Kreps, 1987) for intuitive criterion in signalling games.

is required so that types of ideas could be differentiated. This minimum level is the maximum level that a type-l idea owner will be able to afford. This is given by,

$$\bar{e}_l = \beta + \sqrt{\beta^2 + 2\alpha} = e_h^{AI} \tag{3}$$

Therefore the proposed equilibrium strategies would be $(e_h^{eq}, e_l^{eq}) = (0, \bar{e}_l)$.

The beliefs of investors on equilibrium path would be,

$$\mu(h/e) = \begin{cases} 1, & e \geq \bar{e}_l \\ 0, & e < \bar{e}_l \end{cases} \tag{4}$$

This implies that investors consider an idea to be type-h only if the extent of A&F is greater than the minimum level that certainly differentiates the types. Based on the above, the value of ideas to investors can be shown as, $v = \begin{cases} \alpha + \beta e, & e \geq \bar{e}_l \\ 0, & e < \bar{e}_l \end{cases}$

Clearly the best response of entrepreneurs with type-h ideas to investors' beliefs and strategies would be to choose $\bar{e}_l(e_l^* \to 0)$

Based on the above equilibrium analysis, we arrive at the basic hypothesis that, the probability of obtaining external finance increases with the strength of the signal (A&F). [6]

To extend the main hypothesis it is also interesting to consider who may actually finance in this type of signalling scenario. Ueda (2004) puts forward a similar signalling approach to show that it is the entrepreneur with little collateral and tight protection of IPR that drives the entrepreneur to approach the venture capitalist for financing due to decreases in threat of expropriation. These propositions are consistent with our model. The fact that the entrepreneur realises the value of tight IPR and also the disadvantages of having low collateral, is consistent with the insight that the entrepreneurs use IPR to serve as a signal. More recently Engel and Keilbach (2007) show that "higher innovativeness in venture funded firms is due to the selection process of the venture capitalist prior to the funding rather than to the venture funding itself". Venture capitalists accomplish this by selecting firms that already have patents prior to obtaining

[6] It is very intuitive to prove this since different appropriability mechanisms are possible, we consider these under a continuum with a ranking such that having a patent and also a prototype is ranked highest against having only a prototype, only a patent or nothing ,subsequently. The costs increase with the same order and therefore the value attached by the investor to the idea also increases, thus increasing the chances of obtaining finance.

funding. Our model though hypothesises that even if tighter IPR regime and patents are present, in many cases the entrepreneurs with stronger signals (feasibility) may acquire external finance and possibly equity would play a prominent role. In the empirical analysis we not only concentrate on VCs (which are well versed in receiving signals) but also business angels and show that signals work with them as well.

Other studies that have used the signalling approach. Myers and Majluf (1984), for example, have used a similar signalling game but they assumed the firm to be already earning positive profits. Leland and Pyle (1977) also have used a signalling approach to convey that firms can obtain external finance if they could signal their market value via offering costly collaterals. Similarly, Bhattacharya and Ritter (n.d.) assume that signalling can occur only through channels that lead to leakage of knowledge. In our approach we show that signalling can also occur through intangible assets and the firms need not achieve profits beforehand (since they are nascent entrepreneurs). In addition, it can also be observed that having a prototype is probably a reliable way to avoid any leakage of sensitive information about innovations to competitors. To empirically test our hypotheses, we use discrete choice models on a new dataset of nascent entrepreneurs, which is explained in the following section.

2 Data

2.1 *Building the Innovative Nascent Entrepreneurs Database (INED)*

To test the two main propositions linking the financial structure of nascent entrepreneurs to their ability to undertake and signal innovative activity, the types of data sets providing information about the financial structure of (new) firms that have been used in previous studies are of little use. This is because of the focus in this paper on nascent entrepreneurs rather than established firms, however young they may be. Thus, a very different type of dataset providing information on both individuals who are considering launching a new venture, that is nascent entrepreneurs, as well as their innovative activity and financial prospects is required to test the hypotheses posited in the previous section.

Finding a dataset possessing information both on nascent entrepreneurs' in-

novation activity and their finance is rare. In this paper a new data set is developed and applied, which consists of 4,122 entrepreneurs (including individuals who are considering launching a new business), investors and others. The data set was created for the Ewing Marion Kauffman Foundation by the Center for Innovative Entrepreneurship (CIE) in May-June, 2005 and consists of a web-based survey of potential entrepreneurs. CIE surveyed visitors of the web site http://www.vfinance.com, which is a location for entrepreneurs seeking finance and interested in finding the names of potential angel investors or venture capital firms. CIE implemented the survey using two methods. This first was to send each web site visitor an email inviting her to participate in the survey. The second method involved soliciting a random sample of web site visitors to participate in the survey. An important qualification of this data base involves selection bias. The data base consists solely of individuals sufficiently interested in obtaining finance that they visited the web site. Thus, individuals not interested in obtaining finance for a new venture are not included in the data base. However, it is important to emphasise that the two major hypotheses do not imply starting with a sample of individuals representative of the overall working population and then identifying which ones constitute nascent entrepreneurs. Rather, in this study the starting point should consist of individuals who are already nascent entrepreneurs. Thus, the appropriate data base should exclude those not considering launching a new venture and include only those individuals who can be reasonably classified as being a nascent entrepreneur. Thus, while the well-known PSED (Panel Study of Entrepreneurial Dynamics), for instance, is a representative sample of American adults and was initiated to "provide systematic, reliable and generalizable data on important features of the entrepreneurial or start-up process" (Reynolds et al., 2004), it is more appropriate for testing hypotheses distinguishing between nascent and non-nascent entrepreneurs. While the sampling mechanism used in PSED is appropriate to generate a sample that is nationally representative with respect to population characteristics, like age or education, it might not be ideal to analyze innovative nascent entrepreneurs' sources of external finance, where a data base consisting solely of innovative nascent entrepreneurs is more appropriate.

