The Inventor's Role: Was Schumpeter Right?

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January 2007

Abstract
According to Schumpeter, the creative process of economic development can be divided into three distinguishable stages of invention, innovation (commercialization) and imitation. We show why there is a rationale for the Schumpeterian entrepreneur to also include the inventor in the innovation process. In addition, we provide a framework where the theories of Knight's risk defining entrepreneur and Schumpeter's innovative entrepreneur can be bridged. Merging the two enhances the possibilities of successful commercialization since the inventor may further adapt the innovation to customer needs, transmit information and reduce uncertainty. This serves to expand the market opportunities for the entrepreneur. The empirical analysis is based on a survey covering Swedish patents granted to individuals and small firms, with a response rate of 80 %. The results show improved commercialization performance when the patent is licensed or sold to an entrepreneur, or if the inventor is employed in an entrepreneurial firm, as compared to commercialization in the inventor's own firm. Another important result is that, irrespective of commercialization mode, an active involvement of the inventor is shown to have a positive impact on performance.

Key words: Entrepreneur, inventor, innovations, commercialization.

JEL: 031, 032, M13

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The authors would like to thank Erik Mellander, Magnus Henrekson, Lars Persson and the seminar participants at the Oslo Entrepreneurship Workshop for constructive comments as well as Jakob Eliasson for collection of and work with the database. This paper was awarded the price "Best paper in Entrepreneurship and Innovation" at the Oslo Entrepreneurship Workshop. The Bank of Sweden Tercentenary Foundation and Söderbergs Foundation are acknowledged for generous financial support.

1. Introduction

Perhaps more than any other writer, Schumpeter (1911, 1934) is explicit about the economic function of the entrepreneur. By introducing innovations to the market, the entrepreneur distorts the prevailing equilibrium, challenges existing structures and sets industrial dynamics and economic development into motion. According to Schumpeter, the process of economic development can be divided into three clearly separate stages. The first stage implies technical discovery of new things or new ways of doing things, which Schumpeter refers to as invention. In the subsequent stage innovation occurs, i.e. the successful commercialization of a new good or service stemming from technical discoveries or, more generally, a new combination of knowledge (new and old). The final step in this three-stage process – imitation – concerns a more general adoption and diffusion of new products or processes to markets.

For our purpose, the interesting part consists of the separation between the stages of invention and innovation. Schumpeter (1947) himself claims that “the inventor produces ideas, the entrepreneur ‘gets things done’ ….. an idea or scientific principle is not, by itself, of any importance for economic practice.” Thus, Schumpeter views the creation of opportunity as being outside the domain of the entrepreneur. Rather, the exploitation of such opportunities is what distinguishes entrepreneurs, i.e., innovation. Neither did Schumpeter view entrepreneurs as risk-takers, even though he did not completely dismiss the idea and was aware that innovation contains elements of risk also for the entrepreneur. But basically, that task was attributed the capitalists who financed entrepreneurial ventures.

This paper seeks to answer two questions associated with the way Schumpeter disconnected inventions and innovators. The first is simply whether Schumpeter was right on this issue and to what extent disconnecting the stages influences the success of commercialization. Focusing on entrepreneurs and small firms, is it the case that invention and innovation take place in independent units? And is commercialization performance contingent upon the separation of these activities? Over the last decades, there are plenty of examples of fast-growing entrepreneurial firms that are based on individuals’ inventions, where Microsoft probably constitutes the most conspicuous case of a successful combination of the inventor and innovator role. However, there is also ample evidence of the opposite. Going back a few decades, but remaining within the same industry, William Shockley’s invention known as the semiconductor was brilliant. Still, his company − Shockley’s Semiconductors − performed less well but inspired several entrepreneurial employees who later choose to leave and try their own innovative capabilities. Thus, judging from anecdotical evidence, there seem to be examples of both inventors and innovators that have successfully commercialized new products.

The second question concerns the involvement of the inventor in the commercialization process. More precisely, can we observe that entrepreneurs and small firms that actively involve the inventor in the commercialization of new products are more profitable? This is associated with the way inventive activities are organized, i.e. the degree of vertical integration of inventive and innovative stages.[1] This issue has not been empirically examined in the previous literature, with the exception of more explorative studies (Teece 1988). We argue that the integration of the two stages may, in fact, be considered as part of the entrepreneurial ability as envisioned in the Schumpeter world, that is, in the process of commercialization. It is associated with entrepreneurs' "combinatorial capability". It is also likely to reduce uncertainty in entrepreneurial activities, as defined by Knight (1921), since commercialization also implies the adaptation of the original invention to specific market and firm conditions. Such adaptation relies on the private knowledge embodied in the inventor. In addition, the entrepreneur also reduces the risks of being exposed to increased competition from follow-up innovations by the inventor, or from other firms to which the inventor may find it profitable to license an invention. In fact, this suggests a bridge between Knight's and Schumpeter's approaches to entrepreneurship.

To empirically address these issues, we will implement a unique database on Swedish patents granted to individuals and small firms. Data is collected through a survey with a response rate of 80 percent. In particular, the database contains information about the extent of commercialization of individual patents, whether the commercialization was successful and the role of the inventor in the commercialization process. Using discrete statistical models, we empirically examine how different explanatory factors (e.g., commercialization mode, firm type, activity of inventors) affect the performance. To the best of our knowledge, such an empirical analysis, where explanatory factors are related to the performance of patent commercialization, has never previously been carried out.

The paper is organized as follows. Section 2 presents a brief discussion of the inventor and the entrepreneur, drawing on previous insights in industrial organization theory and search cost theory. The database and basic statistics are described in section 3. The statistical model and hypotheses are set up in section 4. The empirical estimations are shown in section 5, and the final section concludes.

[1] Taking all firms into account, irrespective of size, there has been a clear tendency in the 20th century towards an increased vertical integration of inventive (R&D) and producing activities (Teece 1988, Aghion and Howitt 1998).

2. Entrepreneurs, invention and innovation

Most contemporary theories of entrepreneurship build on the seminal contributions by Schumpeter (1911, 1934) who stressed the importance of entrepreneurs as the main vehicle to move an economy forward from static equilibrium, Knight's (1921) proposed role of the entrepreneur as someone who transforms uncertainty into a calculable risk and, somewhat later, Kirzner's (1973) view that the entrepreneur moves an economy towards equilibrium (contrasting Schumpeter) by taking advantage of arbitrage possibilities. More generally, the research field of entrepreneurship has recently been defined as analyses of "how, by whom and with what consequences opportunities to produce future goods and services are discovered, evaluated and exploited" (Shane and Venkataraman, 2000).[2]

As regards by "whom", an eclectic definition of the entrepreneur, which has become increasingly accepted, is suggested by Wennekers and Thurik (1999). The entrepreneur: i) is innovative, i.e. perceives and creates new opportunities; ii) operates under uncertainty and introduces products to the market, decides on location, and the form and use of resources; and iii) manages his business and competes with others for a share of the market.[3] Apparently, this definition can be linked to all three contributions referred to above. Note that invention is not explicitly mentioned in this definition, nor excluded from the interpretation of entrepreneurship. Thus, it deviates, but is not completely disentangled, from Schumpeter's (1911) traditional view on innovation and invention:

> "Economic leadership in particular must hence be distinguished from 'invention'. As long as they are not carried into practice, inventions are economically irrelevant. And to carry any improvement into effect is a task entirely different from the inventing of it, and a task, moreover, requiring entirely different kinds of aptitudes. Although entrepreneurs of course may be inventors just as they may be capitalists, they are inventors not by nature of their function but by coincidence and vice versa ... it is, therefore, not advisable, and it may be downright misleading, to stress the element of inventions as much as many writers do".

Obviously, Schumpeter foresaw possible situations when the inventor role may coincide with the innovator, albeit such situations were considered to be exceptions to the rule.

The Schumpeterian distinction between inventor and entrepreneur has previously been challenged by Schmookler (1966), who, based on case studies, believed that entrepreneurs discover opportunities to do promising R&D rather than merely discovering promising outcomes of R&D that has been conducted by others. On a more aggregate level, the merging

[2] A related strand of the literature focuses on differences in individual capabilities (Carroll and Hannan, 2000), or the interaction between the characteristics of opportunity and the characteristics of the people who exploit them (Casson, 2005). Schumpeter also considered individual's psychological capacity as the key in identifying opportunities.

[3] We adopt the somewhat modified version as introduced by Bianchi and Henrekson (2004).

of the inventive and innovative stages is clearly stated in the neo-Schumpeterian growth models (Aghion and Howitt, 1998). These models, however, share the later Schumpeter's (1942) view of innovation as becoming routinized, where markets become dominated by a limited number of large firms. Hence, this approach would not be well-designed to analyze the aspects of Schumpeterian entrepreneurship addressed in this paper.[4]

The Wennekers-Thurik definition of entrepreneurs also refers to uncertainty. Doubtlessly, Schumpeter was aware of the fact that new activities do involve elements of risk-taking, even though he did not stress that aspect as a dominating feature of entrepreneurship. Rather, the risk-taking part was orchestrated by capitalists that provided the finance required to embark on new ventures. It was Knight (1921) who developed the strand in entrepreneurial economics that stressed the entrepreneur's role as a risk-bearing agent which to some extent contrasted – but also complemented – Schumpeter's view.[5]

Innovative activities by entrepreneurs are thus undertaken in order to create profit opportunities for themselves. Our focus concerns the relationship between the inventor and the innovator, such that successful commercialization can be accomplished. What guidance can be found in contemporary theoretical literature?

