INTELLECTUAL PROPERTY STRATEGIES AND FIRM GROWTH: EVIDENCE FROM FINNISH SMALL BUSINESS DATA

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Abstract

The goal of this study is to shed light on the relationship between intellectual property (IP) strategies and firm growth. In brief, IP strategies are means of capturing returns on innovation investments. Employment effects and sales growth effects of innovations have been studied extensively in both theoretical and empirical economic literature but prior research has seldom included IP strategies into the analysis. There is little knowledge, whether there exists growth rate differences among firms that use different IP strategies and do patenting firms effectively demonstrate stronger growth than their non-patenting counterparts. Present study considers IP strategies as potential firm growth determinants.

Available data enables studying relation between firm growth and four IP strategies (patents, secrecy, speed and complements) among innovative Finnish small businesses. The small business perspective is important because previous studies have suggested that the patent system favors large companies at the cost of smaller firms. The data consists of merged survey and financial statement data of 469 innovative Finnish small businesses. The surveys were carried out in the beginning of millennium and employment and turnover figures cover years 2001-2010 and 2001-2009 respectively.

Findings provide evidence that between 2001 and 2008 the turnover growth rates of sample firms differed statistically significantly between firms, which utilized different IP strategies. During the period patenting firms had statistically significantly higher turnover growth rates than firms relying on secrecy-based strategies and firms, which reported not to use any IP strategies. However, the difference in turnover growth rates between patenting firms and firms using "Open"-strategies (speed and/or complements) was not statistically significant. The results indicate that patenting may have provided competitive advantage for innovative small firms during 2001-2008 but the advantage was not significant in comparison to firms, which relied on speed and complements.

Keywords

intellectual property strategy, innovation returns, firm growth, employment effect of innovation, innovation policy, incentives to innovate, IPR system, patent system

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Tiivistelmä
Tutkimuksen tavoitteena on valottaa IP-strategioiden ja yritysten kasvun välistä yhteyttä. IP-strategioilla yritykset pyrkivät maksimoimaan innovaatioista saamansa tuoton. Tässä tutkimuksessa niihin luetaan patentointi, salassapito, markkinoilletulon nopeus sekä innovaatioita tukevat tuotteet, palvelut ja tuotanto. Innovaatioiden vaikutusta yritysten kasvuun on tutkittu melko laajasti, mutta harva aiempi tutkimus on ottanut huomioon innovaatioiden suojausnäkökulman. Aikaisempaa yritysten IP-strategioiden ja kasvun välistä yhteyttä tarkastelevaa empiiristä tutkimusta on hyvin rajallisesti ja vähän tiedetään esimerkiksi siitä, ovatko patentoivat yritykset saavuttaneet kasvuetuja hyödyntämällä kvasi-monopolista asemaansa. Tämä tutkimus tarkastelee IP-strategioita yritysten kasvun potentiaalisena lähteenä.

Suomalaisista pienistä innovatiivisista yrityksistä koostuva aineisto mahdollistaa yritysten kasvun ja neljän IP-strategian (patentointi; salassapito; nopeus; innovaatioita tukevat tuotteet, palvelut ja tuotanto) välisen yhteyden tarkastelun. Pienyritysnäkökulma on tärkeä, koska aikaisemmissa tutkimuksissa on esitetty patenttijärjestelmän suosivan suuria yrityksiä pienten yritysten kustannuksella. Aineisto koostuu 2000-luvun alussa toteutetuista kyselyistä, jotka on yhdistetty Y-tunnusten avulla yritysten työllisyyden 2001-2010 ja liikevaihdon 2001-2009 kasvulukuihin.

Regressioanalyysin tulokset osoittavat, että IP-strategioilla on ollut tilastollisesti merkitsevä yhteys yritysten liikevaihdon kasvuun tarkasteluajanjaksolla 2001-2008. Samalla aikavälillä patentoivien yritysten liikevaihdon kasvu ylitti tilastollisesti merkitsevästi salassapitoon nojaavien yritysten kasvun sekä niiden yritysten kasvun, jotka eivät 2001 raportoineet käyttävänsä mitään yllämainituista IP-strategioista. Ero kasvuasteissa patentoivien ja "avointa strategiaa" (nopeus ja/tai innovaatioita tukevat tuotteet, palvelut ja tuotanto) hyödyntävien yritysten välillä ei kuitenkaan ollut merkitsevä. Tulosten pohjalta voi todeta, että patentointi on mahdollisesti tuonut kilpailuetua innovatiivisille pienille yrityksille aikavälillä 2001-2008, mutta etu ei ole kasvulla mitaten ollut merkittävä verrattuna avointa IP-strategiaa hyödyntäneisiin yrityksiin.

Asiasanat
IP-strategia, innovaatiotuotot, yrityksen kasvu, innovaatioiden työllisyysvaikutus, innovaatiopolitiikka, innovaatiokannustimet, immateriaalioikeusjärjestelmä, patenttijärjestelmä

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1 INTRODUCTION

Sir Isaac Newton himself acknowledged, "If I have seen far, it is by standing on the shoulders of giants." Most innovators stand on the shoulders of giants, and never more so than in the current evolution of high technologies, where almost all technical progress builds on a foundation provided by earlier innovators.

- Suzanne Scotchmer (1991)

Economists are unanimous on only a few issues but a consensus prevails that technological progress is a key driver of economic growth. Technological progress and productivity growth are based on innovations[1], which enable more efficient use of scarce resources. Stock of labor and capital are limited but the potential of technological progress is in principle infinite. Our modern welfare societies are built on sequential and cumulative flow of innovations made by individual innovators and the youngest generation always "stands on the shoulders of giants" as Scotchmer states above. Since innovations are so crucial for us and our standard of living, it is of great importance to study how the creation and diffusion of innovations could be promoted optimally. Thus, policy-makers need empirical evidence on the efficiency of existing institutions and innovation system in order to assess how it could be improved further.

This study aims at shedding light on the relationship between intellectual property strategies and firm growth - an issue that has received surprisingly little attention in economic literature. In brief, IP strategies are means of capturing returns on innovation investments[2] (Leiponen & Byma 2009). In this study four IP strategies are considered: speed (equivalent to lead time), complements, secrecy and, in particular, patenting. Patent system is an innovation policy instrument, which seeks to resolve the tension between incentives for innovation and widespread diffusion of benefits (Levin et al. 1987). In other words, patent system aims at enhancing the incentive to innovate and simultaneously disseminate information, since a patent

[1] "An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations." (OECD 2005)

[2] An alternative definition used by Levin et al. (1987): "alternative means of capturing and protecting the competitive advantages of new or improved processes and products".

application must contain sufficient information to make it possible for a skilled person to reproduce the particular innovation (Kultti et al. 2007). An exclusive right related to a patent[3] enables in theory a monopolistic position, which implies higher profits due to market power[4]. Having this kind of market power may moreover ease the attraction of private equity and external finance: empirical evidence has indicated that firms with higher innovative output (measured by number of patent applications) have a higher probability of acquiring venture capital (Engel & Keilbach 2007, see also Hsu & Ziedonis 2011). It has been also found that patenting has a statistically significant positive relationship with sales of new products (Hussinger 2006) and patenting activity seems to have a positive effect on employment growth (Niefert 2005) and asset growth (Helmers & Rogers 2011) as well. A central hypothesis of this study is that patenting firms should have higher growth rates than their non-patenting counterparts and more generally: growth of firm is expected to be dependent on chosen IP strategy. Employment effects of innovations cannot be fully understood without taking into account firms' intellectual property strategies, since they probably have a major effect on market power and growth prospects. If the formulated hypothesis is rejected then the efficiency of patent system could be questioned. In other words, if patenting firms do not have higher growth rates, it might be that they cannot utilize their quasi-monopolistic position, which in turn may lead to lower incentives to patent in the future.

The present study selectively combines previous research from the fields of innovations, IP strategies and firm growth. Two closely related fields of innovation research are linked: growth effects of innovations (Brouwer et al. 1993 Blechinger et al. 1998, Harrison et al. 2008, Hall et al. 2007, Ali-Yrkkö & Martikainen 2008) and methods for capturing innovation returns (Levin et al. 1987, Harabi 1995, Cohen et al. 2000, Arundel 2001, Cohen et al. 2002, Leiponen & Byma 2009). With Finnish small business data, the relationship between firm's IP strategies and growth is analyzed using a variety of different methods. Analysis is expanded by adding speed and complementing products, services and production as IP strategies to accompany usually applied patents versus secrecy set-up (e.g. Hussinger 2006). A special contribution is the small businesses perspective, as former research and findings have to a great extent based only on data samples consisting of large companies. For instance, European studies based on Community Innovation Surveys (CIS) (e.g. Blechinger et al. 1998, Arundel 2001) exclude firms with under 10 employees. Small business perspective is especially important because former studies have

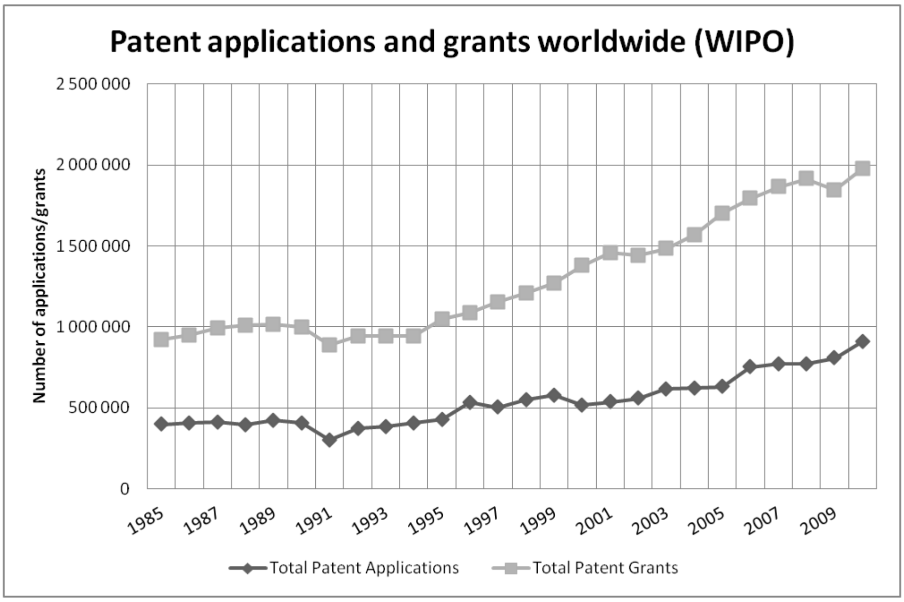
[3] "Patent is an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem. In order to be patentable, the invention must fulfill certain conditions" (WIPO). These conditions involve requirement for novelty, non-obviousness and technical feasibility. Patent length is generally 20 years from filing of application and related renewal fees are normally rising over time. Patents are territorial rights i.e. Finnish patent is in force only in Finland and not in other countries.

[4] According to Cabral (2000, p.6) market power can be defined as the firm's ability to set prices above marginal cost i.e. the cost of producing one extra unit.

provided evidence that small and medium sized enterprises (SMEs) cannot utilize the intellectual property system as efficiently as large firms (Leiponen & Byma 2009, Kotala 2010). It has also been noted that that lack of empirically-based information on relationship between SMEs and IPR prevents better policy development (Iversen et al. 2009).

Figure 1-1 depicts the worldwide patent applications and grants over time and shows clear growth trend in patenting activity. This phenomenon has triggered several economists to study what are the causes behind it (e.g. Kortum & Lerner 1999, Hall & Ziedonis 2001, Hall 2004). For example Hall (2004) concluded that in the U.S. observed growth reflects a strategic shift in patenting, which is mainly concentrated in the electrical, electronics, computing and scientific instruments industries. Strategic patenting has become commonplace and firm's may use patents defensively or offensively depending on the situation (see e.g. Cohen et al 2000). All in all, as firms' investments in global markets are increasingly directed to intangible assets instead of tangible (Maliranta & Rouvinen 2007), the role of intellectual property rights – in particular patents – is becoming more and more important. Hence, empirical economic research concerning patent systems and innovation investment return appropriation methods has clearly gained momentum.

Figure 1-1: Patent applications and grants worldwide[5]



The remainder of the study is structured as follows: Chapter 2 reviews the theoretical background of firm growth and incentives to innovate. Chapter 3 consists of a brief literature review of previous empirical studies. In chapter 4 the relation between IP strategies and growth among innovative Finnish small businesses is studied and findings are presented. Chapter 5 concludes and discusses possible policy implications.

[5]Source: World Intellectual Property Organization

2 GROWTH, INNOVATION[6] AND INCENTIVES

The technological progress as a driving force of economic growth (see appendix 1 for further discussion) is eventually based on the innovation activity of individual firms and their effectiveness in commercialization of innovations. Innovation policy is a public tool with an objective to maximize the welfare-enhancing innovation activity. The patent system is an instrument of innovation policy and an incentive system, which stimulates firms to invest in R&D, innovate and disseminate technical knowledge.

Although efficient dissemination of knowledge promotes cumulativeness of innovations, at industry- and firm-level creative destruction can have growth effects, which are very hard to predict. For example technological unemployment might occur if new innovations force firms with obsolete products and services to exit or reduce labor due to decreased demand. Hence, creating institutions that simultaneously optimize innovations, economic growth and employment is an extremely difficult task. Next, the theoretical background relating to this great challenge is reviewed. The objective of this chapter is to provide a compact overview of the theoretical economic literature considering the relationship between innovation and firm growth.

2.1 Determinants of firm growth

The economic development as a whole is shaped by choices and actions of individual agents. Technological progress – a key driver of economic growth – makes no difference. Technological progress is not exogenous, "manna from heaven" (as demonstrated in appendix 1), but an outcome of research and development and innovation activity. Ultimately, it is the R&D&I investment decisions of private and public sector that determine technological progress. In

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[6] An innovation can be generally defined as "an invention that has been commercialised on the market by a business firm or the equivalent" (Palmberg et al. 2000, p.10). In the context of present study innovations refer only to technological innovations not non-technological. See Ali-Yrkkö & Martikainen (2008) for comparison of technological and non-technological innovation impacts on firm growth.

this context, the focus is on firms and public sector i.e. universities and public research institutions are left outside the scope.

Maximization of profits is the ultimate goal of (most) firms and bigger profits generally require growth of turnover and employment alongside. Employment growth is a special object of interest for policy-makers as minimization of unemployment is one important policy goal. Effective design of innovation policy requires understanding micro-level employment effects of innovations (Harrison et al. 2008). This section provides a brief theoretical background on firm growth. We begin by introducing stochastic model of firm growth, in which firm growth is assumed to be totally random process. Gibrat's law is derived and brief review of empirical studies is made. After that, the role of innovations is considered as determinants of individual firm growth. An introduction of the theoretical employment effects of innovations finishes the section.

2.1.1 Gibrat's law of proportionate effect

Gibrat's law (1931) forms the basis of the stochastic models of firm growth. It has been applied to explain the shape of the size distribution of firms in mathematical models (Mansfield 1962). The law proposes that firm growth rates are independent of their sizes. If Gibrat's law was supposed to hold, firms should grow in proportion to their sizes. As Mansfield (1962) compactly expresses "the probability of a given proportionate change in size during a specified period is the same for all firms in a given industry regardless of their size at the beginning of the period". Following this argument, a firm with 100 employees is as likely to double its size as a firm with 1000 employees. Following Nurmi (2004) the firm's proportionate rate of growth as stochastic process can formally be presented as follows[7]:

$$\frac{S_t - S_{t-1}}{S_{t-1}} = \varepsilon_t \quad (2.1)$$

where S_t is the firm size at time t and ε_t is an independently distributed random variable. If it is assumed that initial value of firm size is S_0 and there are n steps before final value, the growth of firm can be expressed as a sum:

$$\sum_{t=1}^{n} \frac{S_t - S_{t-1}}{S_{t-1}} = \sum_{t=1}^{n} \varepsilon_t \quad (2.2)$$

When time intervals are short, the value of ε_t is probably small and equation above can be presented as follows:

[7] See Rantala (2006) for similar expression.

$$\sum_{t=1}^{n} \frac{S_t - S_{t-1}}{S_{t-1}} \cong \int_{S_0}^{S_n} \frac{dS}{S} = \log S_n - \log S_0 \qquad (2.3)$$

which gives:

$$\log S_n = \log S_0 + \varepsilon_1 + \varepsilon_2 + \dots + \varepsilon_n \qquad (2.4)$$

or equivalently:

$$S_t = (1+\varepsilon_t)S_{t-1} = S_0(1+\varepsilon_1) + \dots + (1+\varepsilon_n) \qquad (2.5)$$

If $\log S_0$ and ε_t have identical distributions with mean μ and variance σ^2, then by central limit theorem $\log S_t \sim N(\mu t, \sigma^2 t)$ when $t \to \infty$. The consequence is that the distribution of S_t is lognormal when independent random forces affect firm size time after time. Implied skewed distribution with a large number of small businesses and only few large firms has been observed in practice in empirical studies on firm growth. Law implies also that expected value and variance of the firm size distribution increases over time. In practice this means increasing relative dispersion of firm sizes and increasing industry concentration. (Nurmi 2004, p. 6)

In empirical literature two main approaches have been used to test the Gibrat's law: (1) testing log-normality of firm size distribution by fitting different size distributions into the data (2) testing the hypothesis that firm growth is independent of its size (Nurmi 2004). Following the latter one, below is presented the basic regression formula for testing the validity of Gibrat's law (e.g. Peneder 2012, p.427):

$$\log S_{i,t} = \beta_0 + \beta_1 \log S_{i,t-1} + \varepsilon_{i,t} \qquad (2.5)$$

where
$S_{i,t}$ = Firm i's size at time t
$\log S_{i,t-1}$ = Firm i's size one period earlier
ε = random variable, independently distributed of $S_{i,t-1}$

If Gibrat's law was to hold, the coefficient of logarithmic size level variable β_1 should equal 1. If $\beta_1 < 1$, then small firms are observed to grow faster than large ones and if $\beta_1 > 1$, the opposite holds. The most common growth (and size) measure in the empirical literature has been number of employees (Rantala 2006). Simon & Bonini (1958) stated that the measure of size - be it number of employees, value added, sales, assets, profits – belongs always to the class of highly skewed distributions. The interdependence of aforementioned growth measures might indicate that results are approximately equal no matter which indicator is chosen. However, for example Heshmati's (2001) empirical results indicated otherwise.

Jovanovic (1982) contributed the theory of firm growth by introducing firm life-cycle model, which is based on passive learning. The model takes into account age as a factor that can have an effect on the growth of firm. In Jovanovic's model most efficient firms survive and unprofitable exit, in other words average profits rise as industry matures. Hence, the model predicts positive relation between profits and concentration and age. Jovanovic's model suggest that Gibrat's law holds for mature firms and for firms that entered the industry at the same time (Evans 1987b).

The validity of Gibrat law has been empirically tested in various studies (e.g. Simon & Bonini 1958, Mansfield 1962, Evans 1987a, Evans 1987b, Hall 1987, Heshmati 2001, Nurmi 2004). Many of these have found Gibrat's law to fail i.e. there's evidence that firm growth is not a stochastic process and growth actually is dependent on initial size. The strict form of Gibrat's law does not take into account industry dynamics by assuming that all sizes of firms are as likely to exit the market. Empirical evidence contradicts this, since smaller firms have been observed to have higher death rates (Mansfield 1962)[8]. The results vary depending on how exiting firms are treated: they can be treated statistically as having proportionate growth rate of -100% or they can be excluded from the sample.

Simon and Bonini (1958) introduced the "weak form of Gibrat's law" (term used by Nurmi 2004), which loosens the basic propositions to take into account size classes of firms. According to Simon and Bonini (1958) probability distributions of change in firm size are identical for all firms, whose size is above minimum efficient scale, MES[9]. The underlying assumption is that firms face approximately constant returns to scale after reaching MES. This is due to U-shaped long-run average cost curve faced by firms (Simon & Bonini 1958). However, introducing minimum efficient scale involves some weaknesses. For example, Nurmi (2004) pointed out that larger firms may only move downwards the size distribution whereas small firms hit the exit threshold sooner. When only surviving firms are included into the sample, the relationship between size and growth might be estimated too low. Hall (1987) introduced various methods to control for this sample selection bias.

Mansfield (1962) tested three variants of Gibrat's law with samples of three U.S. manufacturing sectors (steel, petroleum and rubber) and found the law to fail for all versions. Mansfield's (1962) results revealed smaller firms to have relatively high death rates and survivors to have higher and more variable growth rates than larger firms. The finding of negative relationship between growth variability and size has been widely recognized in subsequent studies (e.g. Hall 1987). Mansfield's (1962) results provided also evidence that industry profitability affects remarkably exit and entry rates of firms. Findings suggested for example that doubling of profitability in an industry led to at least 60 percent increase in the entry rate during the period under study. Evans (1987a,

[8] The theoretical model of Klette & Kortum (2004) assumes that exit probabilities are decreasing in firm size.

[9] MES defined by Cabral (2000, p.24): "The lowest output level at which the minimum average cost is attained."

1987b) utilized comprehensive data of U.S. manufacturing and his findings were in line with those of Mansfield (1986) as they indicate Gibrat's law to fail. Evans (1987b) reports an inverse size-growth relationship for 89 of 100 industries studied providing strong evidence of the failure of Gibrat's law. Also Hall (1987) studied the relationship between firm size – measured by employment - and year-to-year growth in publicly traded U.S. manufacturing sector and found Gibrat's law to be weakly rejected for smaller firms. However, Gibrat's law was accepted for large firms. Hall (1987) concluded that "at the firm-level, year-to-year growth rates in employment are largely unpredictable by past characteristics of firm". Nurmi (2004) tested Gibrat's law in Finland directly by studying the impact of plant size and age on the growth of Finnish manufacturing during 1981-1994. Her findings were in line with previous studies: Gibrat's law was rejected and plant growth was found to decrease with plant size and age. Nurmi (2004) applied 5 employees threshold i.e. smaller plants were excluded.

Much of the previous empirical literature concerning Gibrat's law has focused narrowly on large firms. Probably this was long due to lacking data of small firms. More recently Gibrat's law has been tested also for small and micro firms. For example Heshmati (2001) studied the growth of a sample of Swedish firms with 1-100 employees 1993-1998. The size was measured by employees, sales and assets. He found negative relation between employment and growth, positive between sales and growth and insignificant between assets and growth. Heshmati (2001) points out that "the relationship between growth, size and age of firms is very sensitive with respect to the method of estimation, functional form and definition of growth and size".

2.1.2 Innovation

As Schumpeterian theory of creative destruction suggests, innovativeness is crucial for firm survival (see appendix 1). Firms that do not constantly develop their business are at risk to become obsolete as innovative firms capture their market shares with more advanced and cheaper products. In other words, the theory suggests that in practice innovative firms should have higher growth rates or at least better survival rates than non-innovators. Still, empirical evidence on the relation between innovations and firm growth remains ambiguous.

Presumably the most important factor explaining this blurred relation between innovation and growth is that innovations create positive spillovers and the originator firms of innovations cannot fully appropriate innovation returns. Furthermore, successful commercialization and marketing of innovation certainly plays a major role (Engel & Keilbach 2007). For instance, advertising is crucial in obtaining market power (Cabral 2000, p.5). Although, empirical economic studies have often failed to identify statistically significant explanatory variables among presumed causal determinants of firm growth, innovation could at least be called "a major suspect" as a firm growth driver (Peneder 2012, p.432). For instance, Hall et al. (2007) summarize that "the overall effects of innovation on employment appear to be generally positive at the firm level in developed economies".