As pointed out by Davidsson (2006, p. 55) the downside of the 'representative' sample provided by the PSED "is that the sample will be very heterogeneous and dominated by imitative, low-potential ventures". He therefore suggests to "use other sampling mechanisms than probability sampling in order to get sufficient

numbers of high-tech firms, for instance" (Davidsson, 2006, p.56). In this respect, the data base used in this paper based on the CIE survey is a valuable source of information about innovative nascent entrepreneurs, who are, by definition, *seeking finance*. Moreover, as the descriptive statistics presented in Section 4 show, the share of innovative entrepreneurs included in this data base is strikingly high.

2.2 *Variable Definitions*

While the PSED data base consists of a sample presumably reflecting characteristics of the overall population, we created the Innovative Nascent Entrepreneurs Database (INED) from the CIE survey to consist solely of nascent entrepreneurs. However, in creating the INED, a similar criteria were used that a respondent had to meet in order to be considered as a nascent entrepreneur. In particular, for an individual to be classified as a nascent entrepreneur in the PSED, each record had to meet three criteria: (1)"now trying to start a new business", (2)"currently active in a startup effort" and "anticipates part or full ownership of the new business", and (3)"has NOT yet attained positive monthly cash flow that covered expenses and the owner-manager salaries for more than three months"(Reynolds et al., 2004, p. 268).

For the INED, an individual was similarly classified as being a nascent entrepreneur if the three following analogous conditions were met:

- The individual is seeking capital to start a new business,
- The individual intends to be owner or part owner of the business, and
- The business has not generated revenues in 2004 and 2005,

Respondents claiming zero percent ownership or having positive revenues in 2004-2005 were not classified as being nascent entrepreneurs. The questions included in the survey are included in the appendix. The sample can be distinguished as consisting of two major groups, or sub-samples - a group of individuals engaged in the planning stage for starting a new firm and the group of individuals actually engaged in the launch of a new venture. An individual was classified as a planning stage nascent entrepreneur, or belonging to the former group, if she was (1) planning to start a new business, and (2) the start-up was not a business yet, in that it is not in operation and no products or services have been launched

or offered for sale. By contrast, a respondent was classified as being in the early start-up stage if a venture had been launched but was not generating revenue, and if at least a concept had been developed.

Those reporting that they started their business before 2005 and/or that the number of employees, not counting the owners, exceeds one were excluded from the first group (planning stage nascent entrepreneurs). Similarly, those respondents reporting that they started their business before 2003 and/or that the number of employees exceeds ten were excluded from the second group (incipient start-ups). These stringent criteria were for classifying nascent entrepreneurs as either planning stage or incipient start-ups were applied to maintain the integrity and consistency of the data.

External source of finance: The data set contains information about the sources of business financing. Entrepreneurs reported whether they used the following external financing sources to establish their business: 1) bank loans to the business, 2) home equity loan in an owner's name, 3) other bank loans in an owner's name, 4) venture funds in exchange for stock/ownership in company and 5) individual investors or companies in exchange for stock/ownership in company. While the first three sources are indicators of debt, the last two sources represent indicators of equity. The consistency of the responses was checked and verified. First, those records where respondents reported equity finance and 100 percent ownership were excluded from the sample. Second, those records where a respondent reported owning zero percent of the business and at the same time reported having equity as a source of business financing were also excluded from the sample.

Patents and prototype: In the survey entrepreneurs were asked the following question, "Does your business own or have you applied for a patent that is essential to the business? ". This question was used to compute the dummy variable 'patents' which takes the value one if the answer is YES and zero otherwise. Respondents where also asked "Where is your business in the start-up process?" This question was used to compute the dummy variable 'prototype' which takes the value one if the answer is 'prototype developed' and zero otherwise.

Business relevant information: The data set contains additional information about the entrepreneur and the proposed startup. In particular, records

indicate whether a business plan was written, whether the business has international links, whether the respondent is a serial entrepreneur, whether the business was started by a single person or a team of people and whether the respondent owns a house that can be used as collateral (see Appendix for the questions asked).

2.3 *Descriptive Statistics*

The means and standard deviations of all variables are reported in Table 1. As can be seen from the table, 12 percent of the nascent entrepreneurs in the planning stage use debt as an external source of finance. By contrast, 19 percent of nascent incipient entrepreneurs in the very early stage of the venture rely on debt. With respect to equity finance, the difference between both the planning and incipient entrepreneurs is even larger. While only 6 percent of nascent entrepreneurs in the planning stage have equity finance, more than 20 percent of the nascent entrepreneurs in the early start-stage have equity finance. These differences are statistically significant at the 1 percent level. Nascent entrepreneurs in the planning stage choose either debt (25%) or equity (50%), whereas only one entrepreneur of this group relies on both, debt and equity. In the early start-up stage 19% entrepreneurs rely on both sources of external finance while 73% choose only equity and 79% choose only debt.

The fraction of innovative nascent entrepreneurs, which includes those with a patent application or ownership of a business related patent, increases from 15.5 percent in the planning stage to more than 20 percent in the early start-up stage. An even stronger increase can be observed for the fraction of entrepreneurs who report to have developed prototypes. It is 6.1 percent in the planning stage and 25.2 percent in the early start-up stage. In the group of entrepreneurs in the planning stage, 66 applied for a patent or own one and 32 percent of these have also developed a prototype. In the early start-up stage, 155 new ventures have patents or have applied for patents, and 47 percent of these innovative start-ups have also developed a prototype. Although we do not know whether the patents are related to the prototype, it is likely that at least some of the nascent entrepreneurs try to protect their business relevant innovation (prototype) through patents.

[insert table 1 about here]

As can be seen from the Table 1, 63 percent of the nascent entrepreneurs

in the planning stage have developed a concept while 30 percent of them are still in the process of developing a concept. As can be expected, the fraction of nascent entrepreneurs that have developed only a concept is significantly smaller for the group of nascent entrepreneurs in an early start-up stage. Most of them report 'start-up operation' but only 4.6 percent have already launched a product or services. However, this is not surprising since these are start-ups that have not yet generated revenue.