2.1 Costs and the organization of inventive and innovative activities

The role of the inventor in the commercialization process can be linked to at least two strands in contemporary economic literature. The first refers to the organization of inventive activities, while the second concerns information – or search – costs as regards the properties of novel products. The latter aspect is also related to credibility and trust. We will briefly describe each of these strands in the literature.

The first reason stems from the economy's supply side, i.e. the industrial organization of inventive activities. In particular, should inventive activities – commonly featured as R&D – be integrated within firms or undertaken in independent units? The answer is related to market characteristics and the ex ante uncertainty about the outcome of inventive activities. Consider the following simple model. Let v denote the value of an innovation for the customer while e refers to research efforts and E captures investments required in the

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[4] Scherer (1980) claims that innovative entry by entrepreneurs and innovative entry by large firms seem to fulfill complementary roles in the process of turning an innovation into full-scale, welfare enhancing new production activities. Major innovations often emanate in a serendipitous way from ingenious individual entrepreneurs.

[5] They were more aligned on other aspects of entrepreneurship. For instance, both Knight and Schumpeter shared the belief that entrepreneurial talent was a scarce resource. Such scarcity is not so much associated with entrepreneurs' alertness, or with their professionalism, as with their psychology. More recently, Lazear (2005) suggests that entrepreneurs have a more balanced talent that spans a number of skills. This could be argued to strengthen their "combinatorial capacity", as compared to the more limited role of specialists. In the perspective of the issue we raise, the entrepreneur could be viewed as being endowed with multi-task talent, while the inventor is more of a specialist. See Lindbeck and Snower (2000) on multi-tasking.

innovation process by the entrepreneur. Assume the probability (*p*) of a successful innovation to be increasing, strictly concave and separable in e and *E*, then

$$p(e,E) = q(e) + r(E)\,. \tag{1}$$

Both the inventor and the entrepreneur are assumed to be risk-neutral, to have a reservation utility that equals zero ($q,\ r\ \geq 0$) and that costs are assumed to be linear. The welfare maximization problem can then be written in the following way,

$$\max\{p(e,E)\ \ v - e - E\} \tag{2}$$

and equilibrium is attained as,

$$dq/de(e^{*}) = dr/dE(E^{*}) = 1\,. \tag{3}$$

Hence, if perfect information prevailed about the outcome of the inventive activities, the equalization of the marginal contribution of research efforts and capital would form the basis of a contract between the inventor and the entrepreneur. However, the presence of asymmetric information between the inventor and the innovator, and the inherited uncertainty in such processes tend to incur excessive transaction costs in setting up and monitoring such contracts (Grossman and Hart, 1986). Therefore, alternatives to consider for the entrepreneur are to integrate – employ – the inventor, or to buy or license the invention once it has materialized. Similarly, the inventor must ponder whether to supply research efforts as an independent unit or if integration with an entrepreneur is more lucrative.[6]

From a dynamic point of view, commercialization is likely to include a gradual adaptation (specific customer requirements) and follow-up inventions based on the original invention. In that case, the transmission of proprietary information is crucial for successful innovation, which calls for close interaction between the entrepreneur and the inventor or research unit.[7] Assume that future inventions originate in the individual-specific knowledge of the inventor. Consider the non-integrated case where inventions are sequenced over two periods and knowledge transfers (*e*) between the inventor and the entrepreneur influence the

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[6] Whenever the marginal efficiency of the inventor (e^{*}) is sufficiently large relative to that of the entrepreneur (E^{*}), social optimum is attained when the stages of invention and entrepreneurial investment are separated into independent utilities (see Aghion and Howitt, 1998, ch. 13).

[7] See Frankel (1955), Teece (1988) and Aghion and Howitt (1992).

occurrence of an innovation. The value of the innovation is split evenly between the inventor (α) and the entrepreneur ($1-\alpha$). If the inventor chooses to transfer information about invention in the first period, all revenue will be collected in that period. Alternatively, the inventor can wait to the second period and either commercialize the invention or sell the invention to another firm. The decision whether to transfer ($e=1$) knowledge or not ($e=0$) is non-contractible and must be incentive compatible, implying that,[8]

$$\alpha_1 q_0 v_1 \geq v_2, \quad \alpha_1 \geq v_2 / q_0 v_1. \tag{4}$$

We then turn to the integrated case. The entrepreneur is dependent on knowledge transfers by the inventor to accomplish successful commercialization. If the invention – or the customers' required modification of the invention – is not transferred to the entrepreneur in the first period, the inventor will get half of the (expected) value in the first period. The reward to the inventor in the integrated case is then,

$$\alpha_1 q_0 v_1 \geq v_2 / 2, \quad \alpha_1 \geq v_2 / 2 q_0 v_1, \tag{5}$$

implying that the costs (of invention) are lower in the integrated case as compared to the disintegrated case. Thus, in the case of incomplete contracts, there are strong incentives for entrepreneurs to vertically integrate with inventors or research units. Integrating the two stages implies cost savings and risk reduction. Thus, in contrast to Schumpeter, we argue that integration of the inventive and innovative stages may be desirable since it facilitates communication between the entrepreneur and the inventor which serves to maintain competitiveness, facilitate demand for customer-specific adaptions, and reduce the risks for the entrepreneur.

A second reason why commercialization may be more successful if orchestrated by an entrepreneur relates to the demand side of the economy. A necessary condition for commercialization is that information about a new product's attributes is available to the market. If there is no information, there will be no market for the product. Such information can be provided by the inventor (I) or the entrepreneur (E), either separately or jointly. Alternatively, the potential consumer (C) can search for information (e.g. by reading the patent application documents). We would expect these agents to be characterized by

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[8] Where $p = q_0 e + r(E), \quad q_0 > 0$. See Aghion and Howitt (1998) for details.

heterogeneous ability as regards information activities. It depends on their technological and market knowledge, i.e. learning from previous experience and occupation (von Hayek 1937, Frank 1988). Hence, inventors are assumed to possess more of technological knowledge and less of market knowledge, whereas the opposite is the case for consumers. The entrepreneur possesses some of both, which is used to introduce a new product to the market.

Obviously, all information activities require some input of *h* hours at a cost *w* (wage). In addition, at each point in time the number of hours used in information activities depends on the respective agent's previous knowledge – or experience – regarding the market and technology (X_M, X_T).[9] The less experienced agents are, the more resources must be devoted to information activities. Inventors trying to commercialize an invention must provide more hours to marketing than experienced entrepreneurs due to their limited market knowledge, while the costs for obtaining technological information of a new product are higher for a consumer – and also for the entrepreneur – as compared to the inventor. On the other hand, the entrepreneur matches technological knowledge with market knowledge to launch a particular product. Furthermore, the more radical is the innovation and the higher is the degree of technological sophistication (*e*), the higher are the information costs required to assess the value of the innovation.

Hence, information costs are increasing in *w* and *e*, but decreasing in *X*. Assuming linear costs and that *w* is equalized and set to one in equilibrium, the costs function can be expressed in the following for a given level of *e*,

(consumers) $$c_C(w, e, X_M) = hX_M \qquad (6a)$$

(inventors) $$c_I(w, e, X_T) = hX_T \qquad (6b)$$

(entrepreneurs) $$c_E(w, e, X_M, X_T) = h(X_M + X_T)\,. \qquad (6c)$$

Hence, each agent draws on experience in the field where he has been active, and technological and market experiences are assumed to be symmetric. Differentiating equations 6a-6c with respect to experience (*X*) yields the following relationship,

$$dc_C / dX \equiv dc_I / dX = h > dc_E / dX = 2h \qquad (7)$$

[9] See Jovanovic (1982) and Ericsson and Pakes (1995).

implying that the entrepreneur – combining market knowledge and product knowledge – is the most cost efficient information provider. Over time experience, or learning, can be expected to further reduce information costs (Frank, 1988).[10]

In summary, taking a dynamic perspective and drawing on theoretical insights, there seem to be compelling reasons why commercialization should be undertaken by an entrepreneur. However, the simple models outlined above also suggest that – contrasting Schumpeter – integration of inventive and innovative stages should increase the probability of successful commercialization if 1), communication of technological knowledge is important for commercialization (equations 4 and 5), 2) firms have previous experience in commercialization of inventions yielding a cost advantage as compared to start-ups by inventors (equation 7), 3) cooperation between inventors and entrepreneurs enhances technological and market knowledge within a firm (equations 6b, 6c and 7).