Measuring relation between innovation and growth

Studying the connection between innovations and firm growth is quite challenging, since both innovation and growth can be measured in various ways. Varying indicators between studies lead to decreased comparability of results. Firm growth is usually measured by the number of employees, turnover or assets (Heshmati 2001). It should be noted that the growth effects of innovation might differ remarkably between different growth indicators, since initial firm sizes differ depending on the chosen size variable (Heshmati 2001). As an example, firm's turnover might increase at the same time as employment decreases or remains unchanged after introduction of innovation. This might reflect increase in productivity but indicates different growth effects between employment and turnover. Thus, in cases where only one indicator is used, the results and conclusions made should be treated with caution. Table 1-1 below lists innovation indicators:

Table 1-1: Innovation indicators[10]

Input	R&D personnel R&D expenditures R&D intensity Innovation expenditures
Output	Patent applications Granted patents Revenues from technology transfer, selling patents, licenses and knowhow Innovation counts Self-reported statements on product and process innovations Share of turnover attributable to innovations

Generally, innovation indicators used by previous research can be divided into two main categories: those measuring innovation inputs and those measuring innovation outputs. In practice, the most frequently used innovation indicator of firms is R&D expenditures or alternatively R&D intensity, if only financial statement data is available. R&D emphasizes innovation inputs, while studies using patent counts[11] as indicators of innovativeness are innovation output-oriented (Harrison et al. 2008). According to Griliches (1990) the strong relationship between patent numbers and R&D expenditures implies patents to be a good indicator of differences in inventive activity across firms at least for firms above a minimal size. Griliches (1990) further notes that relationship between R&D and patents is close to proportional, although propensity to

[10] Refined from Blechinger et al. (1998).
[11] "To the extent that the most important or valuable ideas are patented, patent counts may provide a simple measure of the number of ideas produced." (Jones 1998, p.84)

patent differs across industries. Klette & Kortum (2004) applied stylized fact "patents vary proportionally with R&D across firms" in their general equilibrium model of technological change grounding the choice mainly on the findings of Griliches (1990). However, patent counts as innovative output indicators have faced also criticism (see e.g. Lanjouw, Pakes & Putnam 1998), since they lack the quality aspect[12]. In addition, larger firms might have lower propensity to patent than smaller firms, since larger firms can protect their innovation returns more comprehensively with other ways than formal patent protection.

Special surveys like CIS (community innovation surveys) provide more detailed data on firm innovativeness since firms are asked to answer whether they have made product or process innovations. The weakness in CIS kind of surveys is that the responds may contain subjective bias, since an innovation from the viewpoint of firm respondent might differ from the view of survey designer. Etlatieto's survey data used in this study is similar to CIS as responding firms have self-reported whether or not they have introduced innovations.

2.1.3 Employment effects of innovations

Promoting innovation activity is at the policy center of governments around the world, since technological progress fosters competitiveness, economic growth and welfare in the long run. According to Blechinger et al (1998) fostering innovations is necessary for international competitiveness. However, due to "creative destruction", innovations can also have negative (domestic) employment effects in the shorter run[13]. Negative socio-economic consequences such as technological unemployment, which may be caused by dissemination of production efficiency-enhancing innovations, are probably not targets of policy-makers.

It is a basic proposition of economic theory that due to productivity and population growth output should be increased to avoid increase in unemployment. However, if there's no excess demand to be satisfied, production is held constant and the consequence is rising unemployment. As a result of this partial trade-off, policy-makers are in challenging position to find compromises, which balance conflicting policy goals between unemployment minimization and competitiveness (innovativeness) maximization. According to Harrison et al. (2008) "understanding the relationship between innovation and employment at the micro level is essential for predicting how innovation might affect employment, and hence for the effective design of innovation policy together with other policy interventions". Presumably it is more

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[12] Forward citations i.e. the citations that patents receive in subsequent patents have been used as a rough quality measure of patents (e.g. Nikulainen et al. 2006).

[13] This phenomenon have been in focus of public debate and inspired several authors, see e.g. Jeremy Rifkin's "The End of Work: The Decline of the Global Labor Force and the Dawn of the Post-Market Era" (1995).

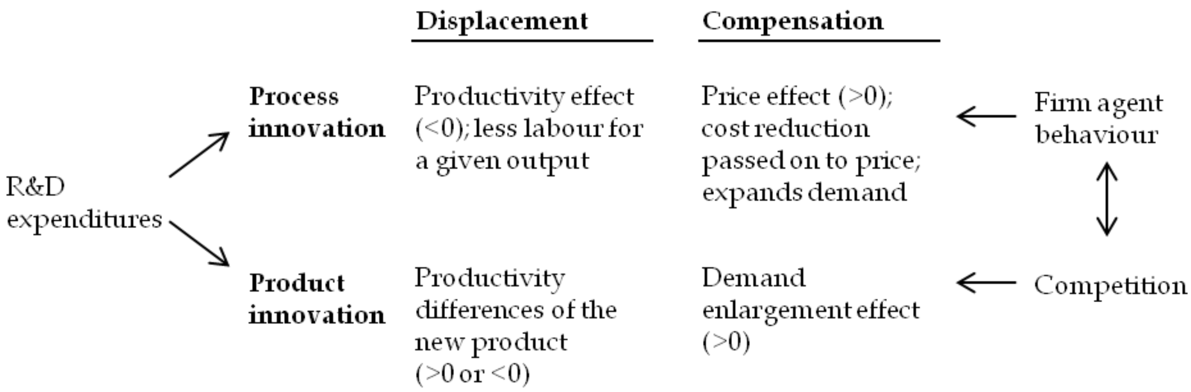
desirable for governments to promote flexibility in labor markets than to try to slow down technological progress, when attempting to minimize unemployment.

Employment effects of innovations can be studied at different levels: firm-, industry-, regional-, national- and global-level. This study focuses mainly on firm-level, but the theoretical effects at higher levels are also briefly considered alongside to construct a big picture of the phenomenon. Short- and long-run are not strictly separated from each other, although changes in employment in practice often occur with a certain lag (due to various inflexibilities). The direction of the effect is here the core object of interest instead of its magnitude. This section begins by reviewing employment effects of innovations from perspective of economic theory creating grounds for interpretation of empirical studies.

The firm-level employment effects of innovations are ambiguous (see eg. Blechinger et al. 1998, Niefert 2005, Harrison at al. 2008). Innovations may destroy jobs (displacement effect) but they may as well increase the demand for firm's products (compensation effect). The directions and magnitudes of these effects vary according to the type of innovation in question. It is quite intuitive that product and process innovations affect firm growth differently, as process innovations are directed to improve production process and lower production costs, whereas product innovations are mainly angled to improve demand (Harrison et al 2008; Niefert 2005; Pianta 2005, p.572-573; Blechinger et al. 1998). In theoretical literature the impact of product innovation on employment has not been studied as widely as the impact of process innovations (Blechinger et al. 1998). Probably, this is due to the productivity-affecting nature of process innovations; they speed the technological progress and are therefore relatively more important for economic growth. On the other hand, product and process innovations often occur simultaneously, which makes the forecasting of employment effects even more complicated in practice (e.g. Harrison et al 2008).

Most previous empirical studies have concluded that product innovations have positive effect on employment and process innovations negative or ambiguous effect (e.g. Hall et al. 2007, Koski 2008). Of course, in practice the effects depend also on the nature of innovations as they can be incremental or radical. According to Blechinger et al. (1998) employment effect of a process innovation is negative if turnover stays constant. However, theoretically process innovations can have positive effect on employment if firm management passes the efficiency gains to customers by lowering prices (Koski 2008 and Koski & Pajarinen 2011). As a result of this compensation, demand and sales increase facilitating employment growth. On the other hand, Koski & Pajarinen (2011) remark that product innovations in turn may have negative employment effects: due to grown market power, the firm could set higher prices and reduce the output and employees to obtain higher profits (monopolistic behavior). The market power and pricing power depends on the level of competition and on innovation imitation cost of competitors. According to Peters (2004), the extent to which cost reductions are passed to output prices, is the higher the more intense the competition is in the markets. In case of product innovation, the effects on employment arise mainly from changes in demand but product innovations may also have similar effects as process innovations: better new product might cannibalize[14] the markets of firm's existing (competing) products, which affects labor demand. An illustrative table of varying employment effects is provided in figure 2-1.

Figure 2-1: Employment effects of innovation[15]



As in figure 2-1 is shown, employment effect conducts of displacement and compensation effects, which differ between product and process innovation. Furthermore, the behavior of customers and reactions of competitors affect the final outcome. For example, in case of price reduction due to production cost lowering process innovation, the change in sales is determined by price elasticity of demand. If customers' demand is elastic the employment effect is supposed to be greater than in case of inelastic demand ceteris paribus, since the increase in sales is greater. (Harrison et al. 2008)

In case of many products, employment effect of innovation depends also on the relation of the product to other products i.e. are they complementary or substitutes. If firm's product is complementary to products of other firms, then the employment effect from the view of whole economy is probably positive. However, if firm's product is a substitute, introduced innovation might increase its employment whereas employment of firms with substituted products is likely to decrease due to lowered demand. The situation, in which introduced innovation decreases the profitability of other firms, is referred to as "business stealing"[16] (Rouvinen 2007). This cross-elasticity of demand is left out of analysis, when studying firm-level employment effects of innovation, albeit at industry-level it certainly may have a major effect.

[14] At industry-level, innovative products may reap the market shares of competing firms' products. This is referred to as "business stealing" (Harrison 2008).
[15] Modified from Harrison et al. (2008).
[16] Cabral (2000, p.253) defines business stealing effect as a transfer of profits between firms, from incumbents to entrants, "that does not correspond to a benefit to society".

If a firm itself has a wide product portfolio, it is hard to distinguish, which part of employment growth is due to sales of new innovative products and which part due to sales of old products[17]. To solve this, Harrison et al (2008) constructed a simple model that divides employment growth factors into four components: (1) the change in efficiency in the production of old products, (2) the change in demand for old products, (3) the expansion in production due to new products and (4) the impact of productivity shocks. Hall et al. (2007) further modified the model of Harrison et al. (2008). Their basic econometric model presented in simple form was:

$$l = a_0 + a_1 d_3 + y_1 + \beta y_2 + u \qquad (2.6)$$

where
a_0 = constant term
l = growth rate of employment during the period
d_3 = process innovation dummy
y_1 = contribution of old products to output growth
y_2 = contribution of new products to output growth
u = error term

The empirical results of Harrison et al. (2008), which utilized comparable CIS data from France, Germany, Spain and UK 1998-2000, show that product innovations are an important source of firm-level employment growth whereas process innovations moderately decrease employment. Further Harrison et al. (2008) found that the displacement effects of productivity growth in production of old products can be large. According to the results of Harrison et al. (2008) the displacement effects associated with process innovation are in contrast small, since they are likely to be compensated by decrease in price. Hall et al. (2007) applied the model specified above to Italian data, which covered the period 1995-2003. Their results supported those of Harrison et al. (2008) partly, as process innovations were found to have no significant employment displacement effects. However, Hall et al. (2007) found employment growth effect of product innovations to be lower for Italian firms than Harrison et al. (2008) found respectively for four aforementioned European countries.

Koski & Pajarinen (2011) applied the same model to Finnish data, which covered data on 15508 firms 2003-2008, as they studied employment effects of business subsidies. They ended up with primarily similar results as Harrison et al (2008) and Hall et al. (2007): product innovation and sales growth of old products seem to promote firm-level employment growth. Also finding of Koski & Pajarinen (2011) that process innovations do not have any significant effect on employment was in line with both Harrison et al. (2008) and Hall et al. (2007). On the basis of their findings, Koski & Pajarinen (2011) suggested as a policy implication that "innovation policy means successfully promoting product innovation should thus produce positive employment effects".

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[17] An example could be a cell phone producer, which launches a novel innovative product but carries still on selling its old models.

Ali-Yrkkö & Martikainen (2008) studied firm growth effects of innovations by dividing innovations into technological and non-technological (e.g. organizational and branding innovations). In 2008 conducted survey sample consisted of 267 Finnish software companies with in-house development operations. The main finding was that in term of employment and turnover firms introducing only technological innovations did not grow more rapidly than other firms. However, those firms that had introduced both technological and non-technological innovations did in contrast have higher than average growth rates.

2.2 Creating incentives to innovate

"In the first place, any information obtained, say a new method of production, should, from the welfare point of view, be available free of charge (apart from the cost of transmitting information). This insures optimal utilization of the information but of course provides no incentive for investment in research. In an ideal socialist economy, the reward for invention would be completely separated from any charge to the users of the information. In a free enterprise economy, inventive activity is supported by using the invention to create property rights; precisely to the extent that it is successful, there is an underutilization of the information."

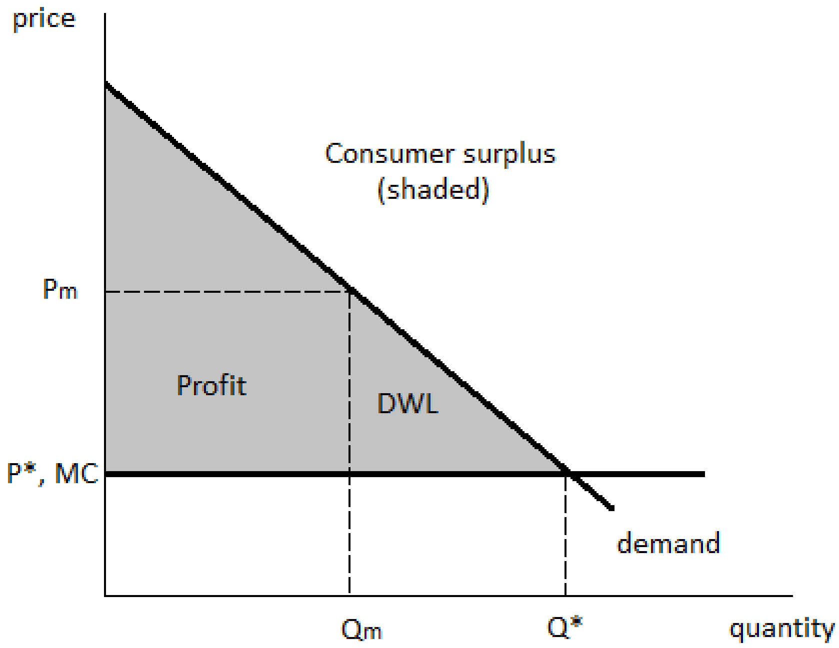
- Kenneth Arrow (1962)

After highlighting the essentiality of innovations and R&D for economic growth in former sections, we now turn to discuss innovation incentives. From an individual firm's perspective R&D requires investments and is a slow process with uncertain outcome: probability of innovating is less than 100%. From the society's point of view executed R&D leads to innovations, fosters productivity growth and promotes standard of living. Therefore, from the welfare perspective, information on e.g. new production method should be available for all free of charge to ensure optimal utilization of that information (Arrow 1962). However, free dissemination of information provides no incentives for investments in research as Arrow (1962) argues above. This forms a fundamental paradox and collision between private and social returns.

As will be shown next, incentives to innovate are though absent or at least weak, if the originator of the invention cannot appropriate the returns properly (see appendix 2 for a demonstration). Appropriability of returns is the key incentive to undertake R&D (Levin et al. 1987). This section focuses on demonstrating, how innovation policy – more precisely patent system - aims at fostering economic growth and social welfare. Last section (2.3) then discusses how successful attempts have been i.e. how firms have responded to the incentives. Before moving on to innovation policy, a graphical demonstration of incentive challenge is provided (Figure 2-2).

Although perfect competition in markets is an unrealistic simplification of reality, as a framework it helps to understand the problematics between incentives and innovations. According to the basic assumptions of competitive markets, information is perfect and agents are rational. Firms are price-takers and prices equal marginal costs. This basic situation is presented in figure 2-2 at intersection of demand and MC. It is assumed that there is no intellectual property rights (IPR) system, which would enable monopoly profits, $(P_m\text{-}MC)xQ_m$. A firm that invests in R&D faces marginal costs greater than market price. Probably R&D leads to new innovative product, which firm then launches to markets. In competitive markets without IPR-system competitors can imitate (perfect flows of information were assumed) the innovative parts of newly launched product without limitations and price it to match up their marginal costs. Hence, the firm that originally invested in R&D cannot raise the price to incorporate the sunk R&D expenses. As a result the firm promoted technological progress but ended up making loss. Where are the incentives?

Figure 2-2: The consumer surplus effect[18]



The given generalized example describes the collision between classical economic theory and economics of ideas and innovations. Policy-makers try to prevent the emergence of monopolies, since economic theory argues that monopolies decrease welfare due to deadweight losses (DWL in figure 2-2), which they create (Jones 1998, p.111). Market power implies loss of allocative efficiency (Cabral 2000, p.292). However, according to economics of ideas firms should be allowed to price above marginal costs to internalize R&D costs and knowledge spillovers or otherwise firms lack incentives to innovate (Jones 1998, p.111). Jones (1998) suggests further that a straight policy recommendation is that policy-makers should weigh monopolistic deadweight losses against incentives to innovate more carefully when making decisions on antitrust regulation. From Schumpeterian perspective, perfect competition is not likely to

[18] Modified from Jones (1998, p.110).

be optimal alternative, but rather a dynamic competition, which involves some degree of monopoly power – at least temporarily (Cabral 2000, p.295, see also figure A in appendix 1). An OECD report summarizes that neither economic theories nor empirical studies have been able to determine, which level of competition maximizes the level of innovative activity (OECD 2007).

2.2.1 Innovation policy

It has been long recognized that innovation is crucial to social welfare but that a competitive market economy produces an inefficient rate of innovation. As a result, numerous policies have been developed to promote innovative activities.

- Tuomas Takalo (2009)

Governments implement innovation policy to increase the quantity and quality of innovations in the markets. Innovations promote technological progress, international competitiveness and economic growth. The rationale for innovation policy lies first and foremost in positive externalities, which innovations create and which undermine the functioning of market mechanism. Arrow (1962) argued in his seminal paper that a free enterprise economy sub-optimally underinvests in R&D because investing is risky, appropriation of product is limited and returns are increasing. Further, he points out that the underinvestment is the greater the more basic (vs. applied) the research is by its nature. Externalities create gap between social and private value of innovations i.e. innovations are less valuable for firms than for society as a whole. Thus, underinvestment in innovations (R&D) creates a sound rationale for public intervention (Takalo 2009). According to Nikulainen (2008) "one of the goals in national innovation policy is to identify the most promising areas where public intervention can have an impact on potential market inefficiencies".

Innovations are in principle commercialized ideas and ideas as a commodity class have some special characteristics. First, they are non-rivalry and non-excludable by their nature (Arrow 1962) i.e. once idea is invented, one additional users cause no additional costs. Therefore, ideas can be compared to public goods. Arrow (1962) highlighted the paradox in the determination of demand for information: " - - its value for the purchaser is not known until he has the information, but then he has in effect acquired it without cost." Once idea is published, everyone can use it without decreasing others' possibilities of usage. A much used example is mathematical formula like Pythagorean theorem.

Published idea is not scarce and marginal costs for an additional user are zero. However, creating ideas requires creative work, most often also investments in R&D. The size of required investments is largely industry-related and so are the needed incentives. For instance, R&D in drugs sector is extremely expensive due to e.g. precious research instruments, while a software developer can pursue R&D with a computer and software. The problem arises from uncertainty: outputs from R&D projects are not completely predictable from the inputs (Arrow 1962). An R&D project might fail to produce profit-generating output in which case some investments become sunk costs (Rouvinen 2007). Nonetheless, conducted R&D adds to cumulative stock of knowledge if the results are properly disseminated for example through freely accessible patent databases.

There are several innovation policy instruments, which all have their own specific incentive characteristics. Takalo (2009) divides these tools into five main categories: (1) intellectual property, (2) subsidies, (3) tax incentives, (4) prizes and contests and (5) public production and procurement. This study focuses solely on intellectual property, more precisely on patent system. According to Takalo (2009) the advantage of intellectual property compared to public subsidies, is that it works like tax incentive: it makes decision making decentralized i.e. all firms are placed on equal position. In contrast, public subsidies are not granted for every firm and they require screening and supervision system. Furthermore, the level of direct subsidies is very difficult to determine due to complexity of externalities; externalities make the optimization problem extremely challenging for policy-makers (Rouvinen 2007). Intellectual property system instead provides exclusive rights to protect creation of mind. The most important intellectual property rights are patents, trademarks, copyrights and industrial design rights. Copyright differs from others, since it arises automatically for the creator, whereas patents, trademarks and industrial design rights must be applied for.

2.2.2 Patent system

At each stage the decisions about the next step should be based on all available information.

-Kenneth Arrow (1962)

From legal perspective an individual patent is a right to exclude others from commercially exploiting the protected invention (see e.g Uotila 2009). The patent system itself is a sophisticated system with a welfare maximizing rationale. Levin et al (1987) describe it as “unnatural barrier to market entry that is erected to facilitate private appropriation”. Thus, first and foremost the patent system is an incentive system. According to Cabral (2000, p.303) “the primary purpose of patent is to reward innovators”. Dolfsma (2004) clarifies the role of patent system further: “ - - in exchange for a temporary exclusive right to use of newly developed knowledge, a party is to make this knowledge publicly available in order for others to build on it”. Due to complexity of the system, this brief review is narrowed to focus mainly on its underlying rationales. In next section will be then discussed more deeply, how firms in practice utilize patents. Studying cross-country differences and qualitative features of the patent system like the length of protection or patentability criteria are beyond the scope of this study, although they expectedly have a major impact on firm behavior.

As was mentioned, the most important roles of the patent system are to (1) operate as an innovation incentive system[19] and (2) as a source of technical information (Kultti et al. 2007). Successful fulfillment of these roles should give rise to increasing number of technological innovations leading to productivity growth that promotes our standard of living. Loosely following Aghion & Howitt (2009, p.249) firms have two ways to generate productivity growth: by imitating existing frontier technologies or by innovating upon the previous technology. The patent system is an institution, which enables this in practice by providing information on cumulative innovations.

According to EPO, current web-based patent databases provide free access to more than 70 million patent documents. Thus, building on existing knowledge – as Arrow (1962) and Dolfsma (2004) pointed out above - is indeed powerfully promoted by the public sector. These rich sources of technical information are becoming all the time easier to access due to digitalization of the content and fast development of data mining software. By efficiently utilizing the patent databases it is possible to avoid ”re-inventing the wheel” i.e. resources are more efficiently allocated when no duplicate R&D[20] is carried out. This describes the twofold nature of the patent system: information is at the same time input for and output of inventive activity (Arrow 1962). The disclosure and dissemination of inventions and technologies promotes creative destruction: novel products and processes obsolete former ones and productivity increases leading to higher standard of living in the long run.

Figure 2-3 below visualizes the relationship between patents, innovations and inventions. "Ideas"[21] is the umbrella term, which consists of inventions and innovations. Innovations in turn are commercialized inventions. The propensity to patent, which will be discussed in more detail in section 3.2, is the overlapping part of innovations and patents. Only a part of inventions meet patentability criteria (see footnote 3, p.2) and not all patented inventions are successfully commercialized i.e. become innovations.

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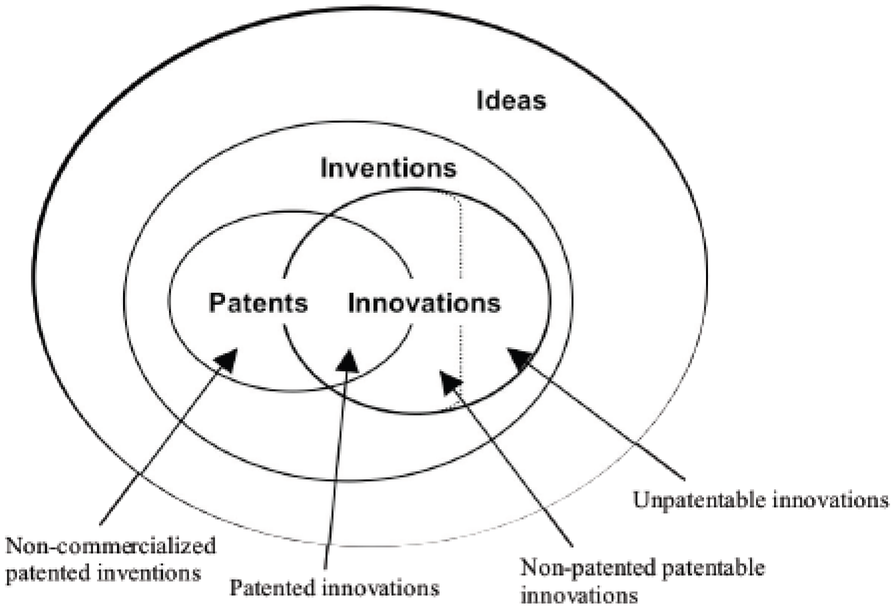
[19] According to Helmers & Rogers (2011) "the patent system specifically aims at encouraging formation of ne firms based on inventions".

[20] In Finland Loikkanen et al. 2009 have pointed out that the proportion of patent applications, which do not eventually lead to a granted a patent due to existing obstacles for novelty, might indicate duplicate R&D. According to their survey, approximately 33% of Finnish patent applications were rejected for this reason. This raises a question of patent applicants insufficient know-how to utilize patent databases.

[21] In economic literature and similarly in this study the boundaries of ideas, knowledge, technological knowledge and information are unfortunately a bit blurred.