There are also significant differences between both groups with respect to the fraction of those entrepreneurs who have written a business plan, who have established links with international partners and who have previously started a business.. In the group of incipient nascent entrepreneurs, these fractions are larger. Moreover, there are more serial entrepreneurs in this group and more team start-ups. The large fraction of teams (50 percent) is consistent with the prevalence of teams reported by the PSED.

[insert table 2 about here]

Table 2 reports the number and share of nascent entrepreneurs who have chosen debt and/or equity finance for sub-samples of innovative (with a patent) and non-innovative (without a patent) nascent entrepreneurs. In the planning stage the fraction of innovative nascent entrepreneurs without external finance (14.6 percent) corresponds with their fraction in the total sample (15.5 percent). With respect to debt and equity they are slightly over-represented in this stage. In the incipient stage, however, they are under-represented in the category 'no external finance' and they are over-represented with respect to equity finance. This points to a remarkable change in the capital structure between these early stages of the new venture.

One obvious explanation for the significant differences between nascent entrepreneurs in the planning stage and their counterparts in the incipient stage of launching a new venture is that at least some of the start-up characteristics may reflect the probability of making a transition from the a nascent entrepreneur in the planning stage to a nascent entrepreneur in the early start-up stage. Consequently, the fraction of start-ups with these characteristics would be higher in later stages of the start-up. Parker and Belghitar (2006) investigated the decision of nascent entrepreneurs to quit, to remain a nascent entrepreneur or to start a new firm. They found, for instance, that preparing business plans and having experience in business ownership do not influence the decision by nascent entrepreneurs, whereas team ventures are less likely to make the transition form

planning stage to launching the new venture. Another interpretation is that many nascent entrepreneurs may begin to write business plans, intensify their innovation efforts or try to establish links to international partners once they have taken the decision to launch a new venture.

In summary, the descriptive statistics suggest that the decomposition of the sample into two groups is reasonable since both groups differ with respect to relevant business characteristics. In the econometric analysis we will therefore investigate each group separately to test how innovative activity influences the capital structure of nascent entrepreneurs.

3 Empirical Results

3.1 *Do Signals Affect External Financing?*

In this section we will present estimates which are obtained from separate estimations of the MNL model for nascent entrepreneurs in the planning stage and nascent entrepreneurs in the early start-up stage. We did not differentiate between nascent entrepreneurs who rely only on equity finance and those who rely on both, equity and debt. Instead, we estimated the MNL model with the three categories 'no external finance', 'debt finance' and 'both sources of external finance'. For the group of entrepreneurs in the planning stage this distinction would be unsuitable since only one entrepreneur has both, debt and equity. For the other group, a Wald test of whether the two categories 'only equity finance' and 'both sources of finance' can be combined suggests that this is the case. Further Wald tests reject the null hypothesis that these categories can be further collapsed indicating that significant differences between the determinants of external sources of finance exist. [7]

A basic assumption of the MNL model is that irrelevant alternatives are stochastically independent from each other (Independence from Irrelevant Alternatives (IIA)-assumption), i.e. the odds ratios in the MNL model are independent of the probabilities of other alternatives(Greene, 2003, p.724). Intuitively, the IIA assumption is not very plausible if nascent entrepreneurs view two alternatives as similar rather than independent. Therefore,we tested for the validity of this assumption. The results of a Hausman-test are reported in Table 3. The test

[7]Test results are available from the authors upon request.

results suggest that the null hypothesis of IIA cannot be rejected for both groups (planning stage, early start-up stage)[8].

The *marginal effects* of the explanatory variables on the probabilities of each category are reported for the group of nascent entrepreneurs in the planning stage and for the group of nascent entrepreneurs in an early start-up stage in Table4. As can be seen from this table, having a patent or a prototype does not affect the probability of obtaining external finance if nascent entrepreneurs are in the planning stage. The estimated marginal effect of the dummy variable prototype on the probability of having no external finance is negative and the marginal effect of this variable on the probability of having both, debt and equity finance is positive (0.16). However, the estimates of these marginal effects are statistically insignificant. The estimated marginal effects of the dummy variable patents are also statistically insignificant.

Other variables do influence the probability of being externally financed. Nascent entrepreneurs in the planning stage who have a business plan, who have started a business before and who (or family members) own a house have a lower probability of having no external sources of finance. The probability of having debt finance is positively affected by the existence of a business plan and by house ownership. Obviously, the existence of collateral is very relevant for bank loans was as found by Ueda (2004). This can be seen as a timing problem that the entrepreneurs may first approach the bank and then if they fail, they prefer equity. In this case it can be argued that banks don't recognise patents and prototypes as signals. But as Ueda (2004) shows, it is the entrepreneurs with low collateral that approach venture capitalists. Therefore it can be self-selection on the part of the entrepreneur that she chooses to approach the VC/business angel first. In this case we can conclude that the entrepreneur directly approaches the VC/BA because she realises that VC/BA might be the right signal receivers, and thus avoids banks altogether. Also, a business plan and a developed concept have a positive impact on obtaining equity. Moreover, being a team start-up reduces the probability of debt finance whereas it is positive for equity.

The results are strikingly different for the early start-up stage. Here, the probability of having no external sources of finance decreases if a start-up owns a patent or has applied for patent, has developed a prototype, has launched prod-

[8]This test compares the estimated coefficients of a model using all three categories and a subset where one of the categories is excluded. If the IIA assumption holds, then the estimation of the restricted and the unrestricted model should provide similar estimates.

ucts/services or has established international links. Again, serial entrepreneurs and team start-ups have a higher probability of choosing external finance. The probability of debt finance is higher if a start-up has launched product/services and as in the planning stage team start-ups have a lower probability of debt finance and existence of collateral increases this probability. The probability of equity finance is higher for nascent entrepreneurs that have developed a prototype and that have contracted with companies or individuals outside the United States for goods or services. As in the planning stage, team start-ups and start-ups with a business plan are more likely to choose equity. The estimated marginal effect of the variable prototype is of the same order of magnitude as for entrepreneurs in the planning stage but now this effect is statistically significant at the one percent level.