2.2 Measuring inventions and commercialization: Previous studies

To measure inventions, the most frequently used variable is patents, where data has been collected from national patent offices. Patent offices do not know whether the patents have been commercialized, or whether the commercialization was successful. Patent databases with detailed information about commercialization have seldom been collected.[11] The few previous studies using such databases have focused on estimating the profits from patenting, or the market value of patents, rather than analyzing how different strategies are related to the performance (Rossman and Sanders, 1957; Sanders *et al.*, 1958; Sanders, 1962, 1964; Schmookler, 1966; Cutler, 1984; SRI International, 1985, Griliches *et al.*, 1987; Hall, 1993). The main conclusions of these studies are that the mean value of patents is positive, but the median value is zero or negative, thus indicating a very large dispersion in economic value.

Another strand of the patent literature has analyzed the renewal of patents (see e.g. Pakes 1986; Schankerman and Pakes 1986; Griliches, 1990). The owners must pay a renewal fee to keep their patents in force – in many countries every year. Griliches argues that the percentage of renewed patents indicates how large a share of the patents has a positive economic value after different numbers of years. The models in Pakes (1986) and Schankerman and Pakes (1986) are based on the assumption that more valuable patents are renewed for longer periods than less valuable patents. The main conclusions of these studies are that most patents have a low value and that it depreciates fast, and only a few have a

[10] Moreover, consumers are likely to trust experienced firms that have an established record of launching new products, which enhances the probability for successful commercialization.
[11] Very few studies have used questionnaires. See, for instance, Griliches (1990).

significant high value. In other words, the value distribution of patents is severely skewed to the right.

There are some problems with the renewal measurement. First, the renewal fee is a relatively low annual cost, implying that patents renewed for the whole statutory period may still have a low value. There is also an identification problem, where it is almost impossible for the observer to know whether the renewed patent has a low or a high value. Second, patents that are not renewed need not have a low value, since the product, based on the patent, might have been commercialized with a short lifetime. In this lifetime, the product could either have been profitable for the owner or not. Finally, the renewal studies do not say anything about whether the patent has been commercialized and whether any innovation has been introduced on the market. Although most commercialized patents can be expected to be renewed and most non-commercialized patents to be killed, there are many exceptions as shown in section 3.

Finally, there is another interesting aspect of previous studies: Irrespective of how the success, or the value, of patents has been measured, these studies have seldom related this measure to explanatory factors. An exception is Maurseth (2005), who tested how patent citations across and within technology fields influence the renewal of patents.

3. Database and descriptive statistics

In order to test how different strategies influence the performance of the entrepreneurship, we use a detailed database on individual Swedish patents.[12] In a previous pilot study (Svensson, 2002), the commercialization started within five years after the application year for most patents. According to Pakes (1986), most of the uncertainty about the value of the patent is resolved during the first three-four years after the patent application. Therefore, patents granted in 1998 were chosen for the current database.[13] In 1998, 2760 patents were granted in Sweden. 776 of these were granted to foreign firms, 902 to large Swedish firms with more than 1000 employees, and 1082 to Swedish individuals and firms with less than 1000 employees. Information about inventors, applying firms and their addresses for each patent

[12] All inventions do not result in patents. However, since an invention, which does not result in a patent, is not registered anywhere, there are two problems in empirically analyzing the invention rather than the patent. First, it is impossible to find these new ideas, products and developments among all firms and individuals. On the other hand, all patents are registered. Second, even if the "inventions" are found, it is difficult to judge whether they are sufficient improvements to be called inventions. Only the national and international patent offices make such judgements. Therefore, the choice of the patent rather than the invention is the only alternative for an empirical study of the commercialization process.

[13] The year the patent is granted is used here, but patents filed in a specific year might have been preferable. The choice of patents granted in a specific year is, however, not a problem in the statistical estimations.

was bought from the Swedish Patent and Registration Office (PRV). Thereafter, a questionnaire was sent out to the inventors.[14]

In the pilot survey carried out in 2002, it turned out that large Swedish firms refused to provide information on individual patents. Furthermore, it is impossible to persuade foreign firms to fill in questionnaires about patents. These firms are mostly large multinationals firms. Therefore, the population consists of 1082 patents granted to Swedish individuals and firms with less than 1000 employees. This sample selection is not a problem, as long as the conclusions drawn refer to small firms and individuals.

In the questionnaire, we asked the inventors about the work place where the invention was created, if and when the patent was commercialized, which kind of commercialization mode was chosen, as well as the outcome of the commercialization. As many as 867 of the inventors filled in and returned the questionnaire, i.e., the response rate was 80% (867 out of 1082). This response rate is satisfactorily high, considering that inventors or applying firms usually regard information about inventions and patents to be secret. Non-responses are primarily due to the addresses from PRV being out of date and to a smaller degree due to inventors refusing to reply. The term commercialization here means that the owners of the patent have introduced an innovation in an existing or in a new firm, licensed or sold the patent.

3.1 Descriptive statistics

The commercialization rate of the 867 patents is described across firm groups in Table 1. The major share – 85 percent – of the patents was applied for between 1994 and 1997. As many as 408 patents (47%) were granted to individual inventors,[15] while 116 (13%), 201 (23%) and 142 (17%) patents were granted to medium-sized firms (101-1000 employees), small firms (11-100 employees) and close companies (2-10 employees), respectively. In 2003, commercialization had been started for 530 of these patents. The commercialization rate of the firm groups varies between 66 and 74%, whereas the corresponding rate of the individuals is not higher than 52%. A contingent-table test suggests there to be a significant difference in the commercialization rate between firms and individuals. The chi-square value is 30.55 (with 3 d.f.), significant at the one-percent level.

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[14] Each patent always has at least one inventor and often also an applying firm. The inventors or the applying firm can be the owner of the patent, but the inventors can also indirectly be owners of the patent, via the applying firm. Sometimes the inventors are only employed in the applying firm which owns the patent. If the patent had more than one inventor, the questionnaire was sent to one inventor only.

[15] The group of individual inventors includes private persons, self-employed inventors as well as two-three inventors who are organized in trading companies or private firms without employees.

******** [Table 1] ********

At the end point of observation (year 2003), the inventors were asked to estimate whether the commercialized invention would yield profit, attain break-even or result in a loss. If they did not know, the reply was registered as a missing value (uncertain outcome).[16] In Table 2, discrete values of the outcome in profit terms are described across firm groups. It would have been desirable to measure the outcome in money terms. However, such information was impossible to collect.[17] Since the patents were granted in 1998 and some of them were commercialized even later, the expected profit level could not be determined for around 12% of the commercialized patents. As described in the table, the outcome is quite different across firm groups, where the group of individual inventors has the least favorable outcome, but there may be other underlying factors explaining this difference, e.g., the commercialization mode or the fact that the new product replaced an earlier one.

******** [Table 2] ********

In Table 3, outcomes are described across commercialization mode and whether inventors were active during the commercialization. Patents commercialized in new firms have a worse performance than the other modes. Let us divide the modes into two groups: 1) somebody else than the inventor is responsible for the commercialization (selling, licensing the patent or the existing firm where the inventor is employed); and 2) the inventor commercializes in his own firm (existing firm where the inventor is an owner, and new firms). It is then obvious that the former group has a better performance. A contingent table test based on the subtotals gives the chi-square-value 28.70, significant at the one-percent level. In the lower part of Table 3, there is no evidence that the activity of inventors during the commercialization has any impact on the performance. Thus, based on descriptive statistics, it seems like the Schumpeter view that the stages of invention and innovation should be separated activities is correct.

******** [Table 3] ********

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[16] For a vast majority of the patents, the commercialization had reached such a stage that there was no uncertainty at all about the performance. The missing values could also be treated as a fourth, uncertain, outcome.

[17] It is very complicated to estimate profit flows, because most firms have many products in their statement of account, and many individuals do not have any statement of account at all.

One objection against the measurement of success in this study would be that the patent might be profitable for the owners, even if it is never commercialized, e.g., if it serves as a shadow-patent. If this is the case, the owner should have more similar granted patents. Among the commercialized patents in the database, 46% of the owners have at least one more similar patent. Among non-commercialized patents, this percentage share is only 33%. If the patent had not been commercialized, the inventor was also asked: why? Among the 337 non-commercialized patents, only 15 inventors answered that the patent served as a defensive patent – with the purpose of deterring competitors from using the invention or defending other patents (shadow-patent). Thus, we conclude that keeping patents to defend other patents is less common among individuals and small firms. This strategy is more frequent among large multinational firms.

In Table 4, the outcome of commercialization is shown for expired and renewed patents. Owners must pay an annual renewal fee to the national patent office to keep their patents in force. If the renewal fee is not paid in one single year, the patent expires. The general pattern is that patents still alive have a higher share of successful outcomes as compared to expired patents, but the probability of a successful outcome also increases the longer the life of the expired patent. However, there are many exceptions. For example, some patents, which expired after only 1-5 years, were profitable, while many patents still renewed and commercialized have been losses to the owners. Thus, by only studying the pattern of renewal rates, as most previous studies have done, incorrect conclusions might be drawn about the profitability of patents.

******** [Table 4] ********

4. Econometric model and hypotheses

4.1 Econometric model

The dependent variable, *PERFORM*, in the empirical estimations measures the performance in profit terms of the commercialization for the original owner of the patent. It can take on three different discrete values denoted by index *k*:

- Profit, *k*=2;
- Break-even, *k*=1;
- Loss, *k*=0.