Figure 2-3: Innovations and patents [22]



One should bear in mind that the relevance of patent protection is very different for distinct industries and depends also on firm size. For example, Levin et al. (1987) and Cohen et al. (2000) findings provide evidence that the effectiveness of patent protection varies widely among industries: in certain sectors, e.g. drugs, pharmaceuticals and chemicals patent are core of business, whereas in most sectors they are not so important. A major obstacle for firms to use patents as means of appropriation is the information disclosure, which is required in patent application (Harabi 1995). After an application is made public[23], competitors can exploit it to get valuable information on profitable research areas and how to invent around the patent (Arundel 2001). For example Mansfield et al. (1981) found that 60% of patented inventions were imitated within 4 years after disclosure. However, at least patents tend to raise imitation costs and time required to duplicate the innovation (Mansfield et al. 1981, Levin et al. 1987). Since patents are effective means of appropriation of innovation returns only in a few industries Harabi (1995) stated that an industry-specific patent policy would be the right solution. For instance, shorter length of patent protection could be more suitable for industries, in which the technological progress is particularly fast and cumulative.

2.2.3 Responses to incentives

Thus far, the study has focused on viewing the patent system from the perspective of a society. Patent system is supposed to create incentives to promote invention-based entrepreneurship and technological progress, from

[22] Replicated from Mäkinen (2007), who has refined the visualization of Basberg (1987).
[23] For example in Finland a patent application is made public after 18 months. Source: NBPR.

which the latter is regarded as the main source of economic growth in the long run. In business and in the mindset of firm's management the driving force is nevertheless profit-maximization and firms' responds to incentives must be judged from this angle. If patent and legal systems were ideal, there would be no need for leaving innovations unpatented i.e. the propensity to patent for patentable innovations would be close to 100% and the diffusion of technological knowledge and innovations would be maximized through freely accessible digital patent databases. However, investigations of the patent system have suggested that patents do not always work in practice as they do in theory (Levin et al 1987). This section discusses briefly, how rational firms would utilize the patent system and how firms actually do.

Managerial perspective

A rational firm management valuates and ranks investments on the basis of net present value, NPV. To succeed, firm's management should execute only investments which produce positive NPV. If there are many positive NPV projects, the ones with the highest profit generating potential, i.e. highest NPV with relatively lowest risks, should be chosen to be carried out. Patents themselves are pure cost factors due to several fees related to them (applying, translating, renewal) and if they are passively held, the NPV is likely to be negative. However, a patent provides a real option to exclude competitors from commercially utilizing the patented invention (in the region they are in force). Furthermore, if a patent office grants a patent, it might be easier for the firm to attract external finance (Engel & Keilbach 2007, Hsu & Ziedonis 2011). Thus, applying for patent protection for an invention can be understood as a strategic investment decision for a firm.

The level of competition in the industry determines to a great extent how actively patents are utilized. The tighter the competition the bigger is the risk that innovation is imitated. Preserving monopolistic position requires active supervision for potential infringements. If a firm actively and successfully enforces patent rights against infringers, the return to patents could be remarkable. By acting as an active enforcer, a firm can signal to current and potential competitors that an infringement may lead to severe consequences. In contrast, if rights are not enforced, then infringement is indirectly accepted and the firm signals that it is not committed to defend its quasi-monopolistic position.

If firms do not patent their inventions, it signals that the expected net benefit related to patenting is not sufficient. In other words the returns do not compensate the associated costs and uncertainties. According to Levin et al. (1987) a firm must be able to appropriate sufficient returns to make the investment worthwhile. Cohen et al. (2000) provide evidence that firms' reasons to patent extend beyond directly profiting from a patented innovation: patents may be used for example to prevent rivals from patenting related innovations, as bargaining chips in negotiations and to prevent suits. Pros and cons related to patenting from the perspective of profit maximizing firm management are presented in table 2-1. These are factors that presumably affect the propensity to patent i.e. the management's patenting decision.

Although, a more detailed review of patent utilization methods is beyond the scope of present study, one certain role of patents is highlighted in this context. Patents have a particular role in venture capital markets (Cohen et al. 2000, Engel & Keilbach 2007, Hall 2009, Hsu & Ziedonis 2011). The basic problem in venture capital markets is that to convince a venture capitalist of the profitability of the investment, a firm has to reveal its idea or invention (Cabral 2000, p.294). In other words, the firm takes a risk to lose its idea without getting funding if idea is not protected decently. Fortunately, patents can alleviate the problem in case the invention meets the patentability criteria (see footnote 3, p.2). Findings of Engel & Keilbach (2007) support this theory. According to their results with German start-up data firm's number of patent applications is positively related to its probability to acquire venture capital.

Table 2-1: Pros and cons of patenting – a managerial perspective

Pros	*legal right to exclude competitors from using the patented invention i.e. potentially quasi-monopolistic position
	*potential cash flow from licensing activities
	*freedom to operate (Cohen et al. 2000, Kotala et al. 2010)
	*cross-licensing (Cohen et al. 2000)
	*signaling capital markets, securing external finance using patents as collateral (Engel & Keilbach 2006, Atun et al. 2007, Uotila 2009, Hall 2009, Kotala et al. 2010, Helmers & Rogers 2011)
	*negotiation power (Levin et al. 1987; Harabi 1995; Cohen et al. 2000; Uotila 2009, pp.267-268; Helmers & Rogers 2011)
	*creating fence around core inventions (Cohen et al. 2000)
	*disrupting competitors i.e. patenting inventions crucial for competitors (Harabi 1995)
	*reputation as innovator, status and marketability of the innovation (Kotala et al. 2010)
	*patents as a means of evaluating the performance of R&D employees (Harabi 1995)
Cons	*disclosure of invention (Harabi 1995)
	*fees (applying, renewal, etc.)
	*patent easy to invent around (Levin et al. 1987)
	*legal costs in case of litigation (Cohen et al. 2000, Leiponen & Byma 2009)
	*uncertain result in litigation i.e. monopolistic position not guaranteed
	*patent thickets (Cohen et al. 2000)

Recent trends

The fast growth in the number of patents has caused some new phenomena. In new technology sectors like ICT, where the phase of technology development has been extremely rapid, the strategic use of patents have evolved (Cohen et al. 2000, Hall & Ziedonis 2001, Hussinger 2006) and for example cross-licensing has become an integral part of business. Patent thickets (see e.g. Cabral 2000, p.297) – common for example among smartphone producers – arise, when it is hard for a company to obtain freedom-to-operate because of fragmented ownership of patents essential for the product. Some owner's of essential patents might be reluctant to license, in which case a patent infringement is inevitable, if the said company still is willing to sell its product. Cabral (2000, p.297) notes that firms can have "sleeping patents", which only purpose is to prevent competitors from inventing similar technology.

Recently non-practicing entities (NPEs or "patent trolls", see Hall 2009) have occurred to the markets, especially in the U.S. (see e.g. Hall 2009). They are patent and technology market players, sort of patent holding companies, which business is aggressively license patent portfolios. Bessen et al. (2011) define NPEs as "firms that license patents without producing goods". Aggressive licensing relies heavily on litigation strategy, i.e. NPE accuses firms of patent infringement and threatens them with litigation. In many cases the accused company – even if innocent to infringement - is reluctant to start costly litigation process and prefers to pay licensing fees.

It is alarming that for example Scotchmer (2004) have noted that in the nineteenth century "patent litigation created uncertainty and slowed the growth of industry". This kind of trend and opportunistic behavior of certain agents raises question, does the current patent system anymore fulfill its original mission: diffusion of technical knowledge. The most disturbing estimates have been proposed by Bessen et al. (2011), who suggested that NPEs lawsuits have caused half a trillion dollar losses to defendants during 1990-2010. According to Bessen et al. (2011) the defendants were mainly ICT and other technology companies. It seems that patent litigation have mostly benefitted American lawyers. In contrast, Hall (2009) argues that the emergence of NPEs might also encourage entry into innovation as they can create secondary market for IP asset, where for example patents of bankrupt companies can be traded.

3 IP STRATEGIES AND FIRM GROWTH

The relationship between innovation return appropriation methods i.e. IP strategies and firm growth has gained relatively little attention in economic literature. This is interesting, since probably even the employment effects of innovations, which were discussed in section 2.2.3, cannot be fully understood without taking into account firms' intellectual property strategies. For example patenting, a formal IP strategy, may have a remarkable positive effect on market power, profits and growth prospects. The model of Harrison et al. (2008) and Hall et al. (2007) (see section 2.2.3 p.13) might produce differing results considering growth effects of firms that use different IP strategies. Furthermore, one underlying hypothesis of this study is that the patent system should guarantee that innovation returns are higher for the firms that patent their innovations than for those that keep them secret. Otherwise, there are no incentives to patent and promote cumulativeness of technical knowledge.

Analyzing the relationship between firm growth and IP strategies may yield interesting results from the perspective of innovation policy. Thus, it is important to gather empirical evidence on the efficiency of current innovation system, since these findings signal what kind of improvements could be made in the future. Due to limited amount of previous research on IP strategies and growth, the emphasis in this chapter is put on reviewing previous studies concerning IP strategies and propensity to patent. Last section (3.3) is devoted to the few papers, which one way or another combine IP strategies and firm growth.

3.1 Intellectual property strategies

In this study, intellectual property strategies refer to methods used by firms to appropriate returns from product and process innovations. IP strategies can be divided into two main categories: formal and informal strategies. Formal strategies consist of utilization of patents whereas informal methods include secrecy, lead time and complementary products and services[24]. In addition,

[24] Rapid publishing of the idea or invention could be a good strategy, if the firm cannot afford to patent and competitors might be developing same kind of idea (Luoma et al. 2010, Kotala et al.

complexity of products and processes is considered as one IP strategy in some studies (e.g. Arundel et al. 2001).

Generally, the ultimate goal of the firms in the long run is to maximize profits. The longer it takes for competitors within an industry to imitate the innovation or to introduce a competing innovation, the greater will be the innovation returns i.e. profits of the innovative firm (Levin et al. 1987). A narrow view is that with IP strategies firms attempt to prevent imitation or at least increase imitation costs of competitors, in other words, inhibit the rent-free commercial utilization of their innovations. In addition, firms can get cash flows by licensing their patents. On the other hand, it may also be in interest of a firm to encourage other firms to copy the innovation so that it will become a standard. Table 3-1 summarizes the relative importance of IP strategies observed in previous studies and shows that differences in IP strategies between product and process innovations are evident.

Table 3-1: Relative importance of IP strategies[25]

	Levin et al. (1987)		Harabi (1995)		Cohen et al. (2000)		Arundel (2001)		Cohen et al. (2002)	
	US n=650		Switzerland n=358		US n=1118/1087		7 European countries n=2849		Japan n=567/522	
	Product	Process	Product	Process	Product	Process	Product	Process	Product	Process
Patents	3	4	4	4	4	4	4	4	2	3
Secrecy	4	3	3	3	2	1	2	3	4	1
Lead time	2	1	2	1	1	2	1	1	1	2
Sales and services	1	2	1	2	3	3	-	-	3	4
Complexity	-	-	-	-	-	-	3	2	-	-

Interestingly, the table indicates that patents are relatively weak innovation return appropriation mechanism, since in most cases informal strategies are ranked higher. Patents are ranked the least important innovation return capture mechanism for process innovations in all studies but one. On the basis of Levin et al. (1987) and Cohen et al. (2002) patents seem to work a bit better for product innovations than process innovations. In Japan patens are considered more important than on average (Cohen et al. 2002). Maybe a bit surprisingly, patents are never ranked as the best IP strategy. However, it should be noted that these are aggregate level rankings and they omit industry heterogeneities.

As was pointed out already in previous section, on industry-level patents seem to be the most crucial for sectors such as drugs, pharmaceuticals and chemicals (Levin et al. 1987, Cohen et al. 2000) and also widely utilized in electronics and machinery. More recently, semiconductor industry has exhibited "a patent explosion" - at least in the U.S - which reflects increase in strategic patenting (Hall & Ziedonis 2001). Simple rankings also ignore the possible simultaneous use of different IP strategies i.e. bundling of IP tools (Hussinger 2006), which have been a common finding in prior studies (Levin et al. 1987, Cohen et al. 2000). Kotala et al. (2010), for instance, argue referring to

2010). Publishing prevents others from patenting the invention later, since publicly disclosed idea becomes prior art and does not meet the patentability criteria i.e. it is not novel anymore.

[25] Modified from Mäkinen (2007)

their empirical findings with Finnish data that informal and formal methods do not seem to be mutually exclusive or even competing but rather support each other[26] (see also Luukkonen 2001 for a biotechnology perspective). In their research Brouwer & Kleinknecht (1999) identify one more appropriation method, which is ”keeping qualified people in the firm”. A remarkable amount of competitive advantage of firms – in particular R&D-intensive firms - derives from tacit knowledge embodied in individual employees. Keeping qualified people in the firms ensures that this knowledge do not spill to competitors.

Lead time is found to be the most important appropriation method in almost all studies presented in table 3-1. According to Arundel (2001) the high importance given to lead-time advantages may indicate that firms forego patenting “if it reduces the ability of the firm to pursue lead-time advantages, e.g., if the time required to prepare patent applications distracts staff from more important tasks”. Intuitively this challenge is greater for smaller firms, since their human resources are scarcer. The boundary between lead-time and secrecy is sometimes hard to distinguish because in principle secrecy provides lead-time advantages as firm can develop its products and processes while competitors try to unravel the secret. Maybe the most classical example of secrecy as an IP strategy is the recipe of Coca-Cola, which the Coca-Cola company has protected since 1886.

Leiponen & Byma (2009) focused on studying IP strategies with Finnish data. The main contribution to existing literature was the applied small business perspective as sample constituted of 504 Finnish SMEs, which all employed less than 100 workers and on average 13 employees in 2001. Leiponen & Byma (2009) concluded that small firms’ IP strategies were qualitatively different from those of large firms: the informal means of protection - in particular speed - were preferred to patenting. Speed to market (closely similar to lead time) was found generally to be most important IP strategy among Finnish small businesses. According to Leiponen & Byma (2009) patents, instead, were the most important IP-strategy only for firms with university cooperation. This is not surprising, since firms involved in university cooperation typically are typically very R&D intensive from the very beginning. Leiponen and Byma (2009) also noted that the lack of resources to apply for patents and first and foremost to defend patents (due to costly litigation process) may substantially lower the attractiveness of patenting as IP strategy for small businesses. Earlier Cohen et al. (2000) and Arundel (2001) have similarly made the notion that the costs of enforcement may discourage patenting. Kotala et al. (2010) found from a survey directed to Finnish SMEs that almost every second firm would use more formal protection methods i.e. intellectual property rights if it would be cheaper to implement.

Another important finding of Leiponen & Byma (2009) was that cooperation with external partners in innovation or other business activities has

[26] Kotala et al. (2010) used informal protection methods as a broad umbrella term. In addition to already introduced informal methods included e.g. loyalty-building among personnel and circulation of staff from task to task.

significant implications for the benefits of different IP-strategies. Small firms are often involved in cooperative activities with larger partners, in which case their bargaining power is weak and it is difficult for them to obtain IP outputs from joint work. The finding conflicts with those of Brouwer & Kleinknecht's (1999), whose results with Dutch data indicated that firms participating in collaborative R&D were more likely to apply for a patent. One explanation for the difference in results is that Byma & Leiponen (2009) focused on small firms (mean≈13 employees) whereas studies utilizing CIS-data as Brouwer & Kleinknecht's do not have firms with less than 10 employees at all in their samples.

3.2 Propensity to patent

A frequently used definition of propensity to patent in economic literature is the portion of innovations that are patented (see figure 2-3 for a visualization). This definition is also applied throughout this study. Another alternative definition is provided by Scherer (1983), who defines propensity to patent as patents per unit of R&D expenditure[27]. Third way to measure propensity to patent was introduced by Arundel & Kabla (1998), who used sales-weighted percentages of innovations for which a patent application was made.

Mansfield (1986) found in his classical paper that a substantial part of patentable inventions[28] made by firms is not patented in the U.S. Mansfield (1986) studied essentiality of patent protection in development and introduction of inventions 1981-1983 with a random sample of 100 U.S. firms from 12 industries. He stated the question how big a portion of inventions would not have been developed and introduced without patent protection. The results indicate that patent protection was the most essential in pharmaceuticals and chemicals, where the shares of not introduced inventions in case of absence of patent protection were 65% and 30% respectively. Mansfield (1986) also found that in petroleum, machinery and fabricated metal products patents were essential for development and introduction for about 10-20% of inventions. According to Mansfield's findings office equipments, motor vehicles, rubber and textiles reported that patents were non-essential for all of their inventions developed or introduced during the period under study.

Arundel & Kabla (1998) studied patenting activity of largest European industrial firms and found that 35.9% of patentable product innovations were applied for patent ranging from 8.1% for textiles and 79.2% for pharmaceuticals. The corresponding numbers for process innovations were mean of 24,8%, from 8,1% for textiles and 46.8% for precision instruments.

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[27] Also used as an alternative by Mansfield (1986). Mansfield note that the results did not differ appreciably between these measures.

[28] Used terminology may be confusing, since often inventions and innovations are mixed (Nikulainen et al. 2006). According to Nikulainen et al. (2006) "an invention is typically defined as a new idea, while an innovation is defined as a commercialized invention."

Generally, Arundel & Kabla (1998) found the propensities to patent of European firms to be lower than those of American firms in the early 1990s.

Empirical results with Finnish data are also in line with the observation of Mansfield (1986) and Arundel & Kabla (1998): Mäkinen (2007) found with comprehensive data of Finnish product innovations (n=791) that less than 60% of them were sought for patent. Mäkinen (2007) studied the propensity to patent with Finnish Sfinno-data[29] (The database of Finnish Innovations maintained by VTT Technical Research Centre of Finland). His results indicated that Finnish firms had U-shaped propensity to patent when linked with firm-size. In other words, small and large firms patent more than medium-sized firms. According to Mäkinen (2007) this U-shaped relationship could be explained to a relatively large extent by economies of scale in patenting activity - i.e. the costs of maintaining a legal department dealing with patents are fixed - and secondly by the important role of patents in start-up ventures.

In addition to dissimilarities in propensity to patent between industries, propensity to patent varies also between innovation classes. Due to different nature of process and product innovations different protection methods are used. Secrecy works better for process innovations than for product innovations (Niefert 2005, Levin et al. 1987, Cohen et al. 2000). That is to say product innovations are more likely to be patented than process innovations (Harabi 1995, Cohen et al. 2000, Hussinger 2006). According to Leiponen & Byma (2009) a process innovation is more effectively kept within a firm and protected with trade secrets, since often legal protection, which patents offer, may not be worth the disclosure of information that is prerequisite in patent application. Still, Arundel (2001) concludes on the basis of various previous survey studies that manufacturing firms generally rate secrecy higher as an appropriation mechanism for both product and process innovations. It should be noted that an innovation can be protected with several patents. According to findings of Acs and Audretsch (1988) the average number of patents per innovation can vary substantially between industries: with American innovation data they found the average number of patents per innovation to be 3.9 ranging from 0.6 (lumber and furniture) to 43.58 (petroleum).

R&D cooperation between firms have become increasingly common since firms more and more focus on satisfying customer needs by producing customized solutions. In buyer-supplier relationships it is usual that innovative components are created during process. Hence, more often firms are facing situations, where contracts on the allocation of IPR outputs have to be made between supplier and customer. Paija (2004) studied what determines the allocation of IPR within cooperating firms with same Etlatieto's survey data, which is described in more detail in the next section. Paija's sample comprised of 302 suppliers from most industrial sectors. Paija focused on estimating importance of two factors recognized to affect allocation of IPR by the theory of

[29] See Palmberg et al. (2000) for a more detailed description of Sfinno-data.

property rights, namely investment criticality and bargaining power. Her findings indicate that Finnish firms allocate control rights according to relative resource contributions i.e. investment criticality. Paija found no inter-industrial differences in allocation. However, she pointed out that IPR ownership may not be the primary objective of both parties and firms might be more concerned about maximizing relationship output than individual benefits reaped by exploiting bargaining power. This is very important matter, since very large portion of firms has a key customer or alternatively supplier (i.e. operate in vertical dependence) and it probably is for them more crucial to preserve good long-term relations than to maximize profits in one individual project. It is expected that this is the case especially in relationships were the relationship between supplier and customer is somehow unbalanced, e.g. the other party is very dependent on the other whereas other has remarkable bargaining power.

Kim & Marschke's (2005) theoretical modeling and empirical findings with U.S. firm-level panel data show that scientist and engineer turnover and firms propensity to patent are positively correlated i.e. labour mobility leads to increasing patenting, since firms use patents to minimize the harm caused by departing employees. Kim & Marschke (2005) argue further that the high employee turnover in small firms might partly explain small firms patenting propensities, which are higher than those of large firms.

Ali-Yrkkö et al. (2004) studied patent-driven M&A with comprehensive Finnish data (817 firms, mostly small and private) during three year period, from the beginning of 1998 to the end of 2000. Their basic argument was that the ownership of patent and the disclosure of the invention might arouse acquisition interest of other firms. Novelty of the exploratory study was the separation between domestic and cross-border M&A. According to the results of Ali-Yrkkö et al. (2004), owning patents rises a firm's probability to be acquired by a foreign company but the same did not hold for acquisitions of domestic companies. Authors suggested this result to indicate that patenting via European patent office (EPO) increases the probability of cross-border M&A. Regression where EPO patent data was replaced with data from National Board of Patents and Registration of Finland indicates that domestic patents did not attract as much M&A activity. This finding of Ali-Yrkkö et al. (2004) could be interpreted that Finnish patents are of limited value for foreign acquirers, since the monopoly right is regionally limited. Finally Ali-Yrkkö et al. (2004) pointed out that lack of data on patent quality (e.g. forward citations) leaves one important factor affecting acquisitions uncovered, because firms owning high-quality patents are probably more prone to be acquired than firms with low-quality patents.

3.3 IP strategies and growth

The common approach to study the effectiveness of IP strategies has ever since Levin et al. (1987) seminal article been analysis of surveys, which try to reveal how firm management subjectively values IP tools. Although, it has long been possible, very little effort has been made to link this valuable survey data with performance figures of firms to find out how well utilized IP strategies have succeeded in practice.

Hussinger (2006) studied the effect of patents and secrecy on firm's sales of new products. Her data sample was based on CIS III data and consisted of 626 observations of German manufacturing firms, which all conducted R&D in 2000 and were additionally product innovators. Hussinger (2006) found a statistically significant positive relationship between patenting and sales with new product. Secrecy in turn did not seem to have a similar effect. On the basis of the results, Hussinger (2006) concluded that "patents turn out to be the more effective tool to protect inventions in the market phase as opposed to secrecy, which is also applied by a large fraction of the sampled firms".

Niefert (2005) had a bit narrower perspective on IP strategies as she studied firm-level employment effects of patents. Other IP strategies were left out of the scope. With panel data sample of 1387 German start-ups founded in the 1990s Niefert (2005) found patenting activity to have a positive effect on employment growth at firm-level. According to the results this effect was the most pronounced two years after application and seemed to diminish with firm's age. Furthermore, Niefert's (2005) results suggested that patenting firms did not on average have higher employment growth rates than their non-patenting counterparts, instead, the growth seemed to be dependent on patenting activity over time.

Helmers & Rogers (2011) studied the effect of patenting on asset growth of all (n=3981) British medium and high-tech start-ups between 2001 and 2005. 303 i.e. 7.6% of the sample firms had applied for a patent during 1999-2001. According to them "if patents fulfill their most fundamental role, allowing innovators to profit from their inventions, patenting firms should ultimately see the competitive advantage conferred by patents reflected in performance superior to similar non-patenting firms". Helmers & Rogers (2011) found patenting firms to have significantly higher survival rate (83%) than the entire sample (60%). Furthermore, their results suggested that patentees had 8%-27% higher asset growth per annum than non-patentees. The findings of Helmers & Rogers (2011) imply that British start-ups benefitted from patenting in two ways: (1) applying for a patent lowered the likelihood of failure and (2) asset growth was higher during the five first years of existence.[30]

There exist no studies known to the author with Finnish data that directly analyze the relationship between IP strategies and firm growth. Ali-Yrkkö & Martikainen (2008) and Koski & Pajarinen (2011) studied growth effects of innovation but intellectual property strategies have been left beyond the scope. Kotala et al. (2010) utilized relatively small survey sample (n=170) of Finnish firms to study the methods that firms adopt to protect their intellectual assets. The study did not find any significant relationship between an SME's

[30] The distribution of asset growth 2001-2005 of sample firms of Helmers & Rogers (2011) is compared to the distributions of employment and turnover growth of the sample firms of this study in appendix 10.

level of innovativeness and its growth rate. However, high-growth SMEs[31] were found to use more actively formal protection practices (patents, utility models, trademarks and design rights) than their non-high-growth counterparts. An interesting finding, although correlation does not imply causation.