Note that estimated marginal effects imply that nascent entrepreneurs with prototypes have a remarkably higher probability of having equity finance. Since the variable prototype is a dummy variable, the estimated marginal effect means that a nascent entrepreneur with a prototype has 16 percent higher probability of being financed by business angels or venture capitalists than other nascent entrepreneurs. In contrast, having a patent does not affect the probability of having equity finance.

[insert table 4 about here]

[insert table 5 about here]

The statistically insignificant effect of patents for equity finance might be explained by the fact that many start-ups with a prototype also report that they have applied for a patent or own a patent. Therefore, we performed additional estimations which take this into account by differentiating between start-ups that report only a patent, start-ups that have a prototype but no patent and start-ups that have both.

The estimation results are reported in Table 5. For the group of entrepreneurs in the planning stage the estimations results are hardly affected. For the group of entrepreneurs in an early start-up stage, however the results now show that especially start-ups that report both, patents and prototypes, have a higher probability of being externally financed and in particular the probability of equity finance is positively affected. However, the results also show that start-ups with a prototype but no patent have a higher probability of equity finance while this is not the case for start-ups with patents but no prototype. The magnitude of the estimated marginal effects is remarkable. It implies that a nascent entrepreneur

who possesses a prototype and a patent has a 26.3 percent higher probability of being financed by business angels or venture capitalists than are nascent entrepreneurs without patents and prototypes. A nascent entrepreneur who has a prototype but no patent has a 16 percent higher probability while the estimated marginal effect of the dummy variable "only patents" is positive but much lower (6 percent) and statistically insignificant.

3.2 *Robustness checks*

In order to check the robustness of our estimation results we performed additional regressions using the subsample of nascent entrepreneurs in the early startup-up stage. Marginal effects based on the results of probit model estimations are reported in Table 6. Column (1) simply reproduces the results based on multinomial logit estimations reported in column('Both')in Table 5. As can be expected, the results are very similar. Column (2) contains the results of a probit estimation including controls (dummies) for industry-specific fixed effects[9]. The estimated marginal effects of the variables are hardly affected by the inclusion of industry effects. Since equity is used as a dependent variable, the previous results are based on the implicit assumption that the probability of being financed by a venture capitalist is affected by the same factors as the probability of being financed by a business angel. However, there might be differences between venture capitalists and business angels. Column(3) reports estimations results where the dependent variable takes the value 1 if the nascent entrepreneur is financed by a venture capitalist and Column (4), reports on estimation results where the dependent variable takes the value 1 if the nascent entrepreneur is financed by a business angel. Again, the results are very similar. The estimated marginal effect of patents plus prototype is higher than the marginal effect of patents alone. We tested for differences between the marginal effects and the tests show that the differences are also statistically significant.

A problem of our approach might be the potentially endogenous dummy variables, prototype and patents. One might consider the dependent binary variable 'equity' as simultaneously determined with the dichotomous regressors 'patents' and 'prototype'. If this were the case our estimates would be biased because of endogenous dummy variables. Monfardini and Radice (2008) have proposed a test of exogeneity of a dichotomous regressor which is based on the estimation of

[9]dummies are 10 sectors

a recursive bivariate probit model. In our case this model consists of a reduced form equation for the potentially endogenous dummy variable 'patents' ('prototype') and a structural form equation for equity. This enables a test whether the correlation between the residuals of these equations is zero which is the null hypothesis (exogeneity).

To ensure that the other variables are exogenous we included only the variable 'team', which is very likely to be exogenous, and the sector dummies in our model. One might suspect that the the variables 'business plan' and 'international links' which have a significant effect on the probability of having equity finance are also endogenous. A venture capitalist may force, for instance, nascent entrepreneurs to write a business plan or to have international links. Although we think that this is not very likely, we conservatively exclude these variables from the subsequent analysis. In principle, formal identification of the recursive bivariate model does not require additional exogenous regressors (instruments) if there is sufficient variation in the data (Wilde, 2000). However, Monfardini and Radice (2008) show that instruments are important because they preserve the validity of the LR testing approach in the presence of misspecification.

Therefore, we make use of two additional instrumental variables that do not have a direct influence on the probability of obtaining equity finance but do affect the probability of having patents and/or prototypes. In the survey respondents where asked the following question:"*How important were these factors to you in the decision to start your business*?" Among others, two possible answers were "*Be innovative and in the forefront of technology*" and "*Develop an idea for a product*". Respondents were asked to assess the importance of the factors on a four point Likert scale. We used these scores to compute two dummy variables. The dummy variable 'innovative' takes the value one if respondents assess being innovative as important or very important and zero otherwise. The dummy variable 'idea' takes the value one if respondents assess development of product ideas as important or very important and zero otherwise. These two dummy variables are included as regressors in the reduced form equation for the dummy variable 'patents' and 'prototype'.

Estimation results are reported in Table 7. Columns (1),(2), and (3) report the results of three different estimations where the potentially endogenous variable is 'patents', 'prototype' or 'patents and prototype'. As can be seen from the table, the estimated coefficients of these variables are positive and statistically significant. Moreover, the results of the corresponding LR-tests suggest that

the null hypothesis of exogeneity of these dummy variables cannot be rejected at conventional significance levels. Hence, the results of the robustness checks confirm the previous estimation results.

4 Discussion and Conclusion

We developed two main arguments in this paper: First, *nascent entrepreneurs* who can signal appropriability and feasibility would be expected to have a higher probability of obtaining finance. Second, the stronger is the appropriability and feasibility mechanism, the higher is the probability of obtaining external finance.