Since it is possible to order the three alternatives, an ordered probit model is applied.[18] A multinomial logit model fails to take the ranking of the outcomes into account. On the other hand, an ordinary regression would treat the differences between 0 and 1 the same as those between 1 and 2. This would be an error, since the discrete outcomes are only ranked. The ordered probit model can be described in the following way (Greene, 1997):

$$y_i^* = X_i \alpha + \varepsilon_i \quad , \tag{8}$$

where $\mathbf{X_i}$ is a vector of patent-specific characteristics. The vector of coefficients, α, shows the influence of the independent variables on the profit level. The residual vector $\boldsymbol{\varepsilon_i}$ represents the combined effects of unobserved random variables and random disturbances. The residuals are assumed to have a normal distribution and the mean and variance are normalized to 0 and 1. The vector with the latent variable, $\mathbf{y_i^*}$, is unobserved. The model is based on the cumulative normal distribution function, $F(X\alpha)$**,** and is estimated via maximum likelihood procedures. The difference with the two-response probit model is here that a parameter (threshold value), ω, is estimated by α. The probabilities $P_i(k) = P_i(y=k)$ for the three outcomes are:

$$P_i(0) = F(-X\alpha) \quad ,$$

$$P_i(1) = F(\omega - X\alpha) - F(-X\alpha) \quad , \tag{9}$$

$$P_i(2) = 1 - F(\varpi - X\alpha) \quad ,$$

$$where \sum_{k=0}^{2} P_i(k) = 1 \quad .$$

The threshold value, ω, must be larger than 0 for all probabilities to be positive.

An objection against the sample and the chosen statistical model would be that the patents, which are commercialized, are not a random sample of patents, but have specific characteristics that led to them being commercialized in the first place. This could result in misleading parameter estimates. An appropriate statistical model is therefore an ordered

[18] There were 86 observations in the database, where the owner could not specify the expected profit level of the commercialization. These missing values could also be treated as a fourth, uncertain, outcome of *PERFORM*. A multinomial logit model, where all four alternatives were included, was estimated. Then, we accomplished a test for independence of irrelevant alternatives (Hausmann and McFadden, 1984). When excluding the uncertain alternative in the multinomial logit model, this test cannot be rejected. Thus, the parameter estimates between the other outcome alternatives are almost unaffected if the uncertain alternative is excluded. Then, there is no problem in excluding those patents with unknown profit-levels from the estimations.

probit model with sample selectivity (Greene, 2002). In the first step, a probit model estimates how different factors influence the decision to commercialize the patent:

$$d_i^* = Z_i \theta + u_i \quad , \qquad (10)$$
$$d_i = 1 \;\; if \;\; d_i^* > 0 \;\; and \;\; 0 \;\; otherwise,$$

where d_i* is a latent index and d_i is the selection variable, indicating whether the patent is commercialized or not. $\mathbf{Z_i}$ is a vector of explanatory variables which influence the probability that the patent is commercialized and $\boldsymbol{\theta}$ is a vector of parameters to be estimated. $\mathbf{u_i}$ is a vector of normally distributed residuals with zero mean and a variance equal to 1.

From the probit estimates, the selection variable d_i is then used to estimate a full information maximum likelihood model of the ordered probit model (Greene, 2002).[19] At the same time, the first step probit model is re-estimated. The residuals [ε, u] are assumed to have a bivariate standard normal distribution and correlation ρ. There is selectivity if ρ is not equal to zero.

4.2 Explanatory variables

In this section, we will present the expected impact of the explanatory variables on the performance of commercialization. The basic statistics regarding the explanatory variables are shown in Table 5. Our prime interest concerns the role of the inventor.

There are five main modes of commercialization: 1) selling the patent; 2) licensing the patent; 3) commercialization in an existing firm where inventors are employed; 4) commercialization in an existing firm where inventors are owners; and 5) commercialization in a new firm. We define four different groups of dummies for the commercialization mode, which are included in four different models.

In our first definition, we use the first mode of commercialization chosen by the owners when the commercialization starts. Since the five modes are then mutually exclusive, four different additive dummies are assigned. *SELL1* takes on the value of 1 if the patent was sold and 0 otherwise. *LIC1* equals 1 if the patent was licensed, and 0 otherwise. *EMPL1* takes on the value of 1 if the patent was commercialized in an existing firm where inventors are employed and 0 otherwise. If the patent was commercialized in a new firm, *NEW1* equals 1, and 0 otherwise. The reference group here is patents commercialized in an existing firm where the inventor is the owner.

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[19] This is not a two-step Heckman model. No Lambda is computed and used in the second step.

The choice of mode is expected to affect the profit level. According to Schumpeter, the inventor should let somebody else accomplish the commercialization. Thus, a positive impact of *SELL1* and *LIC1* on the profit-level is expected. The hypothesized impact of *EMPL1* is also positive, since the owner should have other characteristics necessary for commercialization compared to the inventor, when the patent is commercialized in an existing firm. On the other hand, the inventor should not be competent as firm creator. *NEW1* should therefore have a negative impact on the profit level.

******** [Table 5] ********

However, the owner may change the commercialization mode. This occurs in 46 cases. In our second definition, the mode dummies take on the value of 1 if that mode occurs any time. The four dummies *SELL2*, *LIC2*, *EMPL2* and *NEW2* are similar to the dummies above with the only difference that they also take on the value of 1 if the owner chooses that specific mode at a later time point in the commercialization. *SELL2*, *LIC2* and *EMPL2* are expected to have the highest parameter estimates and *NEW2* the lowest.

In the third definition, we merge the three dummies *SELL1*, *LIC1* and *EMPL1* into one dummy *EXTERN1*. Thus, *EXTERN1* takes on the value of 1 if somebody else than the inventor is responsible for the initial commercialization, and 0 if the inventor commercializes in his own firm (existing or new). In our fourth definition, the dummy *EXTERN2* is similar to *EXTERN1*, but also takes on the value of 1 if the patent is sold or licensed at a later phase of the commercialization. Both *EXTERN1* and *EXTERN2* are expected to have a positive influence on performance – in line with Schumpeter.

According to the theoretical discussion in section 2, it is important that the inventors, who have specific knowledge about the patent, are active during the commercialization which contrasts with Schumpeter's separation hypothesis. Activity is an indication of inventors' knowledge being transmitted during the commercialization, but it is also a signal to the customers. We measure inventor activity (*ACTIVE*) as a dummy, which equals 1 if the inventors had an active role during the commercialization and 0 otherwise. *ACTIVE* is expected to have a positive influence on the profit level.

However, the influence of the inventors' activity should depend on the commercialization mode. When inventors are also owners and commercialize in an existing firm or start a new firm, they are almost always active. When the patent is sold, the activity of inventors should have no impact on the original owners' profit, since the owners have already been paid. The interesting issue to test is when somebody else than inventors is responsible for the commercialization and inventors have an incentive to work hard during the commercialization. *ACTIVE1* is an interaction dummy between *ACTIVE* and *LIC* or *EMPL*. Thus, it takes on the value of 1 when inventors are active and when the patent is licensed or commercialized in an existing firm where inventors are employed. A positive impact on the profit is expected. *ACTIVE2* is also an interaction dummy between *ACTIVE* and the other three modes of commercialization. *ACTIVE2* equals 1 when inventors are active and the patent is sold or commercialized in a new firm or an existing firm where inventors are owners.

It is expected that firms, which have marketing, manufacturing and financial resources in-house, have better possibilities of becoming successful in their commercialization as compared to individuals. *MEDIUM* is a dummy that takes on the value of 1 for medium-sized firms with 101-1000 employees and 0 otherwise. *SMALL* equals 1 for small firms with 11-100 employees and 0 otherwise. Finally, *CLOSE* is a third dummy taking the value of 1 for closely held companies with 2-10 employees and 0 otherwise. All parameter estimates are expected to be positive, since the firm dummies are here related to the reference group of individual inventors. Furthermore, the larger is the firm, the better are the possibilities of becoming successful. Thus, the parameter estimate of *MEDIUM* is expected to be larger than that of *SMALL* which, in turn, is expected to be larger than *CLOSE*.

REPLACE is a dummy that equals 1 if the product based on the patent replaces a previous product of the patent owner, and 0 otherwise. If the new product replaces an earlier product, the commercialization is expected to be facilitated. The owner then already has customers, distribution channels, marketing, etc. A positive impact on the profit level is expected. *MOREPAT* is an additive dummy, which equals 1 if the inventors or the applying firm have more competitive Swedish patents in the same technology area, and 0 otherwise. Given that a patent is commercialized, many similar patents imply a strong position and defense in the market and should increase the probability of success. Many similar patents can also be an indication that the owners have more knowledge and experience of the area. Thus, a positive impact on the ranked outcomes is expected. A further variable measuring the complexity of the product is included. *PARTSYST* equals 1 if the patent is part of a larger system/product, and 0 otherwise. The expected impact on the profit level is unsettled.