[31] OECD-Eurostat definition of high growth firms (HGFs): "All enterprises with average annualized growth greater than 20% per annum, over a three year period, and with ten or more employees at the beginning of the observation period. Growth is thus measured by the number of employees and by turnover" (OECD 2010). According to Deschryvere (2008) roughly 5% of Finnish firms with more than 10 employees were HGFs. In 2006 the precise number was 750, of which 642 grew organically.

4 EVIDENCE FROM FINNISH SMALL BUSINESSES

In this chapter the relationship between IP strategies and firm growth is analyzed among innovative Finnish small businesses. First, some special characteristics of the Finnish market are briefly reviewed in section 4.1. Section 4.2 is dedicated to data description and section 4.3 summarizes the findings before concluding chapter 5.

4.1 Finnish context

In 2009 there were 320 682 firms in Finland. The mean size was 4.5 employees with a little more than one million Euros turnover. 99.8% of Finnish firms were SMEs and the remaining 0.2% large companies. More precisely 94.5% of firm population consisted of micro-firms, which employed less than 10 employees[32]. Although only 7% of Finnish firm population operated in manufacturing sector, manufacturing firms employed almost one quarter (24%) of all Finnish wage earners in 2009. In addition, the proportion of their turnover of the total turnover of all Finnish firms was even more remarkable being 34%. (Statistics Finland)

Finland is a small open economy, which success has based to a great extent on exports. Due to the limited size of domestic market, Finnish firms – in particular those operating in manufacturing sectors – have been forced to seek growth from international markets. During the period 2000-2010 exports remained approximately at 40% of GDP. Three most important export countries for Finnish companies have for long been Sweden, Germany and Russia. According to Nikulainen (2008) "the most important technologies in Finland have traditionally been process and mechanical engineering, which are related to the two cornerstones of Finnish manufacturing industries – forest and paper, and metal and machinery". In particular mechanical engineering is an R&D-intensive sector characterized by a high amount of inventions and

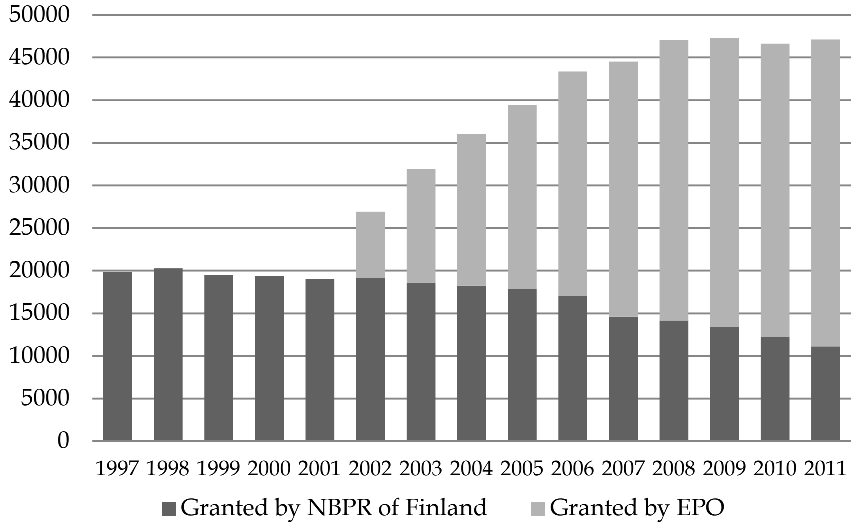
[32] According to the definition of European Commission a microenterprise employs fewer than 10 persons and has annual turnover and/or annual balance sheet total does not exceed 2 million Euros.

innovations. Hence, the role of IP strategies would be expected to play a central role in company management of firms operating in this field.

As investments have increasingly turned from tangible to intangible, the role of intellectual property protection have gained importance in global competition environment. Maliranta & Rouvinen (2007) stated that in the Finnish business sector investments in intangible assets have exceeded the amount directed to tangible assets. According to Maliranta & Rouvinen (2007) research and development expenditures formed approximately one third of the intangible investments among Finnish firms during 2003-2005. The empirical findings of Hyytinen & Pajarinen (2002, table 3.9) showed that a larger portion of Finnish small businesses, which owned patents, had acquired both public and private venture capital financing than their non-patenting counterparts. This may indicate that patents might have had a signaling role for financiers. Nikulainen et al. (2006) emphasized further the rising role of patents as "a central pathway for capturing the value of intangible assets in knowledge-intensive business".

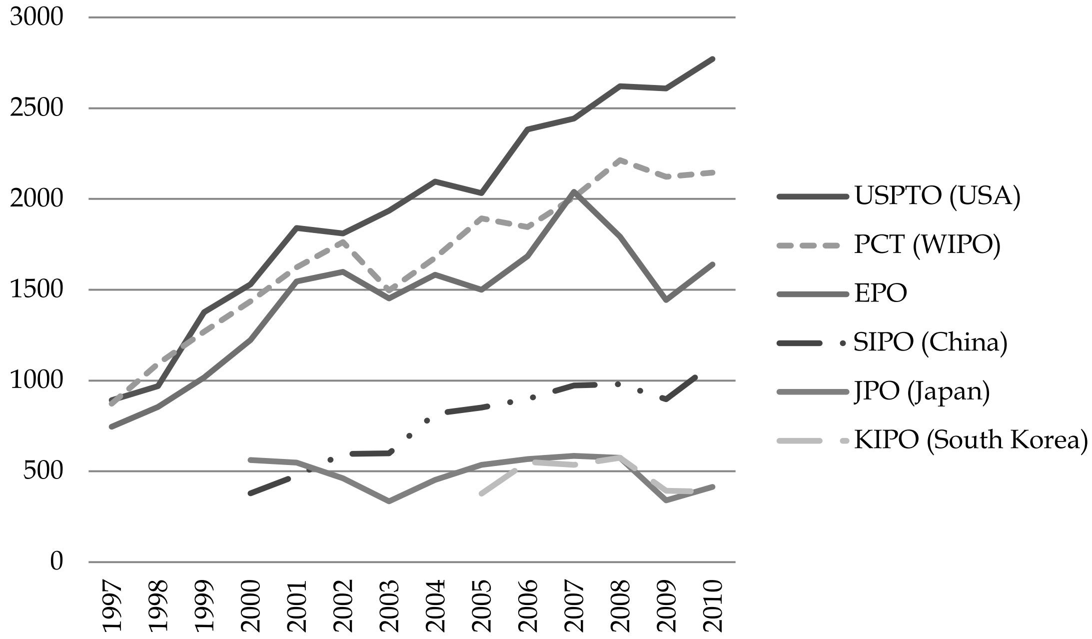
The growth in patenting activity probably reflects the aforementioned changing nature of investments. Finland joined European Patent Convention (EPC) in 1996. EPC enables an inventor to make a patent application to 40 European countries at the same time. Since 1996, the amount of patents in force in Finland has steadily risen while domestic patent applications via NBPR have decreased as can be seen in Figure 4-1. Figure 4-2 in turn depicts a slight upward trend in patenting activity abroad among Finnish companies, especially in the U.S. Nokia is (still) by far the most remarkable Finnish patentee and its significant share in patents and patent applications should always be taken into account when attempting to interpret aggregate data of patents owned by Finnish firms (see Iversen et al. 2009 p.25 for description of "Nokia-effect").

Figure 4-1: The number of patents in force in Finland[33]



[33] Source: NBPR. Data on European patents is not available directly for years 1997-2001.

Figure 4-2: Finnish patent applications in selected patent offices[34]



4.2 Data and descriptive statistics

The data for empirical section was compiled from three sources: (1) firm survey data provided by Etlatieto Oy, (2) financial statement data from Statistics Finland and (3) financial statement data from Asiakastieto Oy. Etlatieto's firm-level surveys include the indicator variables of interest i.e. intellectual property strategies and Statistics Finland and Asiakastieto Oy provided financial statement data on employment and turnovers making it possible to analyze the growth of the sample firms.

Originally the surveys were organized to obtain quantitative information on financial structure and innovativeness of Finnish small businesses (see Hyytinen & Pajarinen 2002 for a more detailed description of the data). The main advantage of Etlatieto's data in comparison to previous studies on innovation return appropriation is its focus on small businesses. For instance, the classical article of Levin et al. (1987) concentrated solely on publicly traded companies leaving small firms out of the scope. Also frequently used CIS (Community innovation surveys) data excludes firms employing less than 10 employees. However, the utilized sample do not perfectly represent the industry structure of Finnish SME population, since the portion of technology intensive small businesses is greater vis-à-vis (Hyytinen & Pajarinen 2002). Additionally, agricultural and real-estate firms are excluded together with proprietorships, partnerships and subsidiaries[35] (Hyytinen & Pajarinen 2002). Survey data consists of three separate telephone interview rounds, which were

[34] Source: NBPR.

[35] Excluding subsidiaries is important, since according to Arundel (2001) "subsidiary firms could rely on their parent firm for major innovations and therefore find patents of less value than secrecy".

targeted at the management of the sampled firms. Originally 936 firms of 2600 contacted firms responded in the first survey conducted in 2001 (respond rate of 36%) and of these 936 firms 830 firms responded to the second one conducted in 2002 (Hyytinen & Pajarinen 2002). The survey data is linked with business IDs to the firm-level financial statement data provided by Statistics Finland and Asiakastieto Oy.

Altogether 535 firms responded to the main questions of interest, which considered actually utilized IP strategies. All of these firms had self-reported[36] to have introduced product or process innovation or both during 1999-2001. Dropping non-innovative firms i.e. limiting the analysis only on innovating firms may lead to sample selection bias, since innovations probably have an effect on firm growth, which is treated as the dependent variable[37]. This type of selection process "can introduce correlation between the error term and regressor, which leads to bias in OLS estimator" (Stock&Watson 2007 p.322). Heckman selection model is generally applied to correct this type of bias. However, no proper instruments were available to specify the selection equation and thus it was not possible to identify the selection model credibly. Therefore, when findings and conclusions on firm growth are interpreted, it should be kept in mind that results are conditional on that firms have made an innovation.

The firms, which had not reported the size of R&D expenditures, were excluded from the sample because R&D expenditures were required to construct a control variable for innovativeness in following regressions. Likewise firms with less than 0.5 or more than 100 employees were dropped together with those that had turnover in 2001 over 10 million Euros[38]. In the end the sample constituted of 469 firms, whose descriptive statistics are summarized in table 4-1. Following Paija (2004) categorical R&D expenditure responses were transformed into numerical observations by assigning the variable mean value of the respective category.

According to Arundel (2001) using R&D expenditure is preferable to R&D-intensity, since "an R&D lab of a given size probably follows the same strategy as those of its peers, regardless of the total number of employees within the firm" and further "a very large firm with relatively high-levels of R&D spending but a low R&D-intensity will follow a similar strategy on patents and secrecy (other factors being equal) than a medium-sized firm with the same amount of spending on R&D"[39]. Comparison of correlations between patenting, R&D expenditures and R&D intensity revealed that R&D expenditures had higher correction coefficient (0.25) with patenting than R&D intensity (0.13). The finding supported the referred argument of Arundel (2001).

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36 Self-reporting may contain subjective bias, which cannot be controlled (see "Innovation indicators" pp.9-10).

37 See appendix 3 for descriptive statistics of the original sample and non-innovative firms.

38 GDP price deflator was used to deflate the turnover figures. Index year is 2000.

39 Also Klette & Kortum (2004) assumed in their theoretical model of innovating firms that "[a] firm that is twice as large will expect to innovate twice as fast by investing twice as much on R&D.

Review of the data further supported Arundel's (2001) argument as the distribution of R&D-intensity of sample firms was extremely skewed. Some firms even had R&D-intensity over 1000% in 2001. These high R&D-intensities imply probably that firms were still developing their products and had not yet remarkable sales. Therefore, in table 4-1 median of R&D-intensity is reported instead of mean.

Table 4-1: Descriptive statistics[40]

Variable	Obs.	Mean	Std. dev	Median	Min	Max	Sum
Continuous variables							
Employees	469	13.9599	16.8953	7	0.5	95.6	6547.2
Age	469	15.0597	13.7751	11	1	109	7063
Turnover (1000€)	397	1705.17	2016.03	874.22	0.327	9524.84	676950.50
R&D expenditures (1000€)	469	152.72	806.52	16.82	0	15200	71627.75
R&D intensity (%)	397			0.0243			

	Count	% of sample
Binary variables		
R&D	408	86.99 %
Product innovation	386	82.30 %
Process innovation	269	57.36 %
Export	237	50.53 %
Vertical cooperation	207	44.14 %
Horizontal cooperation	145	30.92 %
University cooperation	113	24.09 %
Vertical dependence	229	48.83 %
Tekes subsidies or loans	76	16.20 %
IP strategies		
Patenting	83	17.70 %
Secrecy	280	59.70 %
Speed	291	62.05 %
Complements	358	76.33 %

In 2001 an average sample firm had approximately 14 employees and turnover of 1.7 million Euros. An average firm had been active for 15 years and every second of them was an exporter. As was mentioned, all sample firms had introduced innovation during 1999-2001. More precisely, 82.3% of them had introduced product and 57.4% process innovation or multiple innovations during period 1999-2001. Furthermore, 186 of sample firms i.e. 40% had introduced both types of innovations. Cooperation on various levels seemed to be quite common among the sample firms. Horizontal cooperation refers to cooperation with firms in the same industry while vertical refers to inter-industry cooperation. The definition of vertical dependence dummy follows that of Leiponen & Byma (2009): a firm is classified to be vertically dependent if it had a customer, which share of firm's sales was over one third of total turnover or if firm had a supplier, which share of procurements was more than one third. IP strategies reported in table 4-1 describe those actually used by firms whereas figure 4-4 comprises also IP-strategies, which firms have reported as the most important appropriation method in its own field. 83 firms i.e. 17.7% of sample firms had used patenting to appropriate innovation returns.

[40] See appendix 5 for industry-level descriptive statistics.

The data covered yearly employment figures (full-time workers) for the period 2001-2010 and turnover figures for 2001-2009. The turnover data had more missing values than the employment data. This was not a severe problem in calculation of growth rates but it weakens the comparability of yearly figures. Survival rate of firms was 73.8 % for the whole period 2001-2010, since 346 of 469 initial sample firms had employees in 2010. However, it should be noted that using the term "survival rate" may not be appropriate because data set simply was not perfect for some firms. Thus, some firms that had no figures in the end of the period had not actually exited but statistical observation simply is missing. This is especially true for turnover as years 2008 and 2009 had remarkably more observation than 2005, 2006 and 2007, albeit entry of new firms was not allowed in the sample. Table 4-2 presents the figures of annual observations for employment and turnover.

Table 4-2: Annual observations 2001-2010

	Employment				Turnover			
	Obs.	mean	s.d.	median	Obs.	mean	s.d.	median
2001	469	13.9599	16.8953	7	397	1705.17	2016.03	874.22
2002	463	14.5760	21.6231	7	394	1771.73	2647.78	775.83
2003	449	14.4096	20.2354	7	397	1844.80	2945.46	776.99
2004	435	14.1972	18.6065	6.7	370	2009.04	3238.37	791.97
2005	420	14.4560	19.1658	6.75	323	2343.56	4372.56	870.06
2006	403	15.3375	21.0246	6.7	320	2749.12	5251.50	884.34
2007	389	16.1820	22.9073	6.9	308	2873.62	5363.45	984.23
2008	381	16.7588	25.3511	6.7	370	2565.23	5229.90	774.53
2009	370	15.7614	23.5729	6.5	360	2104.52	3837.52	660.45
2010	346	16.0757	24.7595	6.05				

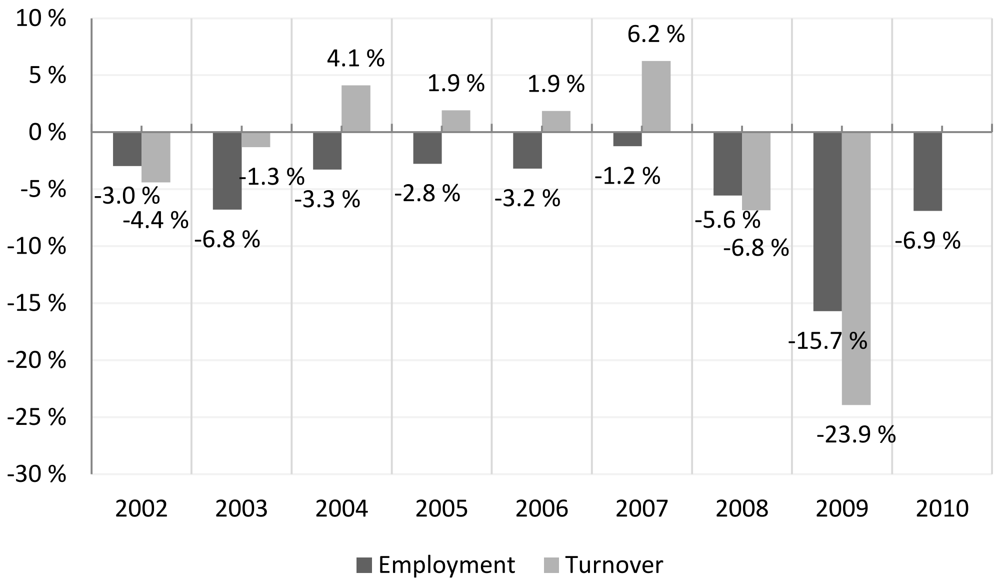
If the most severe impacts of financial crisis were excluded i.e. years 2009 and 2010 were left out of analysis, the survival rate was 81.2% for 2001-2008, since altogether 381 firms had employment in 2008. The impacts of crisis are clearly evident in figure 4-3, which depicts annual growth rates of employment and turnover over the period. The aggregate turnover of the sample firms reached its peak in 2007 and dropped severely after beginning of the global financial crisis[41] (table 4-2). As can be seen in figure 4-3, firms responded to decreasing demand and sales by reducing working hours: between 2008 and 2009 sample firms decreased them on average by 15.7%.

The underlying reasons of firm exits during the period would be an interesting issue to study more deeply, since it relates closely to analysis of firm

[41] The turnover data had more missing observations than the employment data and therefore the statistics should be interpreted as only tentative. Sample selection bias could arise if firms utilizing different IP strategies had different survival rates. However, for example patenting firms had survival rate of 81.9% (61/83) 2001-2008 whereas non-patenting firms had 81.1% (313/386) i.e. no significant difference was found.

growth. Unfortunately there's no data available. The possibility of mergers and acquisition is one important matter, which should be taken into account when survival rates are reviewed. Exits do not always reflect failure of business and bankruptcy, instead, statistical exits can occur due to a fusion or an acquisition. For example, Ali-Yrkkö (2002) pointed out that in most Finnish M&A activity the targets have been small businesses: in roughly 60% of cases size of the target firm has been under 100 employees and 20 percent of targets had less than 10 employees. Thus, it is highly probable that some portion of sample firm exits during the period was due to M&A. Furthermore, Ali-Yrkkö et al. (2005) found that patenting by a Finnish firm correlated positively with probability of M&A. This implies that a larger portion of exits of patenting firms might have been due to M&A than for non-patenting firms respectively. The other side of the coin is that one cannot control how large share of growth of sample firms was organic and how large share inorganic i.e. due to M&A, although probably small businesses in general are not as active acquirers of businesses as large firms.

Figure 4-3: Employment and turnover, annual growth 2001-2010



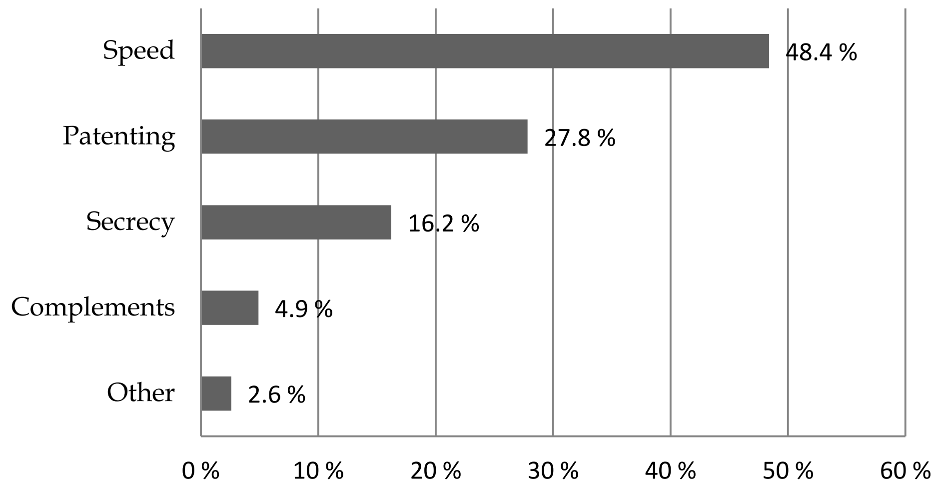
To dig into the heterogeneity of the sample firms, distributions of employment, turnover, age and (logarithmic) R&D expenditures in year 2001 are presented in appendix 4. The size distribution of firms is highly skewed to the right both for employment and turnover. Mean age of the sample firms was approximately 15 years in the beginning of the period in 2001. Altogether 42.7% of firms had been operating less than 10 years. The largest age category is by far the one including firms over 5 and less than 10 years, since 32% of firms belong to this group. Firms older than 30 years were clearly a minority in 2001 and represent 9.3% of the sample. Many firms reported to have no R&D expenditures, which is in line with the stylized fact number 4 of Klette &

Kortum's (2004) model of innovating firms. Their stylized fact states that "a considerable fraction of firms report zero R&D".

Figure 4-4 presents the portion of firms, which have ranked the particular appropriation methods most important in its field of industry. Data on the most important IP strategies is derived from the second survey (conducted in 2002) and involves answers from 345 firms. The results are in line with Leiponen & Byma (2009), who utilized the same data with larger and slightly differently specified sample and found speed to be the most important before patenting and secrecy. Similarly Harabi (1995) found with Swiss data lead time to be the most important appropriation method. However, secrecy was more seldom ranked as the most important appropriation method among innovative Finnish small businesses than it was among U.S. companies (Cohen et al. 2000). Leiponen & Byma (2009) argued that one underlying reason for the low popularity of secrecy might have been the large amount of cooperation, in which small businesses were involved in.

The graph below is closely similar to the one presented by Arundel (2001), although no separation have been made between process and product innovators[42]. Arundel (2001) studied appropriation methods with CIS I data, which covered 2849 firms from Norway, Germany, Luxembourg, Netherlands, Belgium, Denmark and Ireland. Arundel found lead-time to be generally the most important method as 54.5 % of firms ranked it first for product innovations and 46.7% for process innovations. In contrast to Arundel (2001), Finnish small businesses rated patenting (28.7%) more often as the most important appropriation method than secrecy (15.9%). Arundel's (2001) percentages were respectively 11.2% and 16.9% for product innovators and 7.3% and 19.8% for process innovators.

Figure 4-4: The most important appropriation methods



[42] On the basis of the data in hand it is not possible to link IP strategies to type of innovation, since most firms had introduced both types and the survey reports only answers on most important appropriation method in the industry.

Interestingly the IP strategies, which were ranked ranked most important in industry, were not the ones actually utilized by the sample firms – a finding also made by Leiponen & Byma (2009). Table 4-3 presents the actual use of different appropriation methods across industries. NACE classification follows the study of Leiponen & Byma (2009) with the difference that construction (NACE 45) is not excluded and category "firms with other NACEs" includes NACE-classes 40, 50, 52, 55, 60, 63, 70, 80, 90, 92 and 93.

Although complements were ranked the least frequently as the most important appropriation method (figure 4-4), in practice they were by far the most frequently used IP strategy: 358 firms of 469 used complementing services and products as an IP strategy, which is 76.3% of all sample firms. Instead patents, which were ranked as the most important IP strategy in own industry of operations by 27.8% of firms, were actually used only by 83 firms i.e. 17.7% of sample firms. This may indicate that the costs associated with patenting and enforcing patents discouraged patenting among small businesses (Arundel 2001, Leiponen & Byma 2009, Kotala et al. 2010).