Our empirical results suggest that innovative start-ups - with patents and prototype - are indeed more likely to be externally financed, especially by business angels and venture capitalists. It seems that technical knowledge per se does not have a positive influence on the mode of finance. A significant effect only emerges if patents are combined with the development of a prototype. One explanation for this result is that the development of a prototype reduces information asymmetries and resolves the problem of uncertainty associated with the *outcome* of innovation efforts. While prototypes may signal less risk, patents may signal that the nascent entrepreneur is well positioned to appropriate the returns from her investment in intangible assets. Hence, the expected value of an innovative new venture possessing patents and prototype may be more predictable than for innovative new ventures. However, we find this true mainly for individuals in the early start-up stage than those in the planning stage. This may suggest that investors react to signals from nascent entrepreneurs who have at least passed through the planning stage. This would also imply that the stress on protoyping / patenting begins right in the planning stage in order to obtain financing in the start-up stage.

The timing of patenting and involvement of investors is an issue. Are start-ups innovative before they are financed by external investors or do external investors make new ventures more innovative? The results of an empirical study by Hellman and Puri (2000), which is based on cross-section data on 149 Silicon Valley firms in the computer, telecommunication, medical and semiconductor industries, suggest new ventures that follow an innovator strategy have a higher probability of obtaining venture funding than firms following an imitator strategy. Hellman and Puri (2000) use ex-ante information to identify the different

foundation strategies. Their results also suggest that innovators have a significantly higher number of patents than do imitators, which indicates that the "ex ante intent is translated into a realised measure of innovation" (Hellman & Puri, 2000). Our results are consistent with this finding since nascent entrepreneurs who assess innovativeness and development of a product idea as important factors in the decision to start their business are more likely to apply for patents and developed a prototype. Using a sample of young German firms, Engel and Keilbach (2007) find that start-ups that possess patents before the foundation date are more likely to obtain venture finance. This indicates that many start-ups have patents before the involvement of the venture capitalist. We address the problem of endogeneity econometrically by estimating a recursive bivariate probit model, and the results of a test of exogeneity suggest that patents and prototypes are indeed exogenous with respect to external finance. It should be emphasised that that the role of a prototype has not been investigated in the above-mentioned studies. Our results imply that the relevance of patents might be overstated by these studies because they do not control for the development of prototypes. Our study clearly indicates that a prototype itself is a strong signal and is especially strong when combined with a patent.

While a large literature has emerged analyzing the financial decisions of firms, virtually no study has yet been undertaking examining the financial decisions of innovative nascent entrepreneurs. Previous studies in the fields of economics and finance focused primarily on firm characteristics, industry characteristics or macroeconomic effects. Few studies have considered the decision making by potential entrepreneurs that can ultimately lead to the start-up of a new venture and what the role of finance plays in shaping the process by which such new ventures are launched. Hence, this paper contributes to the existing literature.

The limitations as well as opportunities for future research can be observed in many aspects of this paper. We did not track individual nascent entrepreneurs over the start-up process, so that the empiricial evidence is based on cross-sections of nascent entrepreneurs in the planning-stage versus those in the early start-up stage. Availability of the data on timing of patenting/prototyping as well as obtaining finance remains a challenge. We tried to address this issue econometrically but it would be preferable to use a panel structure which exactly identifies the timing. Moreover our dataset needs more information on other innovation efforts of individuals, such as R&D activities,collaborations with other firms or the role of public science institutions, as well as licensing activities. With respect to

the financial sources it would be ideal to have explicit elicitation of entrepreneurs' preferences, which may suggest a future research possibility.

References

Anton, J. J., & Yao, D. A. (2002). The sale of ideas: Strategic disclosure, property rights, and contracting. *Review of Economic Studies*, *69*, 513-531.

Anton, J. J., & Yao, D. A. (2004, Spring). Little patents and big secrets: Managing intellectual property. *RAND Journal of Economics*, *35*(1), 1-22.

Arrow, K. J. (1962). Economic welfare and the allocation of resources for invention. In R. R. Nelson (Ed.), *The rate and direction of inventive activity.* Princeton University Press.

Audretsch, D. B., & Weigand, J. (2005, June). Do knowledge conditions make a difference?: Investment, finance and ownership in german industries. *Research Policy*, *34*(5), 595-613.

Bhattacharya, S., & Ritter, J. (n.d.). Innovation and communication signaling with partial disclosure. *Review of Economic Studies*, *50*, 331-346.

Carpenter, R. E., & Petersen, B. C. (2002, February). Capital market imperfections, high-tech investment, and new equity financing. *Economic Journal*, *112*(477), F54-F72.

Cassar, G. (2004). The financing of business start-ups. *Journal of Business Venturing*, *19*, 261-283.

Cho, I. K., & Kreps, D. M. (1987). Signaling games and stable equilibria. *Quarterly Journal of Economics*, *102*, 179-221.

Davidsson, P. (2006). Nascent entrepreneurship: Empirical studies and developments. *Foundations and Trends in Entrepreneurship*, *2*(1), 1-76.

Engel, D., & Keilbach, M. (2007). Firm-level implications of early stage venture capital investmentan empirical investigation. *Journal of Empirical Finance*, *14*, 150-167.

European competitiveness report 2006 (Tech. Rep.). (2006). European Commission.

Gompers, P., & Lerner, J. (2001). *The money of invention: How venture capital creates new wealth.* Boston, MA: Harvard Business School Press.

Greene, W. H. (2003). *Econometric analysis* (5th ed.). Prentice Hall.

Hall, B. H. (2002, Spring). The financing of research and development. *Oxford Review of Economic Policy*, *18*(1), 35-51.

Hall, B. H., & Ziedonis, R. M. H. (2001). The patent paradox revisited: Determinants of patenting in the us semiconductor industry, 1980-94. *The RAND Journal of Economics*, *32*(1), 101-128.