COMYEAR measures the year when the commercialization started. The later is the starting year, the fewer are the years until the end of the observation (2003). *WAITYEAR* measures the number of years between the application year and the starting year of the commercialization. *COMYEAR* and *WAITYEAR* might, but need not be correlated since the patents have different application years. Neither *COMYEAR* nor *WAITYEAR* have any expected impact on the profit level.

Some specific characteristics of the inventors are also included in the mode. *ETH* measures the share of inventors who belong to ethnical minorities, i.e. an ethnical background other than West European or North American. It is expected that ethnical minorities have more problems with the commercialization. Thus, a negative impact on *PERFORM* is expected. *SEX* measures the share of inventors who are females. No specific influence on *PERFORM* is expected.

Different technologies are likely to be connected with different payoffs and risks. Consequently, the technology class can affect the profit level, given that the patent is commercialized. Patents are divided into 30 technology groups according to Breschi *et al.* (2004). These groups are based on the patents' main IPC-Class. However, all technology groups are not represented in the dataset and some groups do not have enough observations.[20] Therefore, only 16 groups and 15 additive dummies are used in the present study.

The data is also divided into six different kinds of regions according to the Swedish Agency for Economic and Regional Growth (1998): Large-city regions, university regions, regions with important primary city centers, regions with secondary city centers, small regions with private employment, and small regions with government employment. Five additive dummies are included for these six groups in the estimations.

Something should also be said about the explanatory variables, which are expected to affect the commercialization decision (*COM*) and are included in the probit equation when estimating the first step of the Heckman model. The identification of this step is based on the model in Svensson (2004), where the commercialization decision was analyzed using survivals models.[21] *MEDIUM*, *SMALL*, *CLOSE*, *MOREPAT*, *ETH*, *SEX*, the region and technology dummies, as described above, are included in the first step. Furthermore, time dummies for the application year, and six further variables (*GOVRD*, *PRIVRD*, *OTHRD*, *OWNER*, *KOMPL* and *INVNMBR*) are added.[22] On the other hand, variables characterizing the commercialization, e.g., commercialization mode (*SELL*, *LIC, EMPL* and *NEW*), *ACTIVE*,

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[20] A technology class must have at least one observation in each of the three outcome alternatives, to obtain an own technology dummy. Technology classes without enough observations are instead merged with other closely related classes (Breschi *et al.*, 2004).

[21] The difference is that a probit model is used in the first step of the present model, whereas Svensson (2004) used survival models.

[22] *GOVRD* measures how large a share of the R&D-costs that was financed from the government. Similarly, *PRIVRD* and *OTHRD* measure how large shares of this financing were from private venture capitalists and research foundations / universities, respectively. *OWNER* measures how large a share (in percent) of the patent that is directly or indirectly owned by the inventors. The dummy variable *KOMPL* takes on the value of 1 if complementing patents are needed to create a product and 0 otherwise. *INVNMBR* measures the number of inventors of the patent.

REPLACE, etc., cannot be included. This means that different explanatory variables are included in the probit and ordered probit models when sample selectivity is taken into account.

5. Empirical estimations

Four different models are estimated. In Model I, the first definition of commercialization mode is used, i.e. the first choice when the patent is commercialized. In Model II, the second definition is used, where a specific patent can have one or two modes of commercialization. In Models III and IV, we instead include the alternative dummies, *SEP1* and *SEP2*, which measure whether somebody else than the inventor is responsible for the commercialization. To test for robustness, three variants with region and technology dummies are estimated. In these variants, region dummies (A), technology dummies (B) and both region and technology dummies (C) are included. The models are also estimated by full information maximum likelihood, taking account of sample selectivity. The previous inclusion of dummy variables (A-C) is then repeated (D-F).

The results of the ordered probit estimations of Model I are shown in Table 6. In general, sample selectivity (Models D-F) decreases the significance levels of the parameters and reduces the parameter estimates. Considering the commercialization mode, licensing or selling the patent has a positive impact on the profit level as compared to commercializing in an existing firm, where the inventor is the owner. *SELL1* is always significant at the five-percent level, whereas *LIC1* has different significant levels. The parameter of *NEW1* is negative, but not even significant at the ten-percent level. By recalculating the parameter estimates, however, it is easily seen at the bottom of the table that selling or licensing the patent has a positive influence on the profit level as compared to the new firm alternative – the differences are always significant at the five-percent level. Thus, it is more profitable that the inventors let somebody else be responsible for the commercialization than to start a new firm. This corroborates Schumpeter's stage approach.

However, a result that contradicts Schumpeter is that the activity of the inventors during the commercialization is very important for the performance. We are especially interested in *ACTIVE1*, which measures if the inventors were active when somebody else than the inventor is responsible for the commercialization. *ACTIVE1* always has a positive and highly significant impact on the profit-level. Thus, it seems like inventors are more important as knowledge transmitters than as firm creators/entrepreneurs when patents are commercialized. These results also hold when we take account of sample selectivity.

ACTIVE2 is also significant, but the interpretation of this influence is problematic, since it is obvious that inventors are active if they are owners of the patent.

As expected, all firm group dummies have positive and strongly significant impacts on the profit level, implying that patents commercialized by firms have a higher probability of success as compared to patents commercialized by individuals. However, the parameter of *CLOSE* is not significant when sample selectivity is taken into account. Furthermore, the parameters of *MEDIUM*, *SMALL* and *CLOSE* are not significantly different from each other. Among the other variables, only *REPLACE* and *MOREPAT* have significant effects on the profit level. The significance level of *REPLACE* depends on which dummy variables are included, whereas the significance of *MOREPAT* disappears when sample selection is included.

******** [Table 6] ********

In Table 7, the results of Model II are shown. Here, we use another definition of the mode of commercialization. Selling or licensing the patent are still the most favorable alternatives, whereas staring a new firm has the worst performance. The only difference here is that the significance level of *LIC2* is somewhat higher. Once again, *SELL2* and *LIC2* are always significantly different from *NEW2*. Thus, it is more profitable for the inventors to let somebody else accomplish the commercialization. The results for the other explanatory variables are similar in Tables 6 and 7.

******** [Table 7] ********

The main results of Models III and IV are described in Table 8.[23] The estimated parameters of *EXTERN1* and *EXTERN2* are positive and significant, at least at the 5 percent level in all runs. Thus, there is a higher probability of successful commercialization if somebody else than the inventor is responsible for the commercialization, which is in line with Schumpeter.

******** [Table 8 ********

[23] Only the results for the main explanatory variables are shown. The results for the other variables are similar to those in Models I and II (Tables 6 and 7).

The size interpretation of the important or significant estimated parameters is shown in Table 9. These effects are calculated around the means of the x_i:s. The marginal effects on the probabilities are lower when sample selection is included (I-F). If the patent is sold instead of commercialized in an existing firm, where the inventor is the owner, the probability of a profitable commercialization increases by 23 percentage units in model I-F. At the same time, the probabilities of a breakeven or a loss result decrease by 11 and 12 percentage units, respectively. If the inventors are active during the commercialization when somebody else is responsible for the commercialization, the probability of a profitable outcome increases by 17 percentage units in model I-F. The marginal effects of the other dummy variables are interpreted in the same way. We also calculate the marginal effects for *EXTERN1* in Models III-C and III-F. If the inventor is not responsible for the commercialization, the probability of a successful commercialization increases by 23 percentage units, while the probability of a breakeven or loss result decreases by 15 and 8 percentage units, respectively

******** [Table 9] ********

Additive dummies for unique owners (firms/inventors) were also included in the estimations, but this did not work out very well. When including dummies for unique owners, the models were characterized by severe multicollinearity problems with extremely high standard errors for the owner dummies.[24]

6. Concluding remarks

Drawing on insights gained in industrial organization and information economics, we have empirically analyzed Schumpeter's original assertion that the stages of invention and innovations should be separated activities. In addition, we provide a framework where the theories of Knight's risk defining entrepreneur and Schumpeter's innovative entrepreneur can be bridged. An entrepreneur who integrates the inventive stage in the innovation process enhances the possibilities of successful commercialization, since this facilitates customer-specific adaptation and the transmission of information, simultaneously as uncertainty is reduced. This serves to expand market opportunities for the entrepreneur. A future research

[24] Among the 530 commercialized patents in the sample, there are 460 unique owners (firms/inventors). 418 owners only have one commercialized patent, 29 owners have two patents, and only 13 owners have at least three patents. Dummies can only be assigned to those 42 owners with at least 2 patents. The multicollinearity problems occurred even when all technology and region dummies were excluded and when dummies were only included for those 13 owners with at least three commercialized patents.

task would be to provide a rigorous theoretical setting where both these aspects of entrepreneurship are included.