On the other hand, the underlying reason might be the lack of IPR know-how. Secrecy and speed were roughly as popular among sample firms: 59.7% reported secrecy as one of its IP strategy and 62% speed. Table 4-3 reveals clear industry-level differences in actual IP strategies. Firms in industries food, beverages and tobacco (NACE 15-16), printing and publishing (NACE 22), construction (NACE 45) and wholesale trade (NACE 51) exhibit no patenting activity in the period 1999-2001. In contrast, largest portion of patenting firms in the sample belonged to industry groups machinery and equipment (NACE 29); medical, precision, optical instruments, watches, clocks (NACE 33); computer and related activities (NACE 78); chemicals, rubber and plastics (NACE 24-25); and research and development (NACE 73). Mean and median growth rates of firms are reported in industry level in table 4-3. A conclusion can be made that inter-industry growth differences are clearly evident.

Table 4-3: Industries, IP strategies and growth

NACE	Description	Firms 2001	Patent	Secrecy	Speed	Compl.	Firms 2008	Growth (%) 2001-2008 Empl. (n=381) mean	Empl. (n=381) median	Turnover (n=326) mean	Turnover (n=326) median
15-16	Food, beverages, tobacco	12	0	7	8	11	9	3.85 %	0.00 %	23.45 %	5.00 %
17-19	Textiles, apparel, leather	11	1	9	3	6	7	-13.04 %	-15.09 %	-4.95 %	-12.08 %
20-21	Wood, pulp, paper	12	1	5	4	7	10	92.60 %	26.73 %	76.72 %	1.63 %
22	Printing and publishing	14	0	8	8	12	10	0.33 %	-1.17 %	52.08 %	-15.86 %
24-25	Chemicals, rubber, plastics	29	5	22	20	22	20	107.30 %	-6.06 %	117.34 %	31.25 %
26-27	Non-metallic minerals and products; basic metals	6	1	4	1	2	3	-22.76 %	-12.86 %	-7.32 %	-7.32 %
28	Fabricated metal products	14	2	10	5	10	12	5.03 %	0.68 %	33.97 %	33.53 %
29	Machinery and equipment	66	17	36	41	44	58	12.23 %	3.37 %	38.61 %	22.71 %
30-31	Office machinery and computers; other electrical machinery	28	4	21	20	24	27	32.88 %	15.35 %	66.30 %	44.81 %
32	Radio, TV, communication equipment	50	9	31	30	38	40	100.31 %	16.67 %	19.31 %	19.10 %
33	Medical, precision, optical instruments, watches, clocks	38	14	22	28	31	34	7.93 %	-14.87 %	63.54 %	2.74 %
34-35	Transport equipment	12	4	7	7	9	10	82.45 %	-27.53 %	89.69 %	-9.96 %
36-37	Furniture, other manufacturing, recycling	9	2	5	5	6	8	-19.70 %	-15.96 %	-6.86 %	-6.72 %
45	Construction	6	0	2	2	3	6	-26.75 %	-28.45 %	-0.67 %	30.06 %
51	Wholesale trade	20	0	9	10	13	17	10.00 %	0.00 %	117.93 %	7.45 %
64	Post and telecommunications	6	1	4	6	6	4	113.81 %	51.71 %	8.55 %	-13.91 %
72	Computer and related activities	78	7	48	49	67	57	49.49 %	-8.33 %	147.01 %	4.50 %
73	Research and development	16	8	10	14	14	14	49.68 %	26.59 %	456.01 %	54.35 %
74	Other business activities	25	5	14	18	21	19	40.29 %	11.36 %	692.37 %	86.15 %
Firms with other NACEs		17	2	6	12	12	16	358.49 %	-7.85 %	333.70 %	7.96 %
Total		469	83	280	291	358	381	52.60 %	0.00 %	123.87 %	8.19 %

Table 4-3 provides overview of IP strategies actually used by Finnish small businesses, but it lacks one important perspective, namely combinations of IP strategies – naturally IP strategies are not mutually exclusive. To shed light on this issue the IP strategy combinations are put in order by their frequencies in table 4-4. An immediate conclusion can be made that innovative Finnish small businesses almost never relied solely on patent protection because only one firm reported to use patenting as its only IP strategy. Instead 16.6% of sample firms reported to rely exclusively on complements, speed or secrecy, frequencies being 36, 16 and 26 respectively.

Interestingly, the most utilized IP strategy combination during 1999-2001 was the bundle of all IP strategies excluding patenting as 124 i.e. over one quarter of the sample firms reported it. Also the second and the third place were held by combinations of informal appropriation methods. 50 firms reported to have used all four IP strategies. In contrast, every tenth (n=47) small business reported not to protect their innovation returns by any of the suggested IP strategies. Industry level figures of innovation return appropriation methods are provided in appendix 7.

Table 4-4: Ranking of actually utilized IP strategy combinations

	IP strategy	Obs.	% of sample	Cumul.	%
1	sec ∩ sp ∩ c	124	26.4 %	124	26.4 %
2	sp ∩ c	73	15.6 %	197	42.0 %
3	sec ∩ c	52	11.1 %	249	53.1 %
4	p ∩ sec ∩ sp ∩ c	50	10.7 %	299	63.8 %
5	None	47	10.0 %	346	73.8 %
6	c	36	7.7 %	382	81.4 %
7	sec	26	5.5 %	408	87.0 %
8	sp	16	3.4 %	424	90.4 %
9	sec ∩ sp	12	2.6 %	436	93.0 %
10	p ∩ sp ∩ c	11	2.3 %	447	95.3 %
11	p ∩ sec ∩ c	9	1.9 %	456	97.2 %
12	p ∩ sec	4	0.9 %	460	98.1 %
13	p ∩ c	3	0.6 %	463	98.7 %
14	p ∩ sec ∩ sp	3	0.6 %	466	99.4 %
15	p ∩ sp	2	0.4 %	468	99.8 %
16	p	1	0.2 %	469	100.0 %
		469	100.0 %		

p=patenting, sec=secrecy, sp=speed, c=complements

16 IP strategy combinations are identified in table 4-4. However, many of them contained only a few firms. To enable econometric analysis of growth rate differences these original 16 IP strategy combinations were assigned to larger categories, which are described in table 4-5. The growth rate differences between firms, which belong to different categories, are then studied by adding these categorical variables as mutually exclusive explanatory variable dummies into the regressions. Secrecy is used as the reference category, since it enables the growth rate comparison against patenting[43] firms directly. To control for industry differences, which were clearly evident in table 4-3, regressions were run also with industry dummies included.[44] Table 4-6 presents the frequencies of specified IP strategy categories in different industries.

[43] Following Helmers & Rogers (2011) patenting firms are treated equally independently of the number of patents obtained.

[44] In additional regressions the five most important categories by frequencies in table 4-4 (sec ∩ sp ∩ c; sp ∩ c; sec ∩ c; p ∩ sec ∩ sp ∩ c and "None") were determined as category variables and compared to reference category aggregated from eleven other IP strategy combination categories 6-16. See appendix 8.

Table 4-5: IP strategy categories

Category	Description	IP strategy combinatios (table 4-4)	Firms
Patenting	All firms, which have reported using patents as IP strategy.	4, 10, 11, 12, 13, 14, 15, 16	83
Open	Firms reporting to use only speed or complements or their bundle.	2, 6, 8	125
None	Firms reporting to use no IP strategies.	5	47
Secrecy	Firms reporting to use secrecy as IP strategy but not to patent.	1, 3, 7, 9	214

Category patenting was also splitted into two sub-categories:

Category	Description	IP strategy combinatios (table 7)	Firms
All	Firms reporting to use all four IP strategies.	4	50
Formal	Firms using patents excluding those firms that used all four IP strategies.	10, 11, 12, 13, 14, 15, 16	33

Table 4-6: IP strategy categories and industries

NACE	Description	Patenting	Secrecy	Open	None	All	Formal
15-16	Food, beverages, tobacco	0	7	4	1	0	0
17-19	Textiles, apparel, leather	1	8	1	1	1	0
20-21	Wood, pulp, paper	1	5	3	3	0	1
22	Printing and publishing	0	8	5	1	0	0
24-25	Chemicals, rubber, plastics	5	17	5	2	5	0
26-27	Non-metallic minerals and products; basic metals	1	3	0	2	0	1
28	Fabricated metal products	2	8	2	2	1	1
29	Machinery and equipment	17	25	12	12	7	10
30-31	Office machinery and computers; other electrical machinery	4	18	4	2	2	2
32	Radio, TV, communication equipment	9	25	12	4	4	5
33	Medical, precision, optical instruments, watches, clocks	14	11	12	1	9	5
34-35	Transport equipment	4	3	3	2	3	1
36-37	Furniture, other manufacturing, recycling	2	3	2	2	2	0
45	Construction	0	2	1	3	0	0
51	Wholesale trade	0	9	7	4	0	0
64	Post and telecommunications	1	3	2	0	1	0
72	Computer and related activities	7	42	27	2	4	3
73	Research and development	8	3	5	0	6	2
74	Other business activities	5	10	9	1	3	2
Firms with other NACE		2	4	9	2	2	0
		83	214	125	47	50	33

4.3 Results

4.3.1 Preliminary econometric analysis

Gibrat's lawof proportionate effect

Gibrat's law was tested by using two methods: (1) by OLS regression setting hypothesis that β_1=0 and testing it, (2) by following method of Simon & Bonini (1958). First, simple ordinary least square regressions were run to estimate effect of initial size on the growth of subsequent period. The OLS regression approach follows the simplest definition of Gibrat's law (see section 2.1.1) leaving for example industry differences uncontrolled. If smaller firms are found to grow faster on average than larger firms, like has been in several previous studies, then it should be that β_1-1<0. Positive coefficient on the initial size would indicate the opposite. Table 4-7 summarizes the results for both size measures, employment and turnover. The reported figures are estimated coefficients of size, (β_1-1). Heteroscedasticity robust standard errors are reported in parentheses.

As third and fourth column in table 4-7 demonstrate, the level of turnover at the beginning of the period do not appear to be a good estimator of subsequent turnover growth, since primarily the estimated size effects on growth are statistically insignificant. Besides, the sign of the only statistically significant coefficient estimated for year 2006 is positive as opposite to other periods. Closer review of 2006 with a scatter-plot reveals that a few larger firms had especially high positive and a few smaller firms especially high negative turnover growth rates. However, after dropping 30 firms with the highest negative or positive growth rates the estimated coefficient still remained positive at 5% significance level indicating that during 2006-2007 the relation between size and growth was positive. Thus, year 2006 must have been an extraordinary good year for the larger firms in the sample or especially bad year for the smaller firms or both. Gibrat's law tends to hold for longer periods as well, although 2001-2009 the estimated coefficient is statistically significantly negative. According to the results, the annual elasticity of growth proportional to initial size was approximately -0.02 implying that 1% increase in firm size led to 0.02% decrease in subsequent annual growth and vice versa.

Similar regressions were run using employment as the size measure. The data of Statistics Finland comprised employment figures for also year 2010. As for turnovers, no statistically significant explanatory power of size on annual growth was found: the coefficients did not deviate statistically significantly from zero except in 2009-2010. The financial crisis had hit the business then and negative coefficient may indicate that larger firms decreased man-hours more than smaller firms to readjust their supply to meet the weakened demand in the markets. The second lowest column indicates that Gibrat's law did not hold for sample firms for three year and longer periods when the size measure is employment. The estimated size effect on growth is negative and statistically significant 2001-2004 and onwards implying that smaller firms had grown their employment proportionally more than larger firms.

Table 4-7: Gibrat's law of proportionate effect 2001-2010

Model I: $log(SIZE_{i,t}) - log(SIZE_{i,2001}) = \beta_0 + (\beta_1 - 1)logSIZE_{i,2001} + \varepsilon_i$
Model II: $log(SIZE_{i,t}) - log(SIZE_{i,t-1}) = \beta_0 + (\beta_1 - 1)logSIZE_{i,t-1} + \varepsilon_i$

	Employment growth		**Turnover growth**	
	I	II	I	II
t=2002				
β-1	-0.0157		-0.0150	
	(-.0168)		(.0285)	
Observations	463		376	
t=2003				
β-1	-0.0200	0.0100	-0.0177	-0.0209
	(.0124)	(.0166)	(0.0177)	(.0259)
Observations	446	444	363	373
t=2004				
β-1	-0.0201**	-0.0151	-0.0223	0.0007
	(.0097)	(.0174)	(0.0160)	(.0213)
Observations	434	433	332	355
t=2005				
β-1	-0.0243***	-0.0268	-0.0114	-0.0267
	(.0090)	(.0254)	(0.0115)	(.0198)
Observations	417	415	296	312
t=2006				
β-1	-0.0222***	0.0102	0.0087	0.0653***
	(.0076)	(.0185)	(0.0113)	(.0201)
Observations	401	400	292	284
t=2007				
β-1	-0.0200***	0.0123	-0.0103	-0.0388
	(.0071)	(.0157)	(0.0097)	(.0304)
Observations	389	388	276	276
t=2008				
β-1	-0.0147**	0.0076	-0.0211**	-0.0220
	(.0067)	(.0210)	(0.0105)	(.0299)
Observations	381	375	320	293
t=2009				
β-1	-0.0131**	0.0031	-0.0166**	-0.0096
	(.0062)	(.0245)	(0.0080)	(.0564)
Observations	368	366	298	327
t=2010				
β-1	-0.0133**	-0.0560**		
	(.0054)	(.0278)		
Observations	345	341		

The robustness of the regression results considering Gibrat's law for longer periods were tested with additional regressions. First industry dummies were included to take into account industry differences. The results were to a large extent similar to those reported in table 4-7 providing support for the tentative conclusions made in previous paragraph. In addition, same regressions were run using 2002, 2003 and 2004 as initial years with and without industry dummies. The estimated coefficients in case of employment were still negative but remarkably lower and lost their statistical significance when aforementioned years were each in turn determined as initial year.

In case of turnover the results were primarily the same as in table 4-7 when 2002 was placed as initial year: no relationship between initial size and subsequent growth was observed. However, when 2003 and 2004 were applied as beginning years in the regressions, it was found that the estimated coefficients were in many cases statistically significantly positive (e.g. 2003-2006 and 2004-2009) indicating the firms with larger turnover had higher growth rates than their smaller counterparts. The result did not change much when industry dummies were included. Conflicting results imply that the table 4-7 should be interpreted with extreme caution and no generalizing conclusions can be made. More research with larger samples is needed to attain more robust results concerning Gibrat's law among innovative Finnish small businesses.

Simon & Bonini (1958) proposed that "a direct way to test the law of proportionate effect is to construct on a logarithmic scale the scatter diagram of firm sizes for the beginning and end of the time interval in question. If the regression line has a slope of 45 degrees and if the plot is homoscedastic, the law of proportionate effect holds - -." The "scatter-plot-method" of Simon & Bonini (1958) primarily supports the Gibrat's law: it appears that for both size measures, employment and turnover, the relation between initial size and annual growth seem to be proportional, since plotted observations follow closely 45 degree line (light line in figure 4-5). However, the homoscedasticity condition proposed by Simon & Bonini (1958) is not totally met as the variance of growth rates seems to decrease with firm size[45]. This finding is in line with results of Mansfield (1962) and Hall (1987). Figure 4-5 also corroborates the stylized fact "the variance of growth rates is higher for smaller firms" introduced by Klette & Kortum (2004) in their theoretical model of innovating firms.

It should be kept in mind that there is no threshold size for firm-size in this analysis and even the smallest firms are included. Proportional growth rates may be higher for the smallest firms, since hiring one new employee leads to 100% growth for a firm with 1 initial employee. The data on employment is fortunately in "man-hour" –form, which probably reduces this suggested possible bias. All in all, figure 4-5 corroborates the results presented in table 4-7 and indicates further that the observed negative coefficient of initial size is due to relatively higher growth rates of smaller firms and not due to relatively lower growth rates of larger firms.

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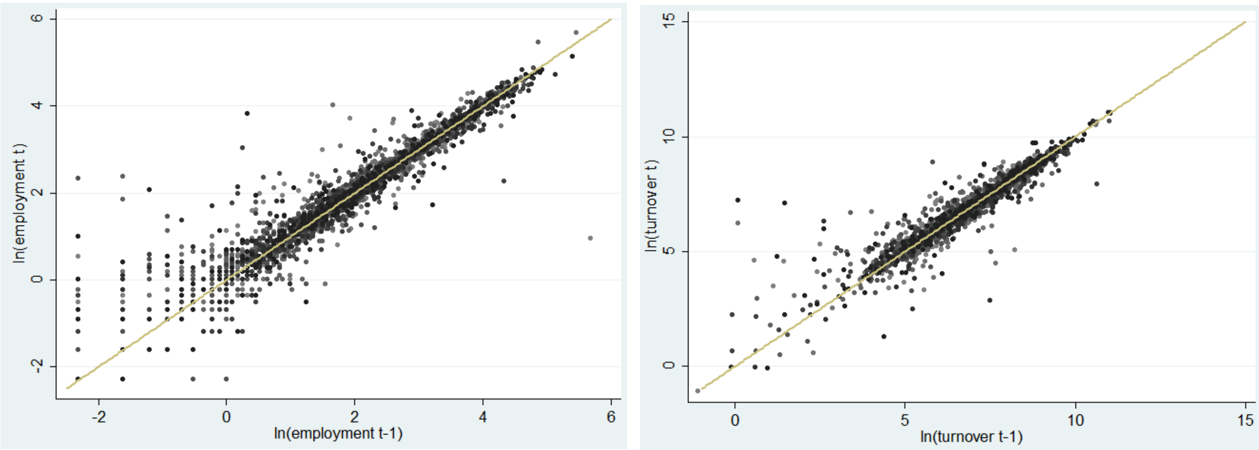
[45] Variance of growth rate was tested also for longer periods. The firms were divided into two groups: one consisting of firms with 10 or less employees and the other with firms more than 10 employees in year 2001. Then a hypothesis was stated that the standard deviations of subsequent growth of these groups were equal. For three first years the growth of smaller firms had statistically significantly higher variability. This scale-related heteroscedasticity contradicts Gibrat's law.

Figure 4-5: Scatter-plots of annual growth and initial sizes 2001-2008



The choice of intellectual property strategy

The empirical review of IP strategies and firm growth among innovative Finnish small businesses is started by estimating which factors affected the choice of specific IP strategy category. The estimation method is probit regression, in which coefficients are estimated using the method of maximum likelihood. Regression is run for every IP strategy category in isolation. In contrast, Leiponen & Byma (2009) applied multinomial logit model by arguing that it takes better into account probabilities of other alternatives. However, Leiponen & Byma (2009) also noted that regressions with probit models in isolation provided approximately same results, at least similar marginal effects, as multinomial logit model. Thus, multinomial logit regression results with sample data are not reported here. Table 4-8 is replicated from Leiponen & Byma (2009) and summarizes the results of probit regressions. It should still be recalled that Leiponen & Byma (2009) estimated, which IP strategy sample firms had reported as the most important in their own industry whereas here the probability of the choice of actually utilized IP strategy is used as the dependent variable.

Table 4-8: The choice of intellectual property strategy[46]

P(IP strategy) = f(Employees, R&D, age, export, innovation type, cooperation, type of innovation) + ε

	Patenting		Open		None		Secrecy		All	
	Coef.	Std.err.	Coef.	Std.err.	Coef.	Std.err.	Coef.	Std.err.	Coef.	Std.err.
Constant	-1.497***	0.449	-0.377	0.379	-0.962*	0.518	-0.368	0.349	-1.094**	0.514
log(employees)	0.092	0.078	-0.085	0.063	-0.008	0.094	0.008	0.058	0.092	0.092
log(R&D)	0.145***	0.044	-0.066*	0.036	-0.112**	0.056	-0.009	0.033	0.141***	0.051
log(age)	-0.120	0.137	0.053	0.107	0.311**	0.152	-0.091	0.099	-0.421***	0.164
Export	0.313*	0.190	-0.203	0.146	-0.277	0.214	0.140	0.135	0.246	0.230
Process innovation	-1.015***	0.321	-0.023	0.198	0.386	0.249	0.221	0.185	-1.200***	0.400
Prod. and proc. innovation	-0.091	0.175	-0.113	0.149	-0.611**	0.254	0.362***	0.138	-0.327	0.204
Horizontal cooperation	0.014	0.198	-0.205	0.168	0.026	0.287	0.197	0.156	0.008	0.228
Vertical cooperation	0.256	0.193	0.126	0.159	-0.219	0.238	-0.152	0.146	0.188	0.228
University cooperation	0.557***	0.201	-0.175	0.187	-0.654*	0.390	-0.149	0.168	0.414*	0.229
Vertical dependence	0.238	0.173	-0.225	0.137	-0.244	0.204	0.186	0.126	-0.045	0.201
Log likelihood	-158.67		-249.13		-113.15		-299.94		-115.92	
LR chi^2	98.44		41.82		74.29		46.71		69.30	
Significance	0.000		0.0450		0.000		0.0199		0.000	
R^2_{pseudo}	0.24		0.08		0.25		0.07		0.23	
Firms	417		463		447		469		399	

The reference industry is NACE 29 (see table 6); the reference innovation class is product innovation; *, ** and *** indicate statistical significance at 10 %, 5% and 1 % level respectively.

The results presented in table 4-8 provide a few findings, which are primarily in line with those of Leiponen & Byma (2009). First, it seems that the level of R&D expenditures raises the probability to choose patenting as IP strategy (estimated coefficient statistically significantly positive at 1% significance level), which intuitively appears logical: more R&D leads to more innovations, which then can be patented. Similarly university cooperation is positively related to the choice of patenting and the result is significant at 99% level of confidence. The finding supports the result of Leiponen & Byma (2009), according to which firms involved in university cooperation were likely to identify patents as the most important method of appropriating innovation returns in their field. Results of table 4-8 also indicate that firms involved in university cooperation are more likely to report using all IP strategies in combination.

Furthermore, table 4-8 provides weak evidence that export activities are both positively related to the probability to protect innovations with patents. Thus, it may be argued that larger firms have more resources – at least human resources – which can be directed into patenting activities. Positive relationship with exports in turn may imply that patents are more important in international markets. However, the data in hand did not include information, in which countries the sample firms had patented their innovations: if they had only domestic patents the above tentative conclusion is not corroborated. When comparing the impact of firm age between categories "None" and "All", it is

[46] Industry dummies were also included in regressions but estimated coefficients are not reported here.

found that older firms were more likely to not protect their innovation returns with any IP strategies and younger firms instead were more probable to use the entire set of innovation appropriation methods.

The results provide evidence that firms, which had introduced product innovation, used different innovation return appropriation methods than process-innovator firms. The reference group was firms, which had introduced a product innovation. According to the results introducing a process innovation in particular decreases the probability to belong to patenting group (1% significance level) and similarly to use combination of all IP strategies (5% significance level. This finding is in line with prior studies, which have provided strong evidence that patents work better for product innovations and secrecy is preferred for process innovations (e.g. Harabi 1995, Cohen et al. 2000, Hussinger 2006).). In contrast, the probability to rely on secrecy is increased (1% significance level) for innovators that had introduced both types of innovations.

4.3.2 IP strategies and firm growth

The data in use is cross-sectional by its nature since subsequent change in firm size is estimated by variables, which were observed in the beginning of the period. Thus, as IP strategies are the object of interest, it is assumed that the sample firms on average did not change protection methods significantly during the period. This is just barely plausible, since in practice it is highly probable that firms adjust their IP strategies in the changing competition environment. A shortcoming is that we cannot dynamically control for innovative and patenting activity of firms during the period. Nevertheless, patenting is maybe the most stable IP strategy, since after a firm is granted a patent, the exclusive right can be held for 20 years if renewal fees are paid.