Hayes, L. D. (1999). What the general practitioner should know about patenting business methods. *The Computer Lawyer*, *16*(9), 3-18.

Hellman, T., & Puri, M. (2000). The interaction between product market and financing strategy: the role of venture capital. *Review of Financial Studies*, *13*, 959-984.

Hilal, D. K., & Soltan, H. (1992). To prototype pr not to prototype? that is the question. *Software Engineering Journal*, *7*(6), 388-392.

Horstmann, I., MacDonald, G. M., & Slivinski, A. (1985). Patents as information transfer mechanisms: To patent or (maybe) not to patent. *Journal of Political Economy*, *93*(5), 837-58.

Hsu, D. (2004). What do entrepreneurs pay for venture capital affiliation? *Journal of Finance*, *59*(4), 1805 – 1844.

Leland, H. E., & Pyle, D. H. (1977). Informational asymmetries, financial structure, and financial intermediation. *Journal of Finance*, *32*(2), 371-87.

Levin, R. C., Klevorick, A. K., Nelson, R. R., & Winter, S. G. (1987). Appropriating the returns from industrial research and development. *Brookings Papers on Economic Activity*(3), 783-831.

Long, C. (2002). Patent signals. *The University of Chicago Law Review*, *69*(2), 625-679.

Mark, A. L. (2001). Rational ignorance at the patent office. *Northwestern University Law Review*, *95*(4), 1495-1532.

Monfardini, C., & Radice, R. (2008). Testing exogeneity in the bivariate probit model: A monte carlo study*. *Oxford Bulletin of Economics and Statistics*, *70*, 271-282.

Myers, S., & Majluf, N. S. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics*, *13*, 187-221.

Nelson, R. R. (1959). The simple economics of basic scientific research. *The Journal of Political Economy*, *67*(3), 297-306.

O'Sullivan, M. (2006). Finance and innovation. In J. Fagerber, D. Mowery, & R. Nelson (Eds.), *The oxford handbook of innovation* (p. 240-265). Oxford: Oxford University Press.

Parker, S. C., & Belghitar, Y. (2006, August). What happens to nascent entrepreneurs? an econometric analysis of the psed. *Small Business Economics*, *27*(1), 81-101.

Reynolds, P. D., Carter, N. M., Gartner, W. B., & Greene, P. G. (2004, November). The prevalence of nascent entrepreneurs in the united states: Evidence from the panel study of entrepreneurial dynamics. *Small Business Economics*, *23*(4), 263-284.

Spence, A. M. (1973). Job market signaling. *The Quarterly Journal of Economics*, *87*(3), 355-74.

Spence, M. (1973). Job market signaling. *Quarterly Journal of Economics*, *87*, 355-374.

Ueda, M. (2004). Banks versus venture capital: Project evaluation, screening, and expropriation. *The Journal of Finance*, *59*, 601-621.

Wilde, J. (2000). Identification of multiple equation probit models with endogenous dummy regressors. *Economics Letters*, *69*, 309-312.

Appendix

Questions used from the CIE questionnaire

Defining and identifying nascent entrepreneurs

- Which category best describes you? (Answer: Entrepreneur seeking capital to start a new business, Entrepreneur seeking capital for an operating business; Entrepreneur interested in business planning services or seminars; Visitor searching for general information about raising capital; Investor interested in investment opportunities; vFinance Investments Client; vFinance Employee or Associate.)
- Are you actively involved in running this business? (Answer: YES/NO)
- What percent of this business do you own? (Answer: 0, 1 - 25, 26 - 50, 51 - 75, 76 - 99, 100)
- Did your business generate revenue in the first quarter of 2005 (January 2005 through March 2005)? (Answer:YES/NO)
- 2004 revenue. In U.S. dollars? (Answer: Over 10 million, 5 million to 10 million, 1 million to 5 million, 500,000 to 999,999, 250,000 to 499,999, 150,000 to 249,999, 100,000 to 149,999, 75,000 to 99,999, 50,000 to 74,999, 25,000 to 49,999, 1 to 24,999, No revenue in 2004.)

Distinguishing between planning stage and early start-up stage

- Which of these best describes you? (Answer: I currently own and operate a business; I am planning to start a new business; I am interested in private investments in businesses; None of the above.),
- Where is your business in the start-up process? (Answer: concept in development, concept developed, prototype developed, start-up operation or product/service launched.)

External sources of finance

- What sources of business financing have you already used to establish this business? (Answer: bank loans to the business, home equity loan in an owner's name, other bank loans in an owner's name, venture funds in exchange for stock/ownership in company, individual investors or companies in exchange for stock/ownership in company.)

Business characteristics

- Does your business own or have you applied for a patent that is essential to the business? (Answer: YES/NO)
- Has your business contracted with any companies or individuals outside the United States for goods or services? (Answer: YES/NO)
- Do you have a written business plan for your business? (Answer: YES/NO)
- Have you started another business before this business? (Answer: YES/NO)
- Do you or anyone in your household own your residence? (Answer: YES/NO)
- Which of the following best describes how your business was started? (Answer: A new business created by a single person; A new business created by a team of people; A business inherited from someone else; Purchase of an existing business; Purchase of a franchise)

Decision to start the business How important were these factors to you in the decisions to start your business? (Answer: very unimportant, unimportant, important and very important)

- Be innovative and in the forefront of technology.
- Develop an idea for a product.
- Fulfill a personal vision.
- Lead and motivate others.