The empirical analysis is based on a survey covering Swedish patents owned by small firms and individuals, where the response rate is 80 percent. The data allows us to observe the performance in profit terms when patents are commercialized as well as which strategies the inventors and owners have used. The estimations show that commercialization performance is superior when a patent is sold or licensed, or when the inventor is employed, as compared to the alternative when the inventor commercializes in his own existing or new firm. In the former case, the probability of a successful commercialization is 23 percentage units higher than in the latter case. This is in line with Schumpeter's view that invention and innovation should be separate stages. However, another result is that the activity of inventors during the commercialization is important for the performance. This is especially interesting to observe when the inventor is not responsible for the commercialization (the patent is licensed, sold or when the inventor is employed and not an owner). The explanation would be that the inventor is important for further adaptation of the innovation and to reduce uncertainty. In this sense, the results contradict Schumpeter's view that invention and innovation are separate stages. The overall interpretation of the estimations is that inventors are more successful as transmitters of knowledge than as firm creators or entrepreneurs.

If it is better to let somebody else be responsible for the commercialization, why do not all inventors sell or license their patents? There are two possible explanations. Firstly, licensing and selling contracts are characterized by asymmetric information. Inventors know much more about the patent than potential manufacturing firms. This causes high transaction and search costs when bringing inventors and manufacturing firms together. It is likely that too few patents are sold or licensed. The only alternative for many inventors is then to commercialize in their own firms. Another explanation for the poor performance of inventors when they attempt to commercialize a new product may be lack of experience and over-optimistic behavior. Such interpretation corroborates previous research by, for instance, de Meza and Southey (1996), Arabsheibani et al. (2000) and Fraser and Greene (2006).

References

Aghion, P. and P. Howitt, 1992, 'A Model of Growth through Creative Destruction', *Econometrica*, 60, 323-351.

Aghion, P. and P. Howitt, 1998, *Endogenous Growth Theory*, MIT Press, Ca. Massachusetts.

Arabsheibani, G., de Meza, D., Maloney, J. and Pearson, B., 2000, "And a Vision Appeared to Them of Great Profit: Evidence of Self-Deception Among the Self-Employed", *Economics Letters*, 67, 35-44.

Bianchi, M. and M. Henrekson, 2004, 'Is the Neoclassical Entrepreneur Really Entrepreneurial?', *mimeo*, Stockholm School of Economics.

Breschi, S., F. Lissoni and F. Malerba, 2004, 'The Empirical Assessment of Firms' Technological Coherence: Data and Methodology', in *The Economics and Management of Technological Diversification*, J. Cantwell, A. Gambardella and O. Granstrand (eds.), Routledge, London.

Carroll, G.R. and M.T. Hannan, 2000, *The Demography of Corporations and Industries*, Princeton University Press, Princeton, NJ.

Casson, M., 2005, 'Review of Scott Shane, A General Theory of Entrepreneurship, Cheltenham: Edward Elgar, 2003', *Small Business Economics*, 24(5), 423-430.

Cutler, R.S., 1984, 'A Study of Patents Resulting from NSF Chemistry Program', *World Patenting Information*, 6, 165-69.

De Meza, D. and Southey, C., 1996, "The Borrower's Curse: Optimism, Finance and Entrepreneurship", *Economic Journal*, 106, 375-86.

Ericsson, R. and Pakes, A., 1995, "Markov Perfect Industry Dynamics: A Framework for Empirical Work", *Review of Economic Studies*, 62, 53-82.

Frank, M.Z., 1988, "An Intertemporal Model of Industrial Exit", *Quarterly Journal of Economics*, 103, 333-44.

Frankel, M., 1955, 'Obsolescence and Technological Change in a Maturing Economy', *American Economic Review*, 52, 995-1022.

Fraser, S. and Greene, F.J., 2006, "The Effects of Experience on Entrepreneurial Optimism and Uncertainty", *Economica*, 73, 169-192.

Greene, W.H., 1997, *Econometric Analysis*, 3rd edition, Prentice-Hall, Upper Saddle River, NJ.

Greene, W.H., 2002, *Econometric Modeling Guide Vol. 1, Limdep Version 8.0*, Econometric Software Inc., Plainview, NY.

Griliches, Z., 1990, 'Patent Statistics as Economic Indicators: A Survey', *Journal of Economic Literature*, 28, 1661-1707.

Griliches, Z., B.H. Hall and A. Pakes, 1987, 'The Value of Patents as Indicators of Inventive Activity', In Dasqupta, P. and P. Stoneman (eds.), *Economic Policy and Technological Performance*, Cambridge University Press, Cambridge, Mass.

Grossman, G. and O. Hart, 1986, 'The Costs and Benefits of Ownership: A Theory of Lateral and Vertical Integration', *Journal of Political Economy*, 94, 691-719.

Hall, B.H., 1993, 'The Stock Market Valuation of R&D Investment During the 1980s', *American Economic Review*, 83, 259-64.

Hausmann, J. and D. McFadden, 1984, ‘A Specification Test for the Multinomial Logit Model’, *Econometrica*, 52, 1219-40.

Jovanovic, B., 1982, “Selection and Evolution of an Industry”, *Econometrica*, 50, 649-70.

Kirzner, I.M., 1973, *Competition and Entrepreneurship*, University of Chicago Press, Chicago.

Knight, F., 1921, *Risk, Uncertainty and Profit*, Houghton Mifflin, Boston.

Lazear, E.P., 2005, ‘Entrepreneurship’, *Journal of Labor Economics*, 23(4), 649-680.

Lindbeck, A. and D. Snower, 2000, ‘Multitask Learning and the Reorganization of Work: From Tayloristic to Holistic Organization’, *Journal of Labour Economics*, 18, 353-376.

Maurseth, P.B., 2005, ‘Lovely but Dangerous: The Impact of Patent Citations on Patent Renewal’, *Economics of Innovation and New Technology*, 14, 351-74.

Pakes, A., 1986, ‘Patents as Options: Some Estimates of the Value of Holding European Patent Stocks’, *Econometrica*, 54, 755-84.

Rossman, J. and B.S. Sanders, 1957, ‘The Patent Utilization Study’, *Patent, Trademark and Copyright Journal of Research and Education*, 1, 74-111.

Sanders, B.S., 1962, ‘Speedy Entry of Patented Inventions into Commercial Use’, *Patent, Trademark and Copyright Journal of Research and Education*, 6, 87-116.

Sanders, B.S., 1964, ‘Patterns of Commercial Exploitation of Patented Inventions by Large and Small Corporations’, *Patent, Trademark and Copyright Journal of Research and Education*, 8, 51-92.

Sanders, B.S., J. Rossman and L.J. Harris, 1958, ‘The Economic Impact of Patents’, *Patent, Trademark and Copyright Journal of Research and Education*, 2, 340-62.

Schankerman, M. and A. Pakes, 1986, ‘Estimates of the Value of Patent Rights in European Countries During the Post-1950 Period’, *Economic Journal*, 96, 1052-76.

Scherer, F., 1980, *Industrial Market Performance and Economic Performance*, Rand McNally, Chicago.

Schmookler, J., 1966, *Invention and Economic Growth*, Harvard University Press, Cambridge, Mass.

Schumpeter, J.A., 1911 [1934], The Theory of Economic Development, Harvard University Press, Cambridge, Mass.

Schumpeter, J.A., 1942, Capitalism, Socialism, Democracy, Harper and Row, New York.

Schumpeter, J.A., 1947, “The Creative Response in Economic History”, Journal of Economic History, 7, 149-159.

Shane, S. and S. Venkataraman, 2000, 'The Promise of Entrepreneurship as a Field of Research', *Academy of Management Review*, 25, 217-221

SRI International, 1985, *NSF Engineering Program Patent Study*, Menlo Park, CA.

Svensson, R., 2002, 'Commercialization of Swedish Patents: A Pilot Study in the Medical and Hygiene Sectors', IUI Working paper No. 583, IUI, Stockholm.

Svensson, R., 2004, 'Commercialization of Patents and External Financing during the R&D-Phase', IUI Working paper No. 624, IUI, Stockholm.

Teece, D., 1988, 'Technological Change and the Nature of the Firm', in Dosi, G. (ed.), *Technical Change and Economic Theory*, Pinter Publishers, London.

van Hayek, F., 1937, "Economics and Knowledge", *Economica*, 4, 879-91.

Wennekers, S. and R. Thurik, 1999, 'Linking Entrepreneurship and Economic Growth', *Small Business Economics*, 13, 27-55.

Table 1. Commercialization of patents across firm sizes and inventors' ownership, number of patents and percent.

Kind of firm where the invention was created	Number of patents: Commercialization Yes	No	Total	Percent Commercialized
Medium-sized firms (101-1000 employees)	77	39	116	66 %
Small firms (11-100 employees)	137	64	201	68 %
Close companies (2-10 employees)	105	37	142	74 %
Inventors alone (1-4 inventors)	211	197	408	52 %
Total	**530**	**337**	**867**	**61 %**

Table 2. Performance of the commercialization across firm groups, number of patents.

Kind of firm where the invention was created	Performance: Profit	Break-even	Loss	Missing value	Total
Medium-sized firms	53	18	3	3	77
Small firms	95	22	15	5	137
Close companies	48	12	27	18	105
Inventors alone	46	43	84	38	211
Total	**242**	**95**	**129**	**64**	**530**

Table 3. Performance of the commercialization across commercialization modes and active role of the inventors, number of patents.