According to Rantala (2006) the standard approach, when studying firm growth factors, is to add new variables into stochastic model (see e.g. Blonigen & Tomlin 1999, Ali-Yrkkö 2007, Ali-Yrkkö & Martikainen 2008). A similar approach is applied here. The basic ordinary least squares regression model, which includes chosen control variables, is presented below. Following Evans (1987a, 1987b) age is added as a control variable to take into account the passive learning hypothesis of Jovanovic (1982), according to which firms of different ages have varying growth rates. In addition, R&D expenditures, which reflect the innovativeness, are controlled.

$$\Delta SIZE_i = \beta_0 + \beta_1 ln(SIZE_{i,t}) + \beta_1 ln(AGE_{i,t}) + \beta_3 ln(R\&D_{i,t}) + e_i \quad (4.1)$$

where

$\Delta SIZE_i = \frac{SIZE_{t+\Delta} - SIZE_t}{SIZE_t}$ = proportional change of firm size

β_0 = constant

$ln(SIZE_{i,t})$ = natural logarithm of initial size

$ln(AGE_{i,t})$ = natural logarithm of age in the beginning of the period

$ln(R\&D_{i,t})$ = natural logarithm of R&D expenditures

e_i = error term

The dependent variable is proportional growth as in the study of Blonigen & Tomlin (1999), who studied the growth of Japanese plants in the U.S. Proportional growth was chosen instead of logarithmic difference, because logarithmic differences apply better for shorter periods and here the studied time periods are several years long. Rejection of Gibrat's law requires that β_1 is statistically significantly different from zero. The chosen time period in main regressions (tables 4-9 and 4-10) is 2001-2008, because it excludes the most severe effects of financial crisis on the growth of Finnish small businesses. The applied baseline OLS regression model (model I in tables 4-9 and 4-10) is therefore:

$$\Delta SIZE_i = \frac{SIZE_{2008} - SIZE_{2001}}{SIZE_{2001}} = \beta_0 + \beta_1 ln(SIZE_{i,2001}) + \beta_2 ln(AGE_{i,2001}) + \beta_3 ln(R\&D_{i,2001}) + e_i \quad (4.2)$$

Model III (table 4-9 and 4-10):

$$\Delta SIZE_i = \frac{SIZE_{2008} - SIZE_{2001}}{SIZE_{2001}} = \beta_0 + \beta_1 ln(SIZE_{i,2001}) + \beta_2 ln(AGE_{i,2001}) + \beta_3 ln(R\&D_{i,2001}) + \beta_4 Patenting + \beta_5 Open + \beta_6 None + e_i$$

Model V (table 4-9 and 4-10):

$$\Delta SIZE_i = \frac{SIZE_{2008} - SIZE_{2001}}{SIZE_{2001}} = \beta_0 + \beta_1 ln(SIZE_{i,2001}) + \beta_2 ln(AGE_{i,2001}) + \beta_3 ln(R\&D_{i,2001}) + \beta_4 Open + \beta_5 None + \beta_6 Formal + \beta_7 All + e_i$$

Next the relationship between introduced IP strategy categories and firm growth is analyzed. The utilized regression model is basic OLS, in which proportional growth of firm 2001-2008 is the dependent variable. Years 2009 and 2010 were excluded, since financial crisis had so severe impacts on Finnish small businesses as figure 4-4 demonstrates. IP strategies are divided into categories by mutually exclusive dummy variables (see table 4-5). Secrecy (IP strategy combinations including secrecy but not patenting) has been used as the reference category to which estimated coefficients are benchmarked in tables 4-9 and 4-10[47]. Review of firm growth rate distributions revealed some outliers and, hence, some exclusions were made to mitigate bias in regressions: firms that had higher than 300% employment growth during the period were excluded in employment growth regressions and firms that had higher than 500% turnover growth were excluded in turnover growth regressions. Tables 4-9 and 4-10 summarize the results.

Model I in table 4-9 reports the estimated coefficients of control variables, which are supposed to have an effect on firm growth. Gibrat's law seems to hold for sample firms after additional variables are controlled, since

[47] Similar regressions were run for using the five most important IP strategy combinations as categorical variables and aggregation of combinations 6-16 in table 4-5 as the reference category. See appendix 8 for results.

the coefficient of initial size of employment does not differ statistically significantly from zero. The finding conflicts with regression results for simple Gibrat's law presented in table 4-7. This indicates that growth rate differences of sample firms can be explained better with other factors than initial size. Age is the only variable that seems to have a statistically significant effect on firm growth. Negative coefficient implies that younger firms grew faster than their older counterparts during the period. When 19 industry dummies are included the effect diminishes marginally but remains statistically significant at 5% significance level. The negative coefficient of age is in line with results of Nurmi (2004), who examined the validity of Gibrat's law in Finnish manufacturing. Nurmi (2004) found also younger plants to have higher growth rates than older ones. According to Nurmi (2004) this empirical finding of negative relationship between age and growth is consistent with theoretical firm growth model of Jovanovic's (1982), "where firms uncover their true efficiencies only gradually over time". Heshmati (2001) found similarly the relationship between age and growth of employment to be negative among Swedish small businesses.

Models 3-6 include IP strategy categories. Secrecy is the reference category and NACE 28 "machinery and equipment" is the reference industry. The results suggest that IP strategies did not have any significant effect on employment growth during the period 2001-2008. The low values of R^2 in all models indicate that the variables can explain only a small portion of firm growth during 2001-2008. However, low coefficient of determination is rather the rule than the exception in growth rate regressions (Coad & Hölzl 2010). Still, fit of the model increases only marginally when IP strategy categories are included indicating that IP strategies are relatively poor explanatory factors of employment growth during the period. It should be pointed out that specified regression models may be vulnerable for omitted variable bias, since many characteristics of firms are left uncontrolled (Stock & Watson 2007, pp.236-237). Uncontrolled heterogeneities cause the estimated coefficients to be inconsistent. For instance, if innovation protection know-how of management (which probably affects also growth of firm) correlates positively with patenting then estimated coefficient of patenting in specified models are positively biased i.e. patenting firms seem to have higher growth although actually IP-strategy know-how is the true causal variable.

Although IP strategies did not have jointly statistically significant effect on employment growth, differing coefficients of IP strategies indicate that their effects on firm growth seem to vary. Wald-tests in models 2 and 5 provide evidence that firms applying "Open" strategy combinations had statistically significantly (5% significance level) differing employment growth rates 2001-2008 than firms, which did not utilize any IP strategies in 2001. On the basis of the coefficients "Open" category had higher growth rates than reference group and "None"-group, had growth rates below reference group, which implies logically that "Open"-category had higher growth rates than "None"-category. When industry differences are controlled in models 4 and 6, the result still remains significant at 10% significance level. Similarly models 3 and 5 suggest patenting firms to have higher employment growth rates than firms, which did not appropriate innovation returns with any suggested IP strategies. However, result is statistically significant only at 90% confidence level and loses statistical significance when industry differences are controlled.

Table 4-9: OLS regressions with employment

	Employment growth 2001-2008					
	I	II	III	IV	V	VI
Constant	0.480***	0.545**	0.434**	0.519**	0.430**	0.516**
	(0.185)	(0.223)	(0.176)	(0.217)	(0.177)	(0.219)
Controls						
Logarithm of 2001 employment	-0.0003	-0.003	-0.001	-0.006	-0.001	-0.006
	(0.034)	(0.037)	(0.034)	(0.036)	(0.034)	(0.037)
Logarithm of age	-0.143**	-0.141**	-0.135**	-0.137**	-0.134**	-0.135**
	(0.061)	(0.067)	(0.060)	(0.067)	(0.061)	(0.068)
Logarithm of R&D expenditures	-0.011	-0.019	-0.016	-0.023	-0.016	-0.023
	(0.018)	(0.020)	(0.019)	(0.021)	(0.019)	(0.021)
IP strategy categories						
Patenting			0.139	0.138		
			(0.124)	(0.124)		
Open			0.124	0.126	0.124	0.127
			(0.091)	(0.093)	(0.091)	(0.094)
None			-0.110	-0.098	-0.110	-0.100
			(0.093)	(0.101)	(0.093)	(0.101)
Formal					0.102	0.080
					(0.175)	(0.180)
All					0.167	0.186
					(0.165)	(0.165)
Industry dummies	No	Yes	No	Yes	No	Yes
F-tests						
Model	1.90	0.99	1.64	1.01	1.41	0.98
Controls		1.65	1.82	1.76	1.76	1.67
IP-strategies			1.95	1.64	1.48	1.29
Industry dummies		0.93		0.91		0.89
Hypotheses						
Patenting=Open			0.01	0.01		
Patenting=None			3.06*	2.66		
Open=None			4.57**	3.62*	4.57**	3.71*
Open=Formal					0.01	0.06
Open=All					0.06	0.11
Formal=All					0.08	0.20
Formal=None					1.27	0.86
All=None					2.41	2.44
R^2	0.020	0.052	0.033	0.064	0.034	0.065
Adjusted R^2	0.012	-0.008	0.017	-0.005	0.015	-0.007
Observations	368	368	368	368	368	368

Heteroscedasticity robust standard errors in parentheses; *, ** and *** indicate statistical significance at 10%, 5% and 1% level respectively. The reference IP strategy category is secrecy. See table 4-5 for in detail descriptions of categories.

Table 4-10 reports results for the same regression models with the difference that turnover growth has been used as the dependent variable instead of employment growth. The estimated coefficient for initial turnover is higher (although not statistically significant) than for initial employment in table 4-9, which may indicate that the size and growth relationship of firms is sensitive for the choice of size measure as has been suggested previously by Heshmati (2001). This time fit of the models is better as coefficients of determination R^2 are more than doubled in comparison to values in table 4-9. Generally, it seems that IP strategies had a stronger relationship with turnover growth as joint hypotheses suggesting that coefficients of all IP strategy category dummies are simultaneously 0 are rejected at 1% or 5% significance level in models 3-6.

Models 3 and 4 provide evidence that the turnover growth rates of patenting firms are statistically significantly higher than those of reference category i.e. firms applying secrecy-based strategies. In contrast, firms that did not utilize any IP strategies (category "None") seem to have statistically significantly lower growth rates than the reference group during 2001-2008. Models 5 and 6 provide evidence that those firms, which combined all IP strategies (group "All") to protect their innovation returns, had the highest growth rates in comparison to reference group. The result is statistically significant at 10% significance level. However, the remaining other patenting firms, group "Formal", did not anymore have statistically significantly higher growth rates than the default group, which implies that the firms, which utilized all IP strategies simultaneously had higher growth rates than other patenting firms 2001-2008.

The hypothesis that patenting firms and firms, which did not apply any IP strategies, had same growth rates on average is rejected at 1% significance level in models 3-6. The difference is the largest between firms using all IP strategies i.e. category "All" and those firms, which belonged to group "None". Furthermore, negative coefficient of "None"–category and positive coefficient of "Patenting", "Formal" and "All"-category indicate that patenting firms had higher growth rates. Similarly firms belonging to "Open" IP strategy combination category seem to have had statistically significantly (1% significance level) higher growth rates 2001-2008 than firms belonging to "None"–category. Instead the growth rates between patenting firms and firms using "Open"-strategy were almost the same on average.

Appendix 10 provides further evidence on the relationship between patenting and employment and turnover growth of sample firms. Presented growth rate distributions support previous interpretations of regression results: patenting is in positive relationship with subsequent turnover growth but the employment growth rates of patenting firms vary more than those of non-patenting firms. The more ambiguous relationship with patenting and employment growth might be due to negative employment effects of innovations – especially process innovations (see section 2.1.3 and especially figure 2-1). The productivity growth associated with innovations may be one reason why the relationship between patenting and turnover growth differs from that of patenting and employment growth.

As a summarizing conclusion active protection of innovation returns seems to be positively related to firm growth as "None"-group performed the worst in all cases. In addition, patenting firms seem to outperform in turnover growth firms, which rely on secrecy-based IP strategies. Thus, weak evidence is provided that patenting provides advantages, which probably increase the incentives to patent and disclose technological information. On the other hand, the results indicate also that firms, which applied "Open"-strategy, had not statistically significantly lower turnover growth rates than patenting firms. Incentives to patent are weakened if firms are indifferent in choice between patenting and openness.

A review of profit figures of the sample firms would provide interesting new information to support or contradict these tentative conclusions and answer to the question "do active protection lead to higher profits?[48]". Previously Geroski (1993) found with data of U.K. manufacturing firms that the number of innovations produced by a firm had a positive effect on its profitability over the period 1972-1983. However Geroski did not account for IP strategies. Unfortunately profit figures were not available for the sample utilized here. Therefore, the analysis of the relation between IP strategies and profitability of innovative Finnish firms must be left for an interesting topic of future research.

[48] On the other hand, growth-oriented firms invest heavily on growth and thus do not report high profits. Therefore, applying profits as performance measure for innovative SMEs may not be appropriate in the short run.

Table 4-10: OLS regressions with turnover

	Turnover growth 2001-2008					
	I	II	III	IV	V	VI
Constant	0.195	0.175	0.132	0.204	0.120	0.192
	(0.380)	(0.507)	(0.381)	(0.513)	(0.382)	(0.511)
Controls						
Logarithm of 2001 turnover	0.075	0.074	0.073	0.063	0.075*	0.064
	(0.055)	(0.060)	(0.053)	(0.058)	(0.053)	(0.058)
Logarithm of age	-0.181**	-0.152	-0.170**	-0.142	-0.167*	-0.137
	(0.092)	(0.105)	(0.089)	(0.102)	(0.089)	(0.103)
Logarithm of R&D expenditures	0.016	0.021	0.001	0.007	0.0002	0.006
	(0.038)	(0.034)	(0.031)	(0.034)	(0.032)	(0.035)
IP strategy categories						
Patenting			0.361**	0.336*		
			(0.180)	(0.176)		
Open			0.212	0.214	0.211	0.216
			(0.158)	(0.163)	(0.159)	(0.163)
None			-0.282**	-0.282*	-0.284**	-0.284*
			(0.133)	(0.154)	(0.134)	(0.154)
Formal					0.306	0.260
					(0.267)	(0.276)
All					0.400*	0.389*
					(0.230)	(0.225)
Industry dummies	No	Yes	No	Yes	No	Yes
F-test						
Model	2.23*	1.04	3.35***	1.25	2.87***	1.22
Controls		1.52	1.81	1.06	1.77	0.98
IP-strategies			5.11***	4.22***	3.83***	3.19**
Industry dummies		0.84		0.82		0.79
Hypotheses						
Patenting=Open			0.5	0.33		
Patenting=None			11.07***	9.56***		
Open=None			8.92***	7.53***	8.93***	7.59***
Open=Formal					0.11	0.02
Open=All					0.52	0.47
Formal=All					0.07	0.13
Formal=None					4.67**	3.68*
All=None					7.88***	7.18***
R^2	0.020	0.053	0.055	0.081	0.055	0.082
Adjusted R^2	0.011	-0.02	0.036	-2.00E-04	0.033	-0.003
Observations	309	309	309	309	309	309

Heteroscedasticity robust standard errors in parentheses; *, ** and *** indicate statistical significance at 10%, 5% and 1% level respectively. The reference IP strategy category is secrecy. See table 4-5 for in detail descriptions of categories.

4.4.3 Sensitivity of the results

Robustness of the employment growth regression results was tested by executing the same regressions for time spans 2002-2008, 2001-2010 and 2001-2007. Primarily no significant differences were found. During 2002-2008 firms using "All"-strategy had the highest employment growth rates when industry differences were controlled and result was statistically significant at 5% significance level. Between 2001 and 2010 the employment growth rate of patenting firms did not differ on average from firms using secrecy-based IP strategies. However, firms applying "None"-strategy in 2001 had lower and firms applying "Open"-strategy higher employment growth rates than the referred group (at 5% significance level). The firms using "Open" strategy were found to have statistically significantly higher growth rates than the firms applying "None"-strategy for time period 2001-2007. The joint hypothesis that IP strategies did not have effect on employment growth was rejected 2001-2010 but supported 2002-2008 and 2001-2007.

Similarly, robustness of turnover growth regression results was tested by additional regressions for periods 2001-2009, 2002-2008 and 2001-2007. The results were mostly the same as is presented in table 4-10 for 2001-2008. IP strategies were found to have a statistically significant relationship with turnover growth in every period. "None"-strategy performed in every time period the worst but the significance of the result varied. Between 2002 and 2008 patenting firms had statistically significantly higher turnover growth than firms relying on secrecy whereas 2001-2007 and 2001-2009 the difference was not statistically significant. The firms applying "Open"-strategy had statistically significantly higher growth rates of turnover than the reference group during 2001-2009.

It should be pointed out that e.g. Coad & Rao (2008) have criticized the use of OLS models in growth rate regressions arguing that "returns to innovation are highly skewed, growth rate distributions heavy-tailed" and OLS regressions focus "on the 'average effect for the average firm'". According to Coad and Rao (2008) quantile regression would suit better. Quantile regression takes into account possible outliers and enables studying do median growth rates of firm's belonging to different categories differ statistically significantly from each other[49]. Quantile regressions similar to OLS regressions in tables 4-9 and 4-10 were run and results are presented in appendix 9. No statistically significant results could be reported, which indicates that mean growth rate differences between IP strategy categories are to a large extent caused by firms with extreme growth rates.

[49] As a defense of OLS regression approach, the primary objective of this study was to concentrate to find out, does there exist growth rate differences among firms that use different IP strategies. Unbiased estimators of the effects, which derive from belonging to certain category were left to the background, since the limited size of the sample would have notwithstanding restricted the generalizability of the results.

5 CONCLUSIONS

Technological progress is unquestionably a key driver of economic growth in the long run. Thus, the positive externalities, which the dissemination of technological knowledge creates, form a sound rational for innovation policy and the patent system. However, empirical studies have provided evidence that the patent system is not as efficient as it could be, since many firms consider secrecy or other methods as more attractive intellectual property strategies (Levin et al. 1987, Cohen et al. 2000). It has been pointed out that in particular smaller firms may not be able to utilize the patent system as effectively as large firms due to the high costs related to patenting and enforcement of rights (Cohen et al. 2000, Arundel 2001, Leiponen & Byma 2009, Kotala et al. 2010). More empirical evidence is needed to reveal, do innovative small businesses gain any advantages from patenting i.e. does patenting foster firm performance. If this is not the case, there may not be sufficient incentives for small businesses to patent and disseminate technical knowledge, which they posses.

This study has focused on analyzing what is the relationship between IP strategies and firm growth, an issue which have gained surprisingly little attention in previous empirical economic literature. In the beginning, a hypothesis was stated that patenting firms should have higher growth rates than their non-patenting counterparts (cf. Helmers & Rogers 2011), since patents can contribute to firm growth at least in two ways: they enable higher market power and may act as collateral for external finance. Prior empirical evidence weakly supports the hypothesis, since e.g. Hussinger (2006) has found patenting to be positively related with the sales of new products.

When firm size, age and R&D expenditures together with industry differences were controlled, the results with innovative Finnish small business data provided weak evidence that patenting firms did have higher turnover growth rates 2001-2008 than firms, which did not use any of the suggested IP strategies or relied on secrecy-based strategies. In other words, patenting may have provided growth advantages, which in turn probably may have increased the incentives to patent and disclose technical information. Previously Klette & Griliches (2000) have pointed out that functional form describing the relationship between patenting and sales remains an open question because it is unclear “does a patent increase demand with a certain percentage, or is the percentage increase in demand from a patent dependent on the stock of patents and the firm's size". The results of this study could not answer this specific question but they provided further (although weak) empirical evidence of the positive relationship between patenting and sales growth.

On the other hand, it was also found that relying purely on open strategy i.e. speed or complements or their combination was associated with turnover growth rates, which did not statistically significantly differ from those of patenting firms. From the point of view of policy-makers this is alarming because incentives to patent i.e. disclose and diffuse technical knowledge may not be sufficient for innovative small businesses if they are indifferent in the choice between patenting and open strategy. The results suggested that the relationship between firm growth and patenting may be dependent on the chosen size measure (turnover, employment, assets), since the relationship between employment and patenting was found to be not statistically significant. The reason for the "negligible employment effect" observed for patenting firms may, however, be due to a finding presented by Niefert (2005), who found empirical evidence that firm growth may not be dependent on patenting in general but instead on patenting activity over time[50].

As investments of firms are increasingly directed to intangible assets (Maliranta & Rouvinen 2007), the role of intellectual property rights in global context becomes more and more important. From the perspective of an economy it is extremely important where intellectual property rights are located, since the location determines where revenues of service exports end up (Pajarinen et al. 2012). The winner countries in global competition are possibly the ones that have the firms with most abundant intellectual property rights and patent portfolios. As competitive advantage of firms is increasingly based on efficient intellectual asset management, a policy implication for any country, which aims to attain competitive advantage in the future, is to determinately foster the IP know-how of SMEs. Innovative SMEs, which have dynamic intellectual property strategies, are probably the ones that will reap the greatest profits and have the brightest growth prospects.

[50] This issue could not be tested in the context of present study because the data on patent counts was not available. The main weakness of patent count data is that it does not provide information on patent quality. Patent citations could be used as a rough measure of patent quality (see e.g. Nikulainen et al. 2006).

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APPENDICES

APPENDIX 1 Technological progress as the key driver of economic growth

The objective of growth accounting is to separate the impact of different factors on growth. The basic neoclassical growth model introduced by Solow (1957) explains production with two basic inputs, labor and capital. In the long run labor depends on the size of human population and working hours i.e. employee preferences between work and leisure, whereas accumulation of capital is dependent on investments and depreciation of existing capital. With technology, goods are produced from these inputs. The Solow growth model with labor augmenting technological progress ("Harrod neutral") can be presented in conventional Cobb-Douglas production function framework as follows (Jones 1998, p.20):

$$Y = F(K,L) = K^{\alpha}(AL)^{1-\alpha} \quad \text{(A1.1)}$$

where
Y = production; K = capital; A = technological progress L = labor; $0<\alpha<1$

The change over time in K i.e. capital accumulation is:

$$\dot{K} = sY - \delta K \quad \text{(A1.2)}$$

where
s = savings rate and δ = depreciation rate

Equation A1.1 states that production is a function of capital and labor inputs and the value of α below one implies decreasing returns to scale. The part of growth, which is left unexplained by the growth of these inputs, is referred to as Solow residual or total factor productivity (TFP) growth. Since model returns are decreasing, economic growth stabilizes after steady state is reached. This implies that economic growth does not depend on labor and capital inputs in the long run. Instead, in the long run the motor of growth is technological progress, A. The incompleteness of the model above arises from its assumption that technological progress is assumed exogenous – "manna from heaven" like Jones (1998, p.33) describes it. Proposition of exogenous growth is unrealistic because it presumes that the actors cannot affect the technological progress themselves.

Solow model can further be extended by introducing human capital as additional factor. Human capital indicates the quality of labor input and years of education is a simple and straightforward way to measure it. Still, empirical evidence shows that the level of human capital (as measured by average years of education) accounts only for a modest amount of differences in output per worker across countries (Hall & Jones 1999). Nevertheless, fostering the level of human capital is desirable, because it enhances technology transfer:

technological advances are adopted faster. As Mankiw (2011) put it: "-- knowledge is the quality of society's textbooks, whereas human capital is the amount of time the population has devoted to reading them." Despite of the high significance of human capital as growth factor, further discussion is beyond the scope of this study.

By assuming that choices and actions of agents and policy-makers can have an effect on technological progress, we have to abandon exogenous neoclassical models and move on to more advanced endogenous ones. The spectrum of endogenous growth models is wide, but in this context the focus will be narrowed on the Schumpeterian innovation-based growth model developed by Aghion & Howitt (1992). The contributions of earlier theories of endogenous growth and in particular industrial organization paved the way to Schumpeterian growth theory. The model is named after Joseph Schumpeter, the father of term "creative destruction" (Schumpeter 1942), since it focuses on quality improving innovations, which obsolete old products and force industries to be in constant progress. A central implication of creative destruction underlying the model is that faster growth rate is associated generally with higher rate of firm turnover because entry of firms with new innovations leads to exit of former innovators i.e. firms with obsolete products (Aghion & Howitt 2009, p.16). Formal presentation of the model is not presented in this context but a few underlying key points of the theory are discussed briefly.

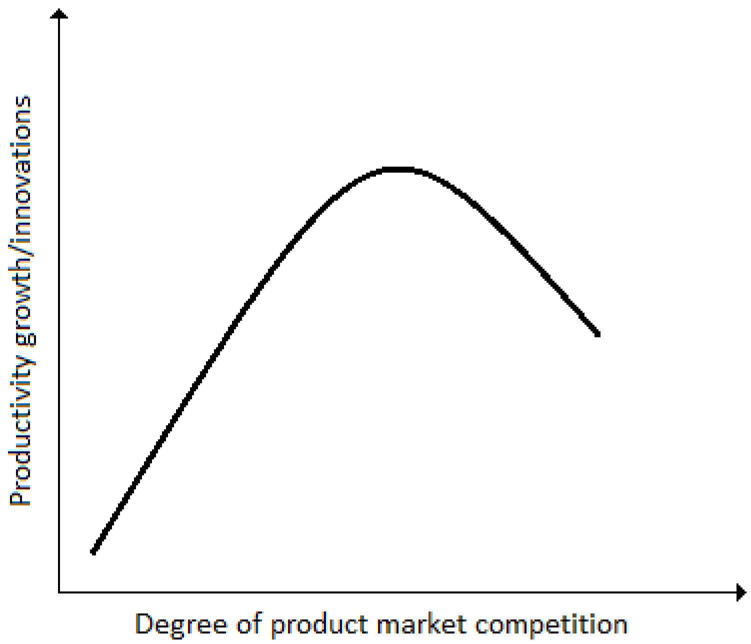
Schumpeterian growth model assumes that economic growth is proportional to the growth rate of productivity and innovations are the source of productivity growth. According to the theory the innovation process is uncertain and innovations occur with probability less than 100%. Probability to innovate depends positively on the amount of research. Derived from these assumptions Aghion & Howitt (2009, p.96) derive and introduce the main proposition of Schumpeterian growth theory:

"In the long run, the economy's average growth rate equals the frequency of innovations times the size of innovations."