A Tables and Figures

Table 1: Descriptive statistics

	planning stage		**early start-up stage**		
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Z-test
Debt	0.120	0.325	0.192	0.394	3.0*
Equity	0.061	0.240	0.204	0.404	6.3*
Patents	0.155	0.362	0.323	0.468	5.9*
Concept in development	0.296	0.457	N.A.	N.A.	N.A.
Concept developed	0.636	0.482	0.304	0.461	-10.0*
Prototype developed	0.068	0.252	0.260	0.439	7.7*
Start-up operation	N.A.	N.A.	0.390	0.488	N.A.
Product/service	N.A.	N.A.	0.046	0.209	N.A.
Business plan	0.601	0.490	0.835	0.371	7.9*
Serial entrepreneur	0.467	0.500	0.600	0.490	4.0*
International links	0.110	0.314	0.215	0.411	4.2*
Team	0.340	0.474	0.479	0.500	4.2*
House	0.587	0.493	0.625	0.485	1.2

Notes: All variables are dummy variables that take on the values one or zero. N.A. means not applicable. Z-test for the equality between two proportions: * denotes significant at the 1 percent level.

Table 2: Descriptive statistics: patents and sources of finance

	planning stage				
	no external	debt	equity	both	Total
no patents	299	40	20	1	360
	(85.4)	(80.0)	(80.0)	(100.0)	(84.5)
patents	51	10	5	0	66
	(14.6)	(20.0)	(20.0)	(0.0)	(15.5)
	350	50	25	1	426
	(100)	(100)	(100)	(100)	(100)
	early start-up stage				
no patents	229	49	34	13	325
	(74.1)	(67.1)	(43.0)	(68.4)	(67.7)
patents	80	24	45	6	155
	(25.9)	(32.3)	(56.7)	(31.6)	(32.3)
	309	73	79	19	480
	(100)	(100)	(100)	(100)	(100)

Notes: Percentage in parentheses.

Table 3: Hausman tests for the validity of the IIA assumption

One of the key assumptions for multinomial logit is that adding another alternative does not affect the odds-ratios amongst other alternatives. This table presents the Hausman test statistic for the null hypothesis (Ho) which tests for the IIA assumption where the null hypothesis (Ho) is that the odds(Outcome-J vs Outcome-K) are independent of other alternatives. The results of the test show that in both planning and early start-up stage, the IIA assumption is satisfied. This is important since the disturbances need to be independent and homoscedastic in order to obtain consistent parameter estimates. Source 1 indicates debt and source 2 indicates equity and compared as odds against no external finance.

Model	**Omitted source of finance**	$\chi^2(10)$	**Evidence**
Planning Stage	1	-5.409 (1.000)	for Ho
	2	0.071 (1.000)	for Ho
		$\chi^2(11)$	
Early Start-up Stage	1	-0.845 (1.000)	for Ho
	2	-5.401 (1.000)	for Ho

Table 4: Determinants of nascent entrepreneurs' external sources of finance

This table shows the results of a multinomial logit estimations based on a sample of 426 nascent entrepreneurs in the planning stage and on a sample of 480 nascent entrepreneurs in the early startup stage.

	planning stage			**early start-up stage**		
Variable	No	Debt	Both	No	Debt	Both
Patents	-0.019	0.028	-0.009	-0.105**	0.041	0.064
	(0.048)	(0.045)	(0.017)	(0.052)	(0.041)	(0.039)
Prototype devel.	-0.139	-0.021	0.160	-0.122*	-0.0335	0.155***
	(0.13)	(0.048)	(0.14)	(0.065)	(0.044)	(0.058)
Concept devel.	0.0192	-0.0547	0.036*	N.A.	N.A.	N.A.
	(0.039)	(0.034)	(0.020)			
Start-up oper.	N.A.	N.A.	N.A.	-0.037	0.036	0.001
				(0.055)	(0.042)	(0.043)
Product/service	N.A.	N.A.	N.A.	-0.211*	0.211*	-0.001
				(0.12)	(0.12)	(0.093)
Business plan	-0.095***	0.0558**	0.0394**	-0.0178	-0.056	0.074*
	(0.031)	(0.027)	(0.018)	(0.059)	(0.049)	(0.040)
Serial entrep.	-0.053*	0.0323	0.0202	-0.106**	0.060*	0.046
	(0.031)	(0.028)	(0.016)	(0.044)	(0.033)	(0.035)
Internat.links	-0.079	0.0346	0.0445	-0.116**	0.0094	0.107**
	(0.059)	(0.050)	(0.036)	(0.058)	(0.043)	(0.047)
Team	0.024	-0.0615**	0.0373*	-0.135***	-0.0616*	0.197***
	(0.033)	(0.026)	(0.021)	(0.046)	(0.034)	(0.037)
House	-0.094***	0.115***	-0.0215	-0.132***	0.114***	0.0178
	(0.032)	(0.028)	(0.016)	(0.043)	(0.032)	(0.035)
χ^2-statistic	60.48			109.9		
Pseudo R^2	0.122			0.128		
Actual Frequ.	350	50	26	309	73	98
Pred. Frequ.	373	39	14	334	71	75

Notes: Multinomial Logit Estimation results. The standard errors are reported in parentheses. The asterisks *, ** and *** denote significant at the 10, 5 and 1 percent level respectively. The estimates reflect the marginal effects of a change of the respective dummy variables from 0 to 1.