Commercialization mode	Performance				Total
	Profit	Break-even	Loss	Missing value	
Sold patent	10	3	7	0	20
Licensed patent	19	9	14	10	52
Existing firm, inventor is employed	103	30	15	10	158
Subtotal	*132*	*42*	*36*	*20*	*230*
Existing firm, inventor is owner	100	45	62	25	232
New firm	10	8	31	19	68
Subtotal	*110*	*53*	*93*	*44*	*300*
Total	**242**	**95**	**129**	**64**	**530**
	Chi-square (3 d.f.) = 28.70 *** (based on sub-totals)				

Active role of the inventors during the commercialization	Profit	Break-even	Loss	Missing value	Total
No	26	18	20	4	68
Yes	216	77	109	60	462
Total	**242**	**95**	**129**	**64**	**530**
	Chi-square (3 df) = 5.50				

Table 4. Performance of the commercialization across renewed and expired patents, number of patents.

Renewed / expired patents		Commercialized patents					Not commer-cialized	**Total**
		Performance				Subtotal		
		Profit	Break-even	Loss	Missing value			
Expired patents, number of years after application	1–3 years	5	5	9	0	19	33	**52**
	4–5 years	11	7	23	0	41	55	**96**
	6–7 years	33	17	29	0	79	58	**137**
	> 7 years	24	6	20	0	50	52	**102**
Subtotal of expired patents		73	35	81	0	189	198	**387**
Patents renewed in 2004		169	60	48	64	341	139	**480**
Total		**242**	**95**	**129**	**64**	**530**	**337**	**867**

Table 5. Explanatory variables and hypotheses.

Variable denotation		Variable description	Expected impact on *PERFORM*	Mean	Std dev.
I	*SELL1*	Dummy which equals 1 if the owners sold the patent (first choice), and 0 otherwise	+	0.043	0.203
	LIC1	Dummy which equals 1 if the owners licensed the patent (first choice), and 0 otherwise	+	0.090	0.287
	EMPL1	Dummy which equals 1 if commercialized in an existing firm (first choice), where inventors are employed (not owners), and 0 otherwise	+	0.318	0.466
	NEW1	Dummy which equals 1 if the owners (inventors) started a new firm (first choice), and 0 otherwise	–	0.105	0.307
II	*SELL2*	Dummy which equals 1 if the owners sold the patent (first or second choice), and 0 otherwise	+	0.116	0.320
	LIC2	Dummy which equals 1 if the owners licensed the patent (first or second choice), and 0 otherwise	+	0.097	0.296
	EMPL2	Dummy which equals 1 if commercialized in an existing firm (first or second choice), where inventors are employed (not owners), and 0 otherwise	+	0.318	0.466
	NEW2	Dummy which equals 1 if the owners (inventors) started a new firm (first or second choice), and 0 otherwise	–	0.116	0.320
III	*EXTERN1*	Dummy which equals 1 if somebody else than the inventor is responsible for the commercialization (first choice), and 0 if the inventor commercializes in his own firm.	+	0.451	0.440
IV	*EXTERN2*	Dummy which equals 1 if somebody else than the inventor is responsible for the commercialization (first or second choice), and 0 if the inventor commercializes in his own firm.	+	0.509	0.456
ACTIVE		Dummy which equals 1 if inventors are active during the commercialization, and 0 otherwise	+	0.863	0.345
ACTIVE1		Interaction dummy between *ACTIVE* and *LIC1* or *EMPL1*	+	0.558	0.497
ACTIVE2		Interaction dummy between *ACTIVE* and *SELL1*, *NEW1*, or if the patent was commercialized in an existing firm where inventors are owners	?	0.305	0.461
MEDIUM		Dummy which equals 1 for medium-sized firms (101-1000 employees), and 0 otherwise	+	0.159	0.366
SMALL		Dummy which equals 1 for small firms (11-100 employees), and 0 otherwise	+	0.283	0.451
CLOSE		Dummy which equals 1 for close companies (2-10 employees), and 0 otherwise	+	0.187	0.390
REPLACE		Dummy which equals 1 if the product replaced a previous product for the owners	+	0.082	0.274
MOREPAT		Dummy which equals 1 if the owners have more substituting patents, and 0 otherwise	+	0.453	0.498
PARTSYSTEM		Dummy which equals 1 if the product is a part of a larger system, and 0 otherwise	?	0.159	0.366
COMYEAR		Starting year of the commercialization	?	1997	2.24
WAITYEAR		Number of years between patent application and start of commercialization	?	1.33	1.64
ETH		Share of inventors with an ethnical background other than Western European or North-American	–	0.023	0.147
SEX		Share of inventors who are females	?	0.021	0.132

Note: The roman figures I, II, II and IV refer to in which model the variables are included. The signs "+.", "–" and "?" indicate a positive, a negative and an unsettled expected influence on the profit level, respectively.

Table 6. Empirical estimations of the ordered probit model. Model I.

Dependent variable: *PERFORM*	Statistical model:					
Explanatory variables	Ordered probit model (without sample selection)			Ordered probit model (with sample selection)		
	Model					
	I-A	I-B	I-C	I-D	I-E	I-F
SELL1 (dummy)	1.06 ***	1.03 **	1.09 ***	0.86 **	0.79 **	0.83 **
	(0.39)	(0.40)	(0.41)	(0.36)	(0.36)	(0.38)
LIC1 (dummy)	1.13 **	1.00 *	1.14 **	0.89 *	0.76	0.83 *
	(0.51)	(0.51)	(0.53)	(0.50)	(0.47)	(0.50)
EMPL1 (dummy)	0.73	0.52	0.74	0.61	0.45	0.58
	(0.49)	(0.49)	(0.50)	(0.45)	(0.43)	(0.45)
NEW1 (dummy)	-0.35	-0.36	-0.37	-0.30 *	-0.29	-0.29
	(0.22)	(0.22)	(0.23)	(0.18)	(0.19)	(0.19)
ACTIVE1 (dummy)	0.57 ***	0.68 ***	0.61 ***	0.48 **	0.55 ***	0.50 **
	(0.21)	(0.21)	(0.22)	(0.21)	(0.20)	(0.21)
ACTIVE2 (dummy)	1.19 ***	1.13 ***	1.22 ***	0.97 **	0.89 **	0.92 **
	(0.43)	(0.44)	(0.45)	(0.41)	(0.39)	(0.41)
MEDIUM (dummy)	1.24 ***	1.33 ***	1.30 ***	0.85 ***	0.83 **	0.79 **
	(0.28)	(0.30)	(0.30)	(0.32)	(0.32)	(0.42)
SMALL (dummy)	0.98 ***	1.03 ***	0.97 ***	0.66 ***	0.64 ***	0.58 ***
	(0.20)	(0.21)	(0.21)	(0.22)	(0.22)	(0.22)
CLOSE (dummy)	0.53 ***	0.64 ***	0.62 ***	0.22	0.27	0.23
	(0.18)	(0.18)	(0.18)	(0.19)	(0.19)	(0.20)
REPLACE (dummy)	0.54 **	0.43	0.47 *	0.49 **	0.39	0.43 *
	(0.26)	(0.26)	(0.27)	(0.23)	(0.24)	(0.24)
MOREPAT (dummy)	0.31 **	0.30 **	0.32 **	0.20	0.18	0.19
	(0.12)	(0.12)	(0.13)	(0.12)	(0.12)	(0.12)
PARTSYST (dummy)	0.20	0.17	0.16	0.12	0.069	0.065
	(0.19)	(0.19)	(0.19)	(0.19)	(0.20)	(0.20)
COMYEAR	-9.4 E-3	4.0 E-3	-7.7 E-3	-6.0 E-3	1.25 E-3	-2.7 E-3
	(0.034)	(0.035)	(0.035)	(0.031)	(0.032)	(0.032)
WAITYEAR	-0.033	-0.043	-0.037	-0.032	-0.040	-0.035
	(0.047)	(0.048)	(0.049)	(0.044)	(0.044)	(0.045)
ETH	0.086	0.22	0.18	0.12	0.23	0.18
	(0.42)	(0.43)	(0.44)	(0.43)	(0.42)	(0.44)
SEX	0.035	-0.012	0.030	0.059	-0.087	0.056
	(0.42)	(0.43)	(0.43)	(0.38)	(0.37)	(0.38)
Intercept	17.33	-6.79	13.75	11.29	-2.75	4.70
Ω (threshold value)	0.69	0.69	0.70	0.60	0.58	0.58
Region dummies	Yes	No	Yes	Yes	No	Yes
Technology dummies	No	Yes	Yes	No	Yes	Yes
Log Likelihood function	-904.2	-901.3	-893.0	-902.0	-899.1	-890.5
Test vs. restricted model (1 d.f.)				4.28 **	4.48 **	4.93 **
Parameter tests						
SELL1 - NEW1	1.41 ***	1.39 ***	1.46 ***	1.16 ***	1.08 **	1.12 **
	(0.48)	(0.49)	(0.50)	(0.42)	(0.43)	(0.44)
LIC1 - NEW1	1.48 **	1.36 **	1.51 **	1.19 **	1.05 **	1.12 **
	(0.58)	(0.59)	(0.60)	(0.54)	(0.52)	(0.54)

Note: The number of observations equals 466. The dependent variable *PERFORM* takes on the values of 2, 1 and 0 for 242, 95 and 129 observations, respectively. Standard errors are in parentheses and ***, ** and * indicate significance at the 1, 5 and 10 percent level, respectively. Dummy variables as well as estimates from the first probit selection step are not shown, but are available from the authors upon request.