According to this proposition, growth increases with the size of innovations e.g. magnitude of productivity improvement factor. That is to say: the bigger the improvement in productivity due to innovations the higher the growth rate. Although not formally derived here, the productivity of research sector (how much innovation-output the economy obtains by investing in research) affects the probability of occurrence of innovations. Thus, investing in higher education should eventually lead to higher productivity of research, more innovations and stronger growth. The theory proposes also that the degree of property rights protection increases growth, since stronger rights imply higher profits due to increased imitation costs of technology used in the intermediate product sector. Research is supposed to intensify as a consequence of increased incentives, which higher profits give rise to. (Aghion & Howitt 2009, p.92-99)

According to Schumpeterian trade-off, growth and product market competition correlate negatively (Aghion & Howitt, p.92) i.e. more competition in the markets leads to lower productivity. This is the same paradox as pointed out by Jones (1998): antitrust policy lowers monopoly profits, hence, incentives to innovate are decreased. However, according to Aghion & Howitt (2009, pp.7-8, 274-275) empirical evidence indicates inverted-U-shaped relationship between product market competition and growth (figure A). As stated above, productivity growth is proportional to innovations, thus the vertical axis variable in figure A can as well be innovations measured by the flow of new patents (ibid.). The assumption that competition and productivity growth correlate negative holds when degree of product market competition is high i.e. when curve presented in figure A is downward sloping. According to the standard Schumpeterian effect (Aghion & Howitt 2009, p.271) increasing competition decreases profits and hence incentives to innovate.

Figure A: Product market competition and productivity growth[51]



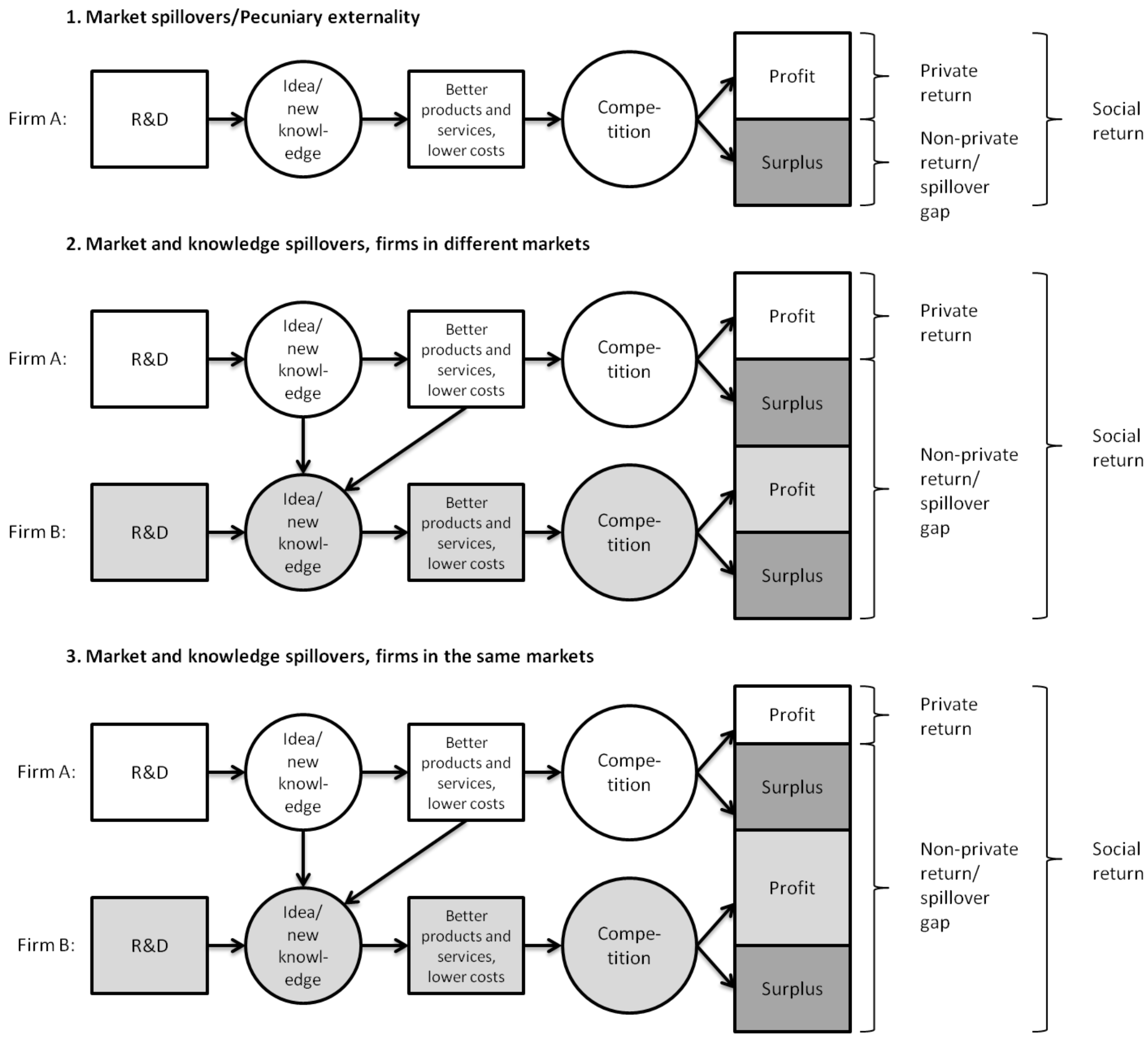
Incentives to innovate are in leading role in technological process and growth. Innovation policy is challenging, since its task is to find optimal innovation incentives, including optimal patent policy and optimal strength of intellectual property rights. Innovation policy and competition policy should be combined in an efficient way. According to empirical evidence depicted by figure A neither extremity is optimal: too fierce competition diminishes profits and incentives to innovate while too strong market power i.e. monopoly seems to lead to inefficiencies.

[51] Aghion & Howitt (2009, p.7)

Klette & Griliches (2000) consider the incentives to innovate separating ex ante and ex post effects of competition on incentives. In their partial equilibrium model of endogenous firm growth one underlying proposition is that "competition in the race to innovate (ex ante) stimulates innovation and R&D expenditures, while competition in the product market (ex post) reduces the innovative effort, due to reduced profitability of innovations" (proposition 6). Klette & Griliches (2000) state that the threat of entry by outsiders pushes forward innovative effort of the incumbent firms. According to Klette & Griliches (2000) an incumbent firm tends to hold back its current R&D effort to avoid losing its current profit - a phenomenon, which is referred to as the Arrow effect. On the other hand, entrants make the competition more fierce in the product markets reducing profits and thus diminishing the returns to innovation (aforementioned Schumpeterian effect).

Aghion & Howitt (2009, chapter 12 pp.267-286) consider the relationship between competition and innovation comprehensively and point out that competition affects incentives to innovate differently at different initial competition environments. According to Aghion & Howitt the overall effect of competition on innovation depends on the fraction of level versus unlevel sectors. Alongside with Schumpeterian effect they introduce "escape-competition effect", which suggests that "more competition induces neck-and-neck firms to innovate in order to escape from a situation in which competition constraints profits". Schumpeterian effect dominates for sectors that are in the level state whereas escape-competition effect dominates for sectors that are in the unlevel state. Inverted-U shape of the curve in figure A is caused by "composition effect" i.e. a change in competition changes the steady state fractions of firms in the level versus unlevel states. (Aghion & Howitt, 2009)

APPENDIX 2 Visualizing externalities[52]



52 Rouvinen (2007, p.93) replicated

APPENDIX 3

Original sample

Variable	Obs.	Count	Mean	Std. dev	Median	Min	Max
Employees	911		11.992	15.422	6	0.5	95.6
Age	901		16.171	15.024	12	1	109
Turnover (1000€)	772		1461.883	1832.781	693.115	0	9524.843
R&D expenditures (1000€)	888		108.855	793.568	3.364	0	15473.290
R&D intensity (%)	754		33 %	370 %	0 %	0 %	7704 %
R&D dummy	911	612	67 %				
Export	911	352	39 %				
Vertical cooperation	911	280	31 %				
Horizontal cooperation	911	203	22 %				
University cooperation	911	151	17 %				
Vertical dependence	911	459	50 %				
Tekes subsidies or loans	911	106	12 %				
Δemployment 2001-2008	734		33 %	285 %	-2 %	-100 %	5717 %
Δturnover 2001-2008	634		101 %	656 %	9 %	-100 %	9544 %

Innovative firms

Variable	Obs.	Count	Mean	Std. dev	Median	Min	Max
Employees	478		13.903	16.769	7	0.5	95.6
Age	478		15.1	13.780	11	1.0	109
Turnover (1000€)	406		1686.536	1998.861	875.396	0.327	9524.843
R&D expenditures (1000€)	469		152.724	806.521	16.819	0	15200
R&D intensity (%)	397		58.4 %	504.4 %	2.4 %	0 %	7703.6 %
R&D dummy	478	417	87.2 %				
Export	478	240	50.2 %				
Vertical cooperation	478	209	43.7 %				
Horizontal cooperation	478	145	30.3 %				
University cooperation	478	114	23.8 %				
Vertical dependence	478	234	49.0 %				
Tekes subsidies or loans	478	76	15.9 %				
Δemployment 2001-2008	388		51.7 %	374.5 %	0 %	-99.5 %	5716.7 %
Δturnover 2001-2008	333		121.6 %	655.4 %	8.4 %	-100 %	9544.3 %

Non-innovative firms

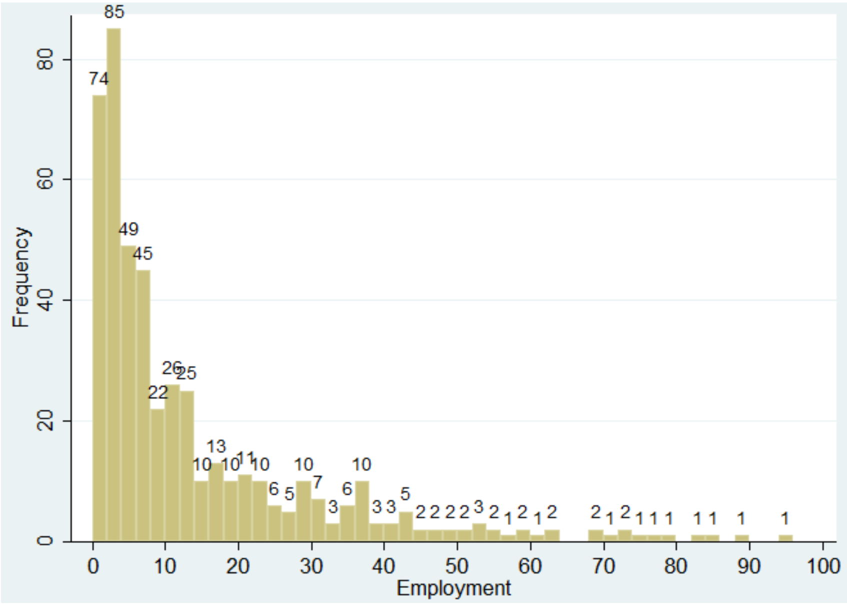
Variable	Obs.	Count	Mean	Std. dev	Median	Min	Max
Employees	433		9.883	13.491	4.9	0.5	86.2
Age	423		17.381	16.248	12	1	105
Turnover (1000€)	366		1212.679	1594.922	576.695	0.000	9175.429
R&D expenditures (1000€)	419		59.751	776.836	0	0	15473.290
R&D intensity (%)	357		5.8 %	66.2 %	0 %	0 %	1241.1 %
R&D dummy	433	195	45.0 %				
Export	433	112	25.9 %				
Vertical cooperation	433	71	16.4 %				
Horizontal cooperation	433	58	13.4 %				
University cooperation	433	37	8.5 %				
Vertical dependence	433	225	52.0 %				
Tekes subsidies or loans	433	30	6.9 %				
Δemployment 2001-2008	346		11.1 %	119.2 %	-5.0 %	-97.1 %	1323.1 %
Δturnover 2001-2008	301		78.8 %	657.0 %	8.6 %	-100 %	9492.4 %

NACE	Description	Original sample	Non-innovative	Innovative
15-16	Food, beverages, tobacco	14	2	12
17-19	Textiles, apparel, leather	19	8	11
20-21	Wood, pulp, paper	28	16	12
22	Printing and publishing	27	13	14
24-25	Chemicals, rubber, plastics	44	14	30
26-27	Non-metallic minerals and products; basic metals	20	14	6
28	Fabricated metal products	36	21	15
29	Machinery and equipment	125	58	67
30-31	Office machinery and computers; other electrical machinery	58	27	31
32	Radio, TV, communication equipment	81	31	50
33	Medical, precision, optical instruments, watches, clocks	55	17	38
34-35	Transport equipment	17	5	12
36-37	Furniture, other manufacturing, recycling	13	4	9
45	Construction	29	23	6
51	Wholesale trade	48	28	20
64	Post and telecommunications	12	6	6
72	Computer and related activities	125	44	81
73	Research and development	23	7	16
74	Other business activities	62	37	25
Firms with other NACE		75	58	17
	Total:	911	433	478

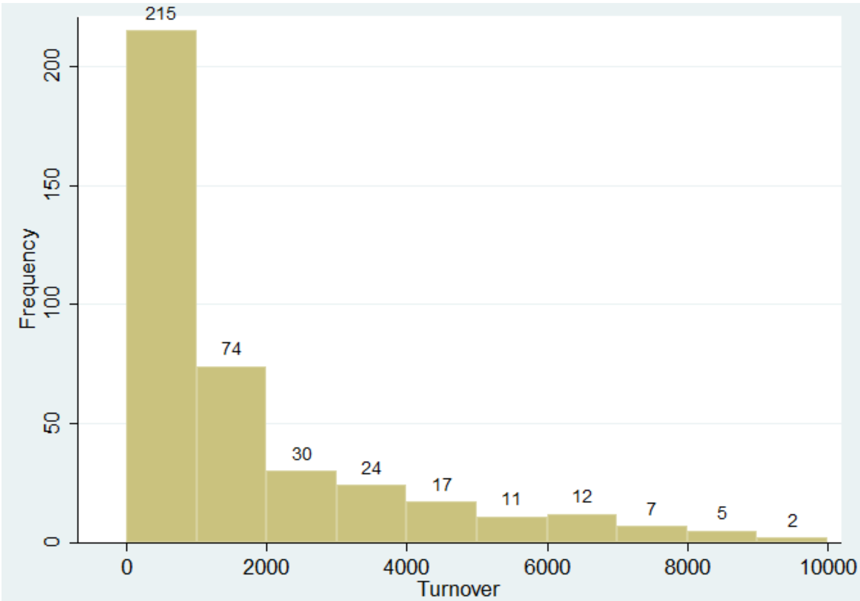
Note: Innovative firms refer to firms, which reported to have introduced a product or process innovation 1999-2001.

APPENDIX 4

Size distribution of firms by employment in 2001

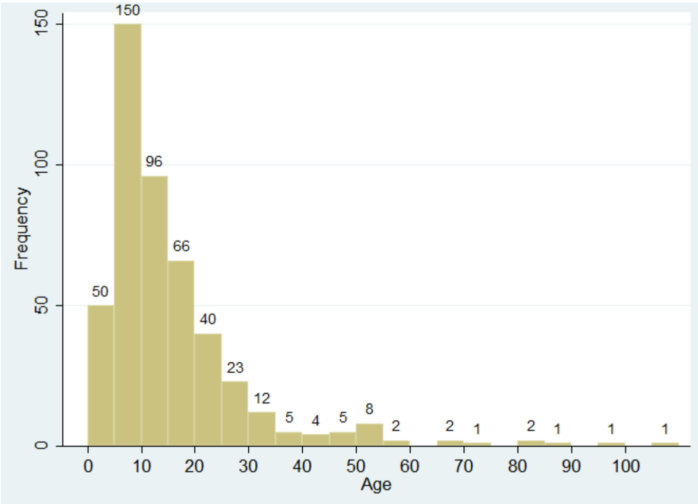


Size distribution of firms by turnover in 2001

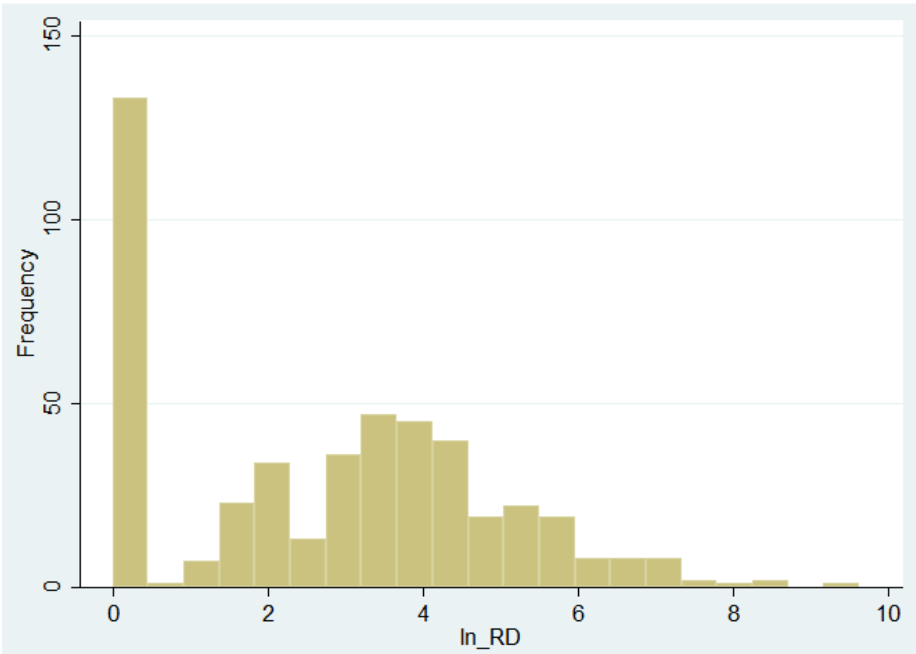


Age distribution of firms in 2001

Age	n	
1-4	50	10.7 %
5-9	150	32.0 %
10-14	96	20.5 %
15-19	66	14.1 %
20-29	63	13.4 %
30-39	17	3.6 %
40-49	9	1.9 %
50-59	10	2.1 %
60-	8	1.7 %
	469	100.0 %



Logarithmic R&D expenditures of firms in 2001[53]



[53] ln_RD=ln(R&D expenditures+1)

APPENDIX 5 Industry-level descriptive statistics

NACE	Description	Firms	Age	Empl.	Turnover	R&D	R&D-intens.	Innovation prod.	Innovation proc.	Exp.	Cooperation Vertic.	Cooperation Horiz.	Cooperation Univ.	Vert. Dep.	Survival 2001-2008	Growth (%) 2001-2008 Empl.	Growth (%) 2001-2008 Turnover
15-16	Food, beverages, tobacco	12	24.25	6.88	1316.27	0.50	0.7 %	0.67	0.75	0.25	0.17	0.25	0.00	0.50	0.75	3.85 %	23.45 %
17-19	Textiles, apparel, leather	11	22.82	20.32	2514.79	0.73	2.7 %	0.73	0.55	0.82	0.27	0.00	0.09	0.27	0.64	-13.04 %	-4.95 %
20-21	Wood, pulp, paper	12	16.08	8.47	1563.71	0.92	3.2 %	0.75	0.75	0.42	0.42	0.17	0.33	0.83	0.83	92.60 %	76.72 %
22	Printing and publishing	14	22.93	12.61	1531.66	0.79	7.4 %	0.71	0.86	0.43	0.50	0.50	0.14	0.50	0.71	0.33 %	52.08 %
24-25	Chemicals, rubber, plastics	29	17.14	10.82	1277.43	0.90	241.1 %	0.83	0.76	0.48	0.34	0.17	0.38	0.45	0.69	107.30 %	117.34 %
26-27	Non-metallic minerals and products; basic metals	6	24.67	28.53	4653.15	0.83	0.3 %	0.50	1.00	0.33	0.33	0.00	0.00	0.67	0.50	-22.76 %	-7.32 %
28	Fabricated metal products	14	18.36	21.11	2339.40	1.00	2.6 %	0.57	0.86	0.43	0.29	0.21	0.14	0.50	0.86	5.03 %	33.97 %
29	Machinery and equipment	66	15.58	19.83	2703.90	0.89	4.2 %	0.77	0.58	0.70	0.52	0.23	0.26	0.47	0.88	12.23 %	38.61 %
30-31	Office machinery and computers; other electrical machinery	28	15.07	18.06	2312.05	0.86	10.3 %	0.96	0.39	0.57	0.50	0.36	0.36	0.54	0.96	32.88 %	66.30 %
32	Radio, TV, communication equipment	50	11.76	15.97	2011.20	0.92	7.9 %	0.76	0.48	0.64	0.52	0.22	0.16	0.58	0.80	100.31 %	19.31 %
33	Medical, precision, optical instruments, watches, clocks	38	13.37	9.18	970.43	0.97	13.0 %	0.92	0.55	0.71	0.47	0.45	0.32	0.37	0.89	7.93 %	63.54 %
34-35	Transport equipment	12	15.67	21.85	2588.41	0.67	2.4 %	0.75	0.50	0.75	0.33	0.33	0.08	0.50	0.83	82.45 %	89.69 %
36-37	Furniture, other manufacturing, recycling	9	15.78	13.36	1127.23	0.56	1.4 %	0.67	0.78	0.44	0.22	0.11	0.11	0.67	0.89	-19.70 %	-6.86 %
45	Construction	6	17.83	19.70	2171.32	0.67	0.6 %	0.67	0.83	0.17	0.17	0.33	0.33	0.33	1.00	-26.75 %	-0.67 %
51	Wholesale trade	20	12.15	4.94	1418.60	0.80	1.8 %	0.95	0.40	0.40	0.40	0.35	0.15	0.70	0.85	10.00 %	117.93 %
64	Post and telecommunications	6	57.83	28.65	3644.47	1.00	8.5 %	0.83	0.50	0.17	0.67	0.50	0.00	0.33	0.67	113.81 %	8.55 %
72	Computer and related activities	78	9.24	11.96	956.62	0.96	25.2 %	0.97	0.45	0.38	0.50	0.45	0.31	0.47	0.73	49.49 %	147.01 %
73	Research and development	16	8.19	13.94	461.56	0.81	446.9 %	0.88	0.56	0.56	0.56	0.56	0.50	0.44	0.88	49.68 %	456.01 %
74	Other business activities	25	14.00	4.89	446.99	0.84	377.4 %	0.92	0.52	0.20	0.36	0.32	0.16	0.40	0.76	40.29 %	692.37 %
Firms with other NACEs		17	19.41	10.05	1660.90	0.76	7.5 %	0.53	0.76	0.24	0.35	0.18	0.18	0.35	0.94	358.49 %	333.70 %
Total		469	15.06	13.96	1705.17	0.87	58.4 %	0.82	0.57	0.51	0.44	0.31	0.24	0.49	0.81	52.60 %	123.87 %