Table 5: Determinants of nascent entrepreneurs' external sources of finance

This table shows the results of a multinomial logit estimations based on a sample of 426 nascent entrepreneurs in the planning stage and on a sample of 480 nascent entrepreneurs in the early startup stage. In this specification we test the effect of possessing both a patent and a prototype on financing. We also identify the effect of having only one of either patent or prototype. As can be observed, the effect of having only prototypes and having both is quite large on external financing.

	planning stage			**early start-up stage**		
Variable	No	Debt	Both	No	Debt	Both
Patents/protot.	-0.140	-0.005	0.145	-0.272***	0.009	0.263***
	(0.13)	(0.057)	(0.13)	(0.080)	(0.057)	(0.081)
Only prototype	-0.121	0.0162	0.105	-0.0929	-0.067	0.160*
	(0.17)	(0.11)	(0.15)	(0.089)	(0.047)	(0.087)
Only patents	-0.020	0.035	-0.015	-0.077	0.016	0.061
	(0.052)	(0.050)	(0.017)	(0.065)	(0.048)	(0.054)
Concept devel.	0.019	-0.055	0.036*	N.A.	N.A.	N.A.
	(0.039)	(0.034)	(0.020)			
Start-up oper.	N.A.	N.A.	N.A.	-0.036	0.035	0.001
				(0.054)	(0.042)	(0.043)
Product/service	N.A.	N.A.	N.A.	-0.215*	0.216*	-0.001
				(0.12)	(0.12)	(0.094)
Business plan	-0.094***	0.055**	0.039**	-0.021	-0.053	0.074*
	(0.031)	(0.027)	(0.018)	(0.059)	(0.049)	(0.040)
Serial entrep.	-0.052*	0.032	0.020	-0.107**	0.061*	0.047
	(0.031)	(0.028)	(0.016)	(0.044)	(0.033)	(0.035)
Internat.links	-0.080	0.035	0.045	-0.116**	0.010	0.107**
	(0.059)	(0.050)	(0.036)	(0.058)	(0.043)	(0.047)
Team	0.025	-0.063**	0.038*	-0.137***	-0.060*	0.197***
	(0.033)	(0.026)	(0.021)	(0.046)	(0.034)	(0.038)
House	-0.094***	0.115***	-0.021	-0.135***	0.117***	0.019
	(0.032)	(0.028)	(0.016)	(0.044)	(0.032)	(0.035)
χ^2-statistic	60.58			111.1		
Pseudo R^2	0.122			0.129		
Actual Frequ.	350	50	26	309	73	98
Pred. Frequ.	373	39	14	334	71	75

Notes: Multinomial Logit Estimation results. The standard errors are reported in parentheses. The asterisks *, ** and *** denote significant at the 10, 5 and 1 percent level respectively. The estimates reflect the marginal effects of a change of the respective dummy variables from 0 to 1.

Table 6: Probability of being financed by business angels and venture capitalists - Results of Probit Estimation

This table concentrates specifically on the private equity market made up of venture capitalists and business angels. The first coloumn estimates the effect on equity without including industry effects while coloumn 2 includes them. Coloumn 3 presents the effects on obtaining only venture capital and coloumn 4 deals with only business angel financing. probit estimation was used since the dependent variable in each specification is a binary choice.

Variable	(1) Equity	(2) Equity	(3) Venture Capital	(4) Business Angel
Patents/protot.	0.273***	0.271***	0.166**	0.228***
	(0.0764)	(0.0788)	(0.0662)	(0.0768)
Only prototype	0.174**	0.153*	0.126*	0.129
	(0.0831)	(0.0847)	(0.0713)	(0.0805)
Only patents	0.0717	0.0550	0.0135	0.0441
	(0.0563)	(0.0541)	(0.0198)	(0.0514)
Start-up operat.	0.00905	0.0186	0.0248	0.0357
	(0.0428)	(0.0426)	(0.0222)	(0.0409)
Product/service	0.00732	-0.0325	0.110	-0.0557
	(0.0976)	(0.0698)	(0.0913)	(0.0580)
Business plan	0.0783**	0.0774**	0.0145	0.0573
	(0.0397)	(0.0364)	(0.0150)	(0.0352)
International links	0.112**	0.111**	0.0123	0.101**
	(0.0497)	(0.0488)	(0.0171)	(0.0467)
Serial entrep.	0.0470	0.0277	0.00941	0.0455
	(0.0354)	(0.0356)	(0.0134)	(0.0329)
Team	0.201***	0.199***	0.0598***	0.154***
	(0.0368)	(0.0364)	(0.0196)	(0.0345)
House	0.0181	0.0145	0.0124	-0.00179
	(0.0358)	(0.0343)	(0.0131)	(0.0327)
Industry Effects	No	Yes	Yes	Yes
Wald test	$\chi^2(10)$	$\chi^2(20)$	$\chi^2(19)$	$\chi^2(20)$
	88.59	111.26	48.02	90.33
Pseudo R^2	0.1816	0.2335	0.2042	0.2070

Notes: Probit estimation results. Robust standard errors are reported in parentheses. The asterisks *, ** and *** denote significant at the 10, 5 and 1 percent level respectively.

Table 7: Results of Recursive Bivariate Probit

In this table we address the issue of the possibility of endogeneity in the model. This we do by estimating a recursive simultaneous bivariate probit where we endogenise patents, prototypes and both in three specifications respectively. The endogenous(binary) variable in each specification is regressed on the presence of a team, whether the entrepreneur thinks whether being innovative and developing ideas for new products is important for businesses. We also include the industry effects in this regression since it might be possible that the field of the entrepreneur is a patentable or innovative field. The results suggest that, after accounting for endogeneity, the results of our model still hold true.

	(1a) Equity	(1b) Patents	(2a) Equity	(2b) Prototype	(3a) Equity	(3b) Prototype & Patents
Patents	1.167***					
	(0.42)					
Prototype			1.179**			
			(0.52)			
Prototype & Patents					1.338**	
					(0.58)	
Team	0.752***	0.452***	0.949***	0.0579	0.888***	0.269*
	(0.19)	(0.13)	(0.17)	(0.14)	(0.17)	(0.16)
Innovative		0.749***		0.707***		1.355***
		(0.23)		(0.26)		(0.46)
Idea		0.839***		1.142***		1.072**
		(0.24)		(0.32)		(0.42)
Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes
Likelihood-ratio test of $\rho = 0$	$\chi^2(1)$ 2.05697		$\chi^2(1)$ 0.779692		$\chi^2(1)$ 0.788504	

Notes: Bivariate probit model estimation results. Robust standard errors are reported in parentheses. The asterisks *, ** and *** denote significant at the 10, 5 and 1 percent level respectively.