Table 7. Empirical estimations of the ordered probit model. Model II.

Dependent variable: *PERFORM*	Statistical model:					
Explanatory variables	Ordered probit model (without sample selection)			Ordered probit model (with sample selection)		
	Model					
	II-A	II-B	II-C	II-D	II-E	II-F
SELL2 (dummy)	0.53 ***	0.69 ***	0.65 ***	0.44 **	0.55 **	0.51 **
	(0.19)	(0.20)	(0.20)	(0.19)	(0.22)	(0.22)
LIC2 (dummy)	0.89 **	0.92 **	0.95 **	0.72 *	0.73 **	0.74 *
	(0.38)	(0.38)	(0.39)	(0.38)	(0.37)	(0.39)
EMPL2 (dummy)	0.42	0.35	0.47	0.37	0.32	0.39
	(0.38)	(0.39)	(0.39)	(0.36)	(0.35)	(0.36)
NEW2 (dummy)	-0.31	-0.27	-0.28	-0.27	-0.24	-0.24
	(0.20)	(0.21)	(0.21)	(0.18)	(0.19)	(0.19)
ACTIVE1 (dummy)	0.58 ***	0.72 ***	0.65 ***	0.50 **	0.61 ***	0.55 ***
	(0.21)	(0.21)	(0.22)	(0.21)	(0.20)	(0.21)
ACTIVE2 (dummy)	0.89 ***	0.96 ***	0.96 ***	0.74 **	0.79 **	0.77 **
	(0.32)	(0.33)	(0.34)	(0.32)	(0.32)	(0.32)
MEDIUM (dummy)	1.28 ***	1.39 ***	1.36 ***	0.92 ***	0.96 ***	0.94 ***
	(0.28)	(0.29)	(0.30)	(0.33)	(0.34)	(0.34)
SMALL (dummy)	1.00 ***	1.07 ***	1.01 ***	0.71 ***	0.73 ***	0.67 ***
	(0.20)	(0.20)	(0.21)	(0.23)	(0.24)	(0.23)
CLOSE (dummy)	0.54 ***	0.67 ***	0.64 ***	0.26	0.34	0.30
	(0.17)	(0.18)	(0.18)	(0.20)	(0.21)	(0.21)
REPLACE (dummy)	0.56 **	0.45 *	0.49 *	0.51 **	0.41 *	0.45 *
	(0.26)	(0.26)	(0.27)	(0.24)	(0.24)	(0.24)
MOREPAT (dummy)	0.30 **	0.31 **	0.32 **	0.20	0.20	0.21
	(0.12)	(0.12)	(0.13)	(0.13)	(0.13)	(0.13)
PARTSYST (dummy)	0.18	0.15	0.15	0.11	0.064	0.064
	(0.19)	(0.19)	(0.19)	(0.19)	(0.20)	(0.20)
COMYEAR	-3.3 E-3	9.3 E-4	-1.3 E-3	-9.2 E-4	4.4 E-3	1.9 E-3
	(0.034)	(0.035)	(0.035)	(0.032)	(0.033)	(0.034)
WAITYEAR	-0.034	-0.047	-0.042	-0.034	-0.045	-0.041
	(0.048)	(0.048)	(0.049)	(0.046)	(0.047)	(0.047)
ETH	0.13	0.25	0.21	0.15	0.27	0.22
	(0.42)	(0.44)	(0.44)	(0.42)	(0.42)	(0.44)
SEX	0.10	0.080	0.12	2.0 E-3	-6.8 E-3	0.025
	(0.42)	(0.43)	(0.43)	(0.37)	(0.37)	(0.38)
Intercept	5.29	-2.88	1.30	1.31	-8.96	-4.32
Ω (threshold value)	0.69	0.70	0.71	0.61	0.61	0.61
Region dummies	Yes	No	No	Yes	No	No
Technology dummies	No	Yes	Yes	No	Yes	Yes
Log Likelihood function	-903.3	-898.2	-891.1	-901.5	-896.5	-889.2
Test vs. restricted model (1 d.f.)				3.68 *	3.46 *	3.83 *
Parameter tests						
SELL2 – NEW2	0.84 ***	0.96 ***	0.93 ***	0.71 ***	0.79 ***	0.75 **
	(0.30)	(0.31)	(0.32)	(0.27)	(0.30)	(0.30)
LIC2 – NEW2	1.20 ***	1.19 ***	1.23 ***	0.99 **	0.97 **	0.98 **
	(0.45)	(0.45)	(0.46)	(0.42)	(0.42)	(0.43)

Note: The number of observations equals 803. The dependent variable *PERFORM* takes on the values of 2, 1 and 0 for 242, 95 and 129 observations, respectively. Standard errors are in parentheses and ***, ** and * indicate significance at the 1, 5 and 10 percent level, respectively. Dummy variables as well as estimates from the first probit selection step are not shown, but are available from the authors upon request.

Table 8. Empirical estimations of the ordered probit model. Models III and IV.

Dependent variable: *PERFORM*	Statistical model:					
Explanatory variables	Ordered probit model (without sample selection)			Ordered probit model (with sample selection)		
	Model					
	III-A	III-B	III-C	III-D	III-E	III-F
EXTERN1	1.07 ***	0.99 ***	1.11 ***	0.86 **	0.62 **	0.73 **
	(0.37)	(0.37)	(0.38)	(0.34)	(0.29)	(0.31)
ACTIVE1 (dummy)	0.51 ***	0.60 ***	0.55 ***	0.43 **	0.45 ***	0.43 ***
	(0.19)	(0.20)	(0.20)	(0.18)	(0.14)	(0.15)
ACTIVE2 (dummy)	1.25 ***	1.24 ***	1.28 ***	0.98 **	0.78 **	0.82 **
	(0.39)	(0.39)	(0.40)	(0.36)	(0.30)	(0.32)

Explanatory variables	Model					
	IV-A	IV-B	IV-C	IV-D	IV-E	IV-F
EXTERN2	0.60 ***	0.76 ***	0.76 ***	0.48 **	0.57 ***	0.56 ***
	(0.20)	(0.21)	(0.21)	(0.19)	(0.22)	(0.22)
ACTIVE1 (dummy)	0.54 ***	0.62 ***	0.58 ***	0.46 ***	0.51 ***	0.48 ***
	(0.19)	(0.20)	(0.20)	(0.18)	(0.17)	(0.17)
ACTIVE2 (dummy)	0.76 ***	0.95 ***	0.90 ***	0.59 **	0.68 ***	0.64 ***
	(0.24)	(0.25)	(0.25)	(0.24)	(0.25)	(0.25)

Note: The number of observations equals 803. The dependent variable *PERFORM* takes on the values of 2, 1 and 0 for 242, 95 and 129 observations, respectively. Standard errors are in parentheses and ***, ** and * indicate significance at the 1, 5 and 10 percent level, respectively. Only the results of the main variables are shown. The results for the other explanatory variables are similar to those in Models I and II and are available from the authors upon request. Dummy variables as well as estimates from the first probit selection step are also available from the authors upon request.

Table 9. Size interpretation of estimated parameters. Ordered probit.

Dummy variables	Marginal effect on probabilities when dummy variables increase from 0 to 1.					
	Model I-C			Model I-F		
	P(0)	P(1)	P(2)	P(0)	P(1)	P(2)
SELL1	-0,20	-0.16	0.36	-0.12	-0.11	0.23
LIC1	-0.22	-0.16	0.38	-0.13	-0.11	0.24
EMPL1	-0.20	-0.09	0.29	-0.12	-0.08	0.20
NEW1	0.12	0.02	-0.14	0.08	0.03	-0.11
ACTIVE1	-0.16	-0.07	0.23	-0.10	-0.07	0.17
ACTIVE2	-0.37	-0.09	0.46	-0.23	-0.10	0.33
MEDIUM	-0.26	-0.18	0.44	-0.14	-0.10	0.24
SMALL	-0.24	-0.12	0.36	-0.12	-0.07	0.19
CLOSE	-0.16	-0.08	0.24	-0.05	-0.03	0.08
REPLACE	-0.12	-0.06	0.18	-0.08	-0.06	0.14
MOREPAT	-0.10	-0.03	0.13	-0.05	-0.02	0.07

Dummy variable	Model III-C			Model III-F		
	P(0)	P(1)	P(2)	P(0)	P(1)	P(2)
EXTERN1	-0.29	-0.09	0.38	-0,15	-0,08	0,23

Note: All marginal effects are calculated around the means of the **x**:s. The sum of the marginal effects on the probabilities equals zero. Similar marginal effects were obtained for Models II and IV, which are available from the authors upon request.