APPENDIX 6 Correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1 Patenting	1																		
2 Secrecy	0.1873*	1																	
3 Speed	0.1669*	0.1368*	1																
4 Complements	0.1268*	0.2175*	0.3708*	1															
5 None	-0.1548*	-0.4062*	-0.4267*	-0.5993*	1														
6 Open	-0.2795*	-0.7337*	0.1137	0.1541*	-0.2012*	1													
7 All	0.7450*	0.2838*	0.2702*	0.1924*	-0.1153	-0.2082*	1												
8 ln(Empl.$_{2001}$)	0.1432*	0.0942	0.0032	-0.0094	0.0339	-0.1510*	0.0851	1											
9 ln(Turnover$_{2001}$)	0.0551	0.045	-0.048	-0.0696	0.0478	-0.106	-0.0115	0.8315*	1										
10 ln(RD)	0.2639*	0.1803*	0.2201*	0.2050*	-0.1749*	-0.1372*	0.2080*	0.3013*	0.2057*	1									
11 ln(age)	-0.0586	-0.0844	-0.1335*	-0.1006	0.1275*	-0.0022	-0.1106	0.2171*	0.2993*	-0.1265*	1								
12 Export	0.2018*	0.1522*	0.0786	0.0411	-0.0959	-0.1366*	0.1345*	0.2280*	0.2464*	0.2679*	0.0309	1							
13 Product inno.	0.0633	-0.0475	0.0525	-0.098	0.0137	0.0555	0.0933	-0.1036	-0.0268	-0.0284	-0.0385	0.0167	1						
14 Process inno.	-0.1565*	-0.1088	-0.2821*	-0.1361*	0.2174*	-0.0142	-0.1240*	0.1088	0.0211	-0.0591	0.0364	-0.0888	-0.3998*	1					
15 Prod.&Proc.inno.	0.0581	0.1329*	0.1670*	0.2053*	-0.1835*	-0.0451	0.0024	0.0199	0.0098	0.0748	0.0105	0.0524	-0.6990*	-0.3759*	1				
16 Vertical coop.	0.1954*	0.0562	0.1377*	0.1818*	-0.1536*	-0.0211	0.1243*	0.021	0.0325	0.1563*	-0.0217	0.0979	0.0324	-0.1759*	0.1045	1			
17 Horizontal coop.	0.1371*	0.0887	0.1905*	0.1771*	-0.1311*	-0.0485	0.0978	-0.0378	-0.0564	0.2196*	-0.0875	0.0805	0.0202	-0.1410*	0.0895	0.4367*	1		
18 University coop.	0.2744*	0.1173	0.1530*	0.1612*	-0.1548*	-0.0803	0.2093*	0.1046	0.0348	0.2530*	-0.1046	0.1486*	0.0384	-0.1306*	0.063	0.4230*	0.3675*	1	
19 Vertical depen.	-0.0171	0.0546	-0.0271	-0.0181	-0.0135	-0.0582	-0.0472	-0.113	-0.0898	-0.1127	-0.1475*	-0.1171	-0.0143	0.05	-0.0246	0.0337	-0.0535	-0.0317	1
20 Tekes sub./loans	0.3419*	0.1725*	0.2247*	0.1904*	-0.1468*	-0.1342*	0.3543*	0.2144*	0.0881	0.3336*	-0.0851	0.2036*	0.0771	-0.113	0.0102	0.2966*	0.2317*	0.4152*	-0.0476

APPENDIX 7 Actually utilized IP-strategy combinations at industry-level

NACE	Description	Firms	None	p	sec	sp	c	pXsec	pXsp	pXc	secXsp	secXc	spXc	pXsecXsp	secXspXc	pXsecXc	pXspXc	pXsecXspXc
15-16	Food, beverages, tobacco	12	1	0	0	0	2	0	0	0	0	1	2	0	6	0	0	0
17-19	Textiles, apparel, leather	11	1	0	4	0	1	0	0	0	0	2	0	0	2	0	0	1
20-21	Wood, pulp, paper	12	3	0	2	0	1	0	0	0	0	2	2	0	1	0	1	0
22	Printing and publishing	14	1	0	0	1	0	0	0	0	0	5	4	0	3	0	0	0
24-25	Chemicals, rubber, plastics	29	2	0	3	1	0	0	0	0	1	4	4	0	9	0	0	5
26-27	Non-metallic minerals and products; basic metals	6	2	0	0	0	0	1	0	0	1	2	0	0	0	0	0	0
28	Fabricated metal products	14	2	0	1	1	1	0	0	0	0	4	0	0	3	1	0	1
29	Machinery and equipment	66	12	0	4	1	3	0	1	1	3	2	8	1	16	3	4	7
30-31	Office machinery and computers; other electrical machinery	28	2	0	1	0	1	0	0	0	1	3	3	0	13	1	1	2
32	Radio, TV, communication equipment	50	4	1	4	2	3	0	0	1	1	5	7	0	15	2	1	4
33	Medical, precision, optical instruments, watches, clocks	38	1	0	2	2	5	0	1	1	0	0	5	1	9	1	1	9
34-35	Transport equipment	12	2	0	0	0	2	1	0	0	0	0	1	0	3	0	0	3
36-37	Furniture, other manufacturing, recyclin	9	2	0	1	0	0	0	0	0	0	1	2	0	1	0	0	2
45	Construction	6	3	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0
51	Wholesale trade	20	4	0	1	0	1	0	0	0	2	4	6	0	2	0	0	0
64	Post and telecommunications	6	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	1
72	Computer and related activities	78	2	0	2	3	10	0	0	0	3	14	14	1	23	1	1	4
73	Research and development	16	0	0	0	1	1	1	0	0	0	0	3	0	3	0	1	6
74	Other business activities	25	1	0	1	1	3	1	0	0	0	1	5	0	8	0	1	3
	Other NACE	17	2	0	0	3	2	0	0	0	0	1	4	0	3	0	0	2
Total		469	47	1	26	16	36	4	2	3	12	52	73	3	124	9	11	50

p=patenting, sec=secrecy, sp=speed, c=complements

APPENDIX 8

Model: $\Delta SIZE_i = \frac{SIZE_{2008} - SIZE_{2001}}{SIZE_{2001}} = \beta_0 + \beta_1 ln(SIZE_{i,2001}) + \beta_2 ln(AGE_{i,2001}) + \beta_3 ln(R\&D_{i,2001}) + \beta_4 sec \cap sp \cap c + \beta_5 sp \cap c + \beta_6 sec \cap c + \beta_7 p \cap sec \cap sp \cap c + \beta_8 None + e_i$

	Employment growth 2001-2008		Turnover growth 2001-2008	
	I	II	I	II
Constant	0.470**	0.549**	0.207	0.239
	(0.200)	(0.239)	(0.384)	(0.507)
Controls				
Logarithm of 2001 employment	0.001	-0.005		
	-0.034	(0.037)		
Logarithm of 2001 turnover			0.080	0.071
			(0.052)	(0.058)
Logarithm of age	-0.131**	-0.132**	-0.169*	-0.140
	(0.061)	(0.069)	(0.089)	(0.104)
Logarithm of R&D expenditures	-0.017	-0.024	-0.0003	0.005
	(0.019)	(0.021)	(0.032)	(0.036)
IP strategies				
1.sec∩sp∩c	-0.017	-0.025	-0.093	-0.071
	(0.095)	(0.100)	(0.162)	(0.172)
2.sp∩c	0.121	0.115	0.163	0.252
	(0.126)	(0.133)	(0.209)	(0.227)
3.sec∩c	-0.087	-0.063	-0.143	-0.033
	(0.122)	(0.126)	(0.214)	(0.239)
4.p∩sec∩sp∩c	0.122	0.141	0.276	0.305
	(0.176)	(0.178)	(0.251)	(0.259)
5.None	-0.157	-0.144	-0.405**	-0.357**
	(0.108)	(0.113)	(0.159)	(0.172)
Industry dummies	No	Yes	No	Yes
F-tests				
Model	1.33	0.97	2.63***	1.2
Controls	1.73	1.67	1.80	1.05
IP-strategies	1.30	1.00	3.08**	2.42**
Industry dummies		0.87		0.85
R^2	0.034	0.064	0.052	0.082
Adjusted R^2	0.013	-0.010	0.027	-0.007
Observations	368	368	309	309

Heteroscedasticity robust standard errors in parentheses; *, ** and *** indicate statistical significance at 10%, 5% and 1% level respectively. The reference IP strategy category is aggregation of classes 6-16 in table 4-4.

The five most important IP strategy combination categories do not have statistically significantly lower or higher growth rates than firms belonging to the reference group. The underlying reason for this result is probably the heterogenous reference group (combinations 6-16 in table 4-4), which includes firms relying on both informal and formal IP strategies. Joint hypothesis that employment growth does not differ among firms using five most frequently applied IP strategy combinations cannot be rejected when initial employment, size and R&D expenditures are controlled. However, differences in turnover growth are more evident. Joint hypothesis that belonging to suggested categories did not have an effect on turnover growth is rejected at 5% significance level even when industry differences are controlled. Firms, which used none of the suggested IP strategies had statistically significantly lower turnover growth rates than the reference group. When the growth rates of the categories were compared mutually, it was found that firms using all IP strategies or speed and complements combination had statistically significantly higher growth rates at 1% significance level than firms belonging to “None” group. Hence, the main conclusion is same as the one made on the basis of tables 4-9 and 4-10: IP strategies seem to have a statistically significant relationship with subsequent turnover growth but not with employment growth.

APPENDIX 9

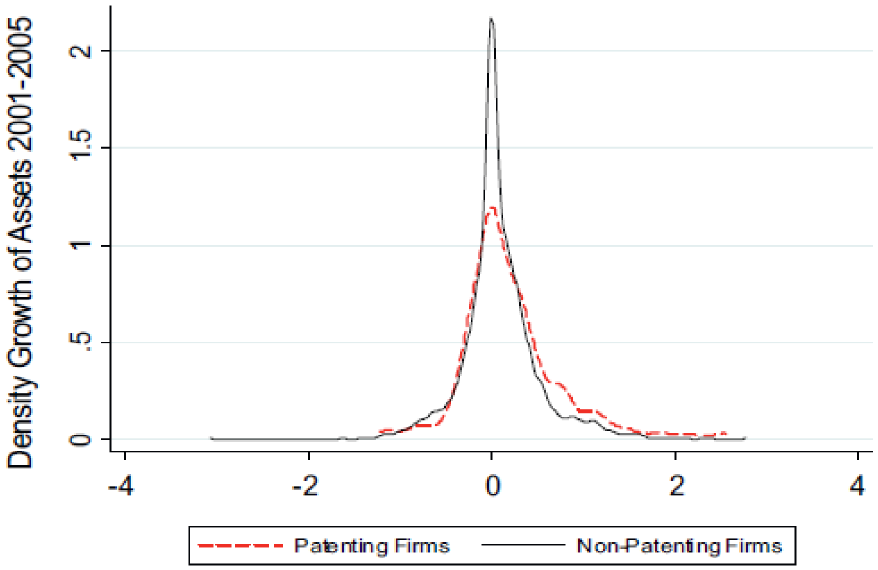
Quantile regressions

	Employment growth 2001-2008		Turnover growth 2001-2008	
	I	II	I	II
Constant	0.228	0.403**	0.117	0.161
	(0.172)	(0.182)	(0.330)	(0.443)
Controls				
Logarithm of 2001 employment	0.009	-0.005		
	(0.036)	(0.034)		
Logarithm of 2001 turnover			0.017	0.001
			(0.045)	(0.049)
Logarithm of age	-0.009	-0.144**	-0.081	-0.033
	(0.036)	(0.057)	(0.092)	(0.096)
Logarithm of R&D expenditures	-0.002	-0.011	0.014	0.035
	(0.020)	(0.019)	(0.030)	(0.032)
IP strategy categories				
Patenting	-0.044	0.105	0.263*	0.163
	(0.113)	(0.104)	(0.159)	(0.165)
Open	0.104	0.141*	0.107	0.107
	(0.098)	(0.087)	(0.150)	(0.148)
None	-0.004	0.12	-0.145	-0.239
	(0.136)	(0.120)	(0.199)	(0.200)
Industry dummies	No	Yes	No	Yes
F-tests				
Model	0.69	1.40	1.10	1.52
Controls	0.88	2.44*	0.41	0.53
IP-strategies	0.55	1.08	1.41	1.20
Industry dummies		1.44		1.59*
Hypotheses				
Patenting=Open	1.35	0.10	0.74	0.1
Patenting=None	0.09	0.01	3.25*	3.00*
Open=None	0.47	0.03	1.42	2.68
Pseudo R^2	0.005	0.02	0.008	0.02
Observations	381	381	326	326

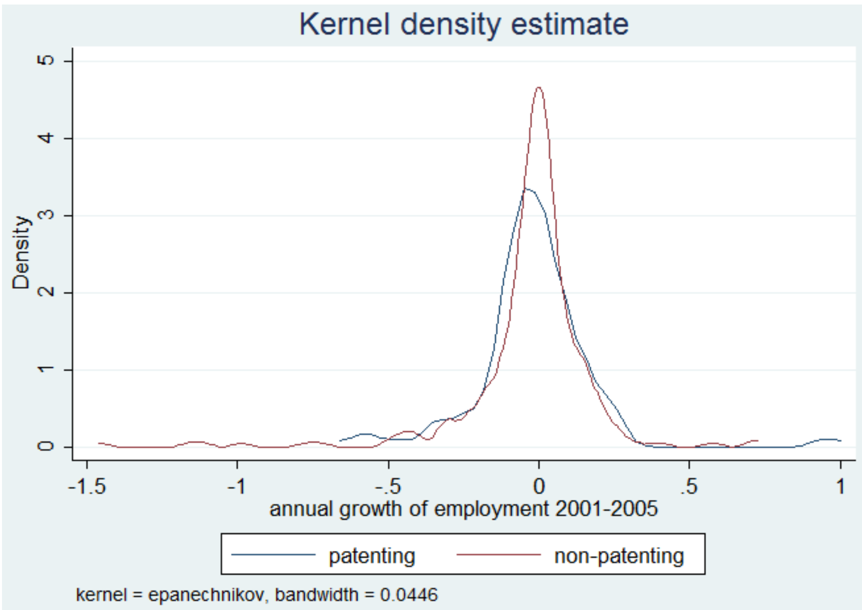
Heteroscedasticity robust standard errors in parentheses; *, ** and *** indicate statistical significance at 10%, 5% and 1% level respectively. The reference IP strategy is secrecy and the reference industry is NACE 28.

APPENDIX 10

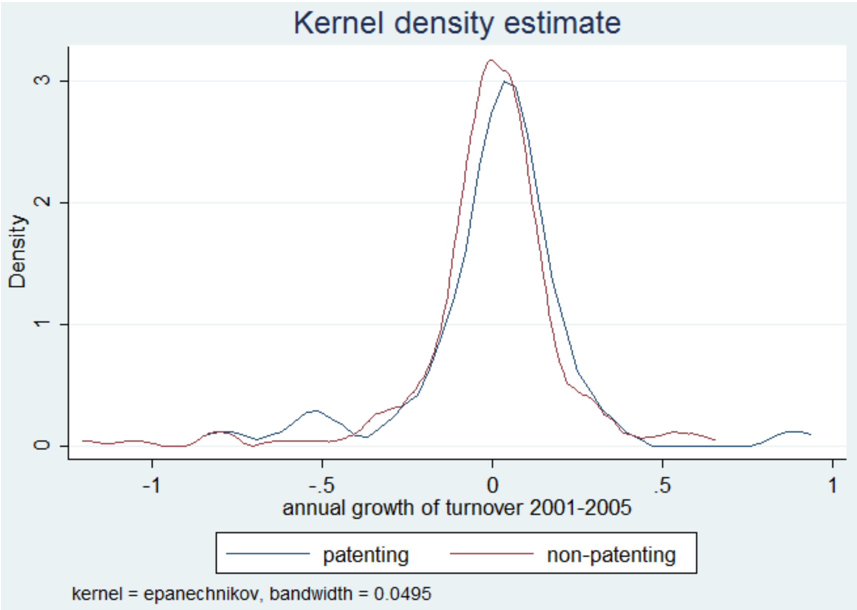
The density distributions of asset growth in Helmers & Rogers (2011)



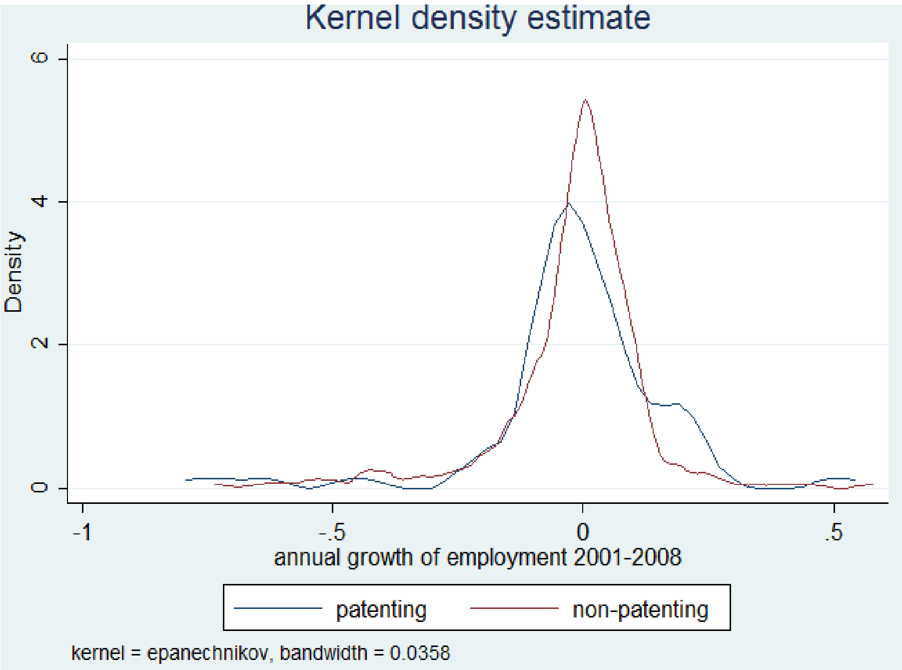
The density distributions of employment of sample firms 2001-2005



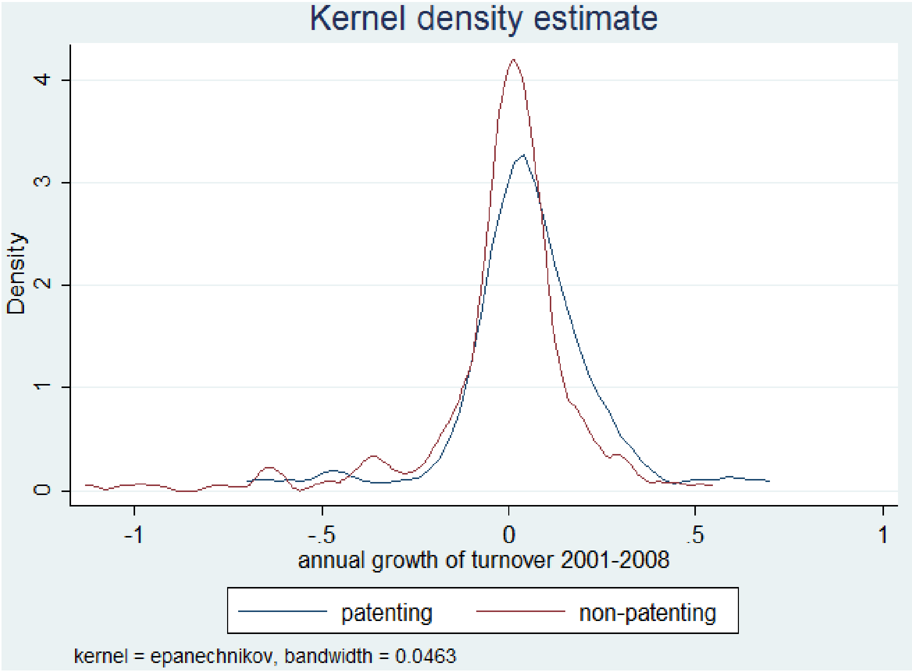
The density distribution of turnover growth of sample firms 2001-2005



The density distribution of employment growth of sample firms 2001-2008



The density distribution of turnover growth of the sample firms



APPENDIX 11

Table A: The major obstacle or limiting factor for innovation activity (n=377)

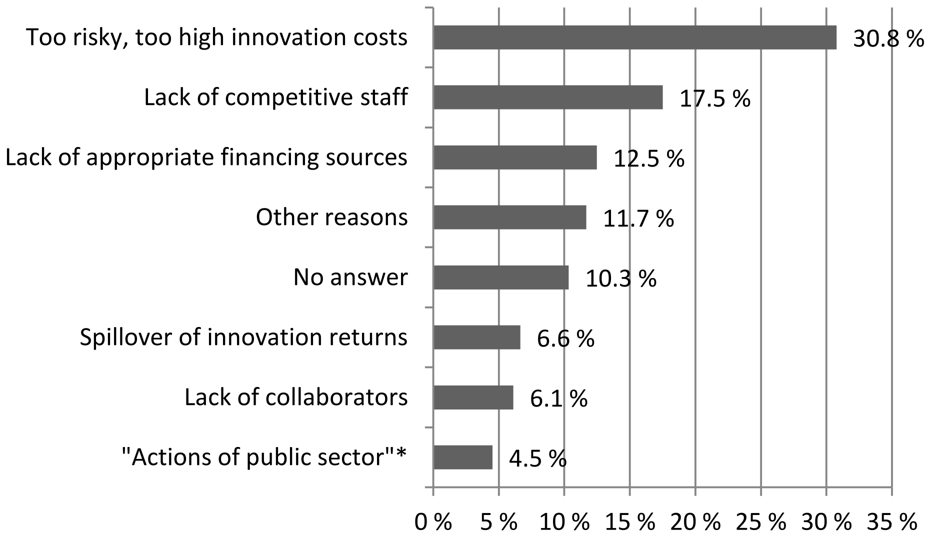


Table A above describes the factors, which sample firms have reported as the major obstacles for innovation activity. Almost one third of respondents have ranked high innovation costs to be the most prominent factor limiting innovation activity. The lack of competitive staff is ranked second before the lack of appropriate financing sources. Spillover of innovation is ranked first by

6.6 % of the sample, which might indicate that these firms cannot protect their innovations sufficiently. "Actions of public sector" may refer to e.g. inflexible legislation.

Table B depicts the amount of positive (Yes) answers of firms to three following questions:

1. "Is it important to protect the output of innovation activity in your industry?"
2. "Have your firm ever started a dispute over issues relating to innovation activity or intellectual property rights?"
3. "Are disputes over intellectual property rights common in your industry?"

There were 377 answers (as in table A) but the proportions presented in table B are in relation to the whole sample (n=469). Of respondents (n=377) 69.8% reported protection of innovation output to be important in their field of industry. 9.0% of respondents had started a dispute themselves while 23.1% reported that disputes are common in their industry.

Table B: The importance of protection and infringements

			1		2		3	
NACE	Description	Firms	n	%	n	%	n	%
15-16	Food, beverages, tobacco	12	6	50.0 %	0	0.0 %	1	8.3 %
17-19	Textiles, apparel, leather	11	8	72.7 %	0	0.0 %	1	9.1 %
20-21	Wood, pulp, paper	12	10	83.3 %	1	8.3 %	1	8.3 %
22	Printing and publishing	14	6	42.9 %	1	7.1 %	1	7.1 %
24-25	Chemicals, rubber, plastics	29	17	58.6 %	3	10.3 %	7	24.1 %
26-27	Non-metallic minerals and products; basic metals	6	1	16.7 %	0	0.0 %	0	0.0 %
28	Fabricated metal products	14	6	42.9 %	0	0.0 %	1	7.1 %
29	Machinery and equipment	66	42	63.6 %	8	12.1 %	10	15.2 %
30-31	Office machinery and computers; other electrical machinery	28	18	64.3 %	3	10.7 %	6	21.4 %
32	Radio, TV, communication equipment	50	22	44.0 %	4	8.0 %	10	20.0 %
33	Medical, precision, optical instruments, watches, clocks	38	26	68.4 %	3	7.9 %	5	13.2 %
34-35	Transport equipment	12	5	41.7 %	2	16.7 %	1	8.3 %
36-37	Furniture, other manufacturing, recycling	9	4	44.4 %	1	11.1 %	1	11.1 %
45	Construction	6	2	33.3 %	1	16.7 %	0	0.0 %
51	Wholesale trade	20	11	55.0 %	1	5.0 %	7	35.0 %
64	Post and telecommunications	6	4	66.7 %	0	0.0 %	2	33.3 %
72	Computer and related activities	78	48	61.5 %	2	2.6 %	20	25.6 %
73	Research and development	16	12	75.0 %	2	12.5 %	6	37.5 %
74	Other business activities	25	10	40.0 %	2	8.0 %	4	16.0 %
	Firms with other NACEs	17	5	29.4 %	0	0.0 %	3	17.6 %
		469	263	56.1 %	34	7.2 %	87	18.6 %