Is Silence Golden?

Patents versus Secrecy at the Firm Level

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Abstract

In the 1990s, patenting schemes changed in many respects: Upcoming new technologies accelerated the shift from price competition towards competition based on technical inventions, a worldwide surge in patenting took place, and the 'patent thicket' arose as a consequence of strategic patenting. This study analyzes the importance of patenting versus secrecy as an effective alternative to protect intellectual property in the inventions' market phase. The sales figure with new products is introduced as a new measure of the importance of IP protection tools among product innovating firms. Focusing on German manufacturing in 2000, it turns out that patents are an effective means to protect intellectual property in the market, whereas secrecy seems to be rather important for inventions that are not yet commercialized.

Keywords: Innovation, Appropriation, Patents, Secrecy

JEL-Classification: C34, C35, O33, O34

1 INTRODUCTION

During the 1990s, important changes in patenting schemes took place: technological and institutional conditions altered, upcoming new technologies accelerated the shift from price competition towards competition based on technological inventions, and strategic patenting gained in importance. At the same time, a drastic surge in patenting took place. These developments call for an investigation of the importance of patenting for the protection of intellectual property (IP). Since the patenting boom was not accompanied by a comparable increase in research and development (R&D) expenditure, patenting may rather indicate strategic firm behavior, while alternatives like keeping a newly developed technology secret may be used for IP protection. This paper analyzes the importance of patents and secrecy in protecting inventions in their market phase focusing on a sample of product innovating firms in German manufacturing in 2000.

The patent system counteracts incentive problems arising from the public-good character of IP by granting the patentee a temporary monopoly on the patented technology, including the right to sue for infringement in case someone makes use of the protected technology. However, filing a patent involves the disadvantage that the patented technology has to be disclosed so that competitors and the court know what is protected. The disclosure requirement generates for the patent holder some disutilities that might outweigh the monopoly benefits. First, a patent hints at a presumably profitable technology field. This enables competitors to jump onto a technological trend by conducting further research related to the patented technology. Second, publicly available patent information facilitates reverse engineering of an invention and may thus encourage a larger number of rival firms to invent around a patent.

Due to the disadvantages of the disclosure requirement in connection with significant patent application costs and potential infringement costs - which might be even higher than the application costs -, some firms may prefer keeping their invention secret instead of filing a patent. IP protection by secrecy is, of course, free of charge, but has the disadvantage that the invention is not legally protected against imitation or even duplication in case the secret is leaked. Therefore, the firms' decision to patent or to keep an invention secret is considered a trade-off between the temporary monopoly position a patent offers and the information spread it leads to.

Empirical studies focusing on the early 1990s, when the surge in patenting was still pending, conclude that firms prefer secrecy over patenting to protect their IP (e.g. Levin et al., 1987) and also that firms retrospectively consider secrecy more effective than patenting (Arundel, 2001). However, significant developments in the recent past concerning institutional and technological conditions of patenting as well as the increased strategic value of patents have evidently made patenting more attractive than it was before, as the worldwide patent surge indicates.

The most drastic institutional changes strengthening the patent holders' rights took place in the US during the 1980s, such as the Bayh-Dole Act and the establishment of the Court of Appeals for the Federal Circuit. These developments set the stage for the pro-patent environment that gradually emerged and ultimately spread far beyond US borders. However, the institutional changes in Europe were not overly drastic. The appropriation of IP has gained in importance in Europe because of the endeavors promoting the international harmonization of the patent law, but also for reasons of competitiveness. Today, the decline in competitiveness of European firms is partly seen as a consequence of their patent behavior, which has been much less aggressive than in other patent nations (Arundel, 2001). The European Commission reacted with the *Green Paper on Innovation*, which puts application and defense costs as important barriers to patenting up for discussion, and the *First Action Plan for Innovation in Europe*, which encourages European firms, especially small and medium sized firms (SMEs), to patent more. Furthermore, patent application costs were lowered and grace periods have been fiercely discussed.[2] In addition,

[2]Grace periods would permit the release of information about an invention, for example, when a mechanical invention requires external testing with the cooperation of another firm, without

initiatives were promoted to support SMEs, and specifically high-technology SMEs, with information and patenting programs.

These institutional developments aimed at making patenting more attractive. However, empirical studies on the US, where the institutional changes were more drastic, have shown that those changes cannot explain the recent increase in patenting. Reasons for the patent surge can rather be found in changes in firms' R&D management and reallocations of their R&D portfolios (Kortum and Lerner, 1999) as well as in strategically motivated patent races and improved patenting management (Hall and Ham Ziedonis, 2001, for the semiconductor industry).

Upcoming new technologies, like biotechnology and information technology, as well as progress in information and communication technology caused the changes in technological conditions and, further, accelerated the shift from price competition towards competition based on technical inventions. These developments may have led to an increased need for patents providing legal IP protection in the face of a fiercer technological competition.

However, the strategic value of patents gained importance as well. Patents became an important tool in licensing as well as in merger and acquisition negotiations. The fact that patents may increase firm value, generate profits from licensing, and serve as positive signals to potential investors became important, especially in the context of an increased number of small, high-technology firms. Those firms often lack market power and the capability to transfer every idea into a new product. For them, patenting is a way of profiting from their inventions at least to a certain degree (Arundel, 2001). A further development is that patents gained in value due to their ability to be linked with other patents, which encourages patenting of marginal inventions. The resulting complex network of single patents that bears many legal pitfalls for patent applicants was given the name 'patent thicket' (Shapiro, 2001). These developments put into question an increased number of patents motivated

revoking the right to apply for a patent at a later time.

by an increased need for IP protection and hint that the strategic value of patents drove the patent surge.
To summarize: on the one hand, recent changes in patenting schemes have caused an elevated need for patents as an IP protection tool. On the other hand, patents gained in importance as strategic instruments.

A look at the development of R&D expenditure as the presumably most important input factor for knowledge production provides a further argument for the hypothesis that the increase in patents rather is motivated by their heightened strategic value. The rising number of patent applications at the German Patent and Trade Mark Office (GPTO) over time stresses the patent surge in the 1990s for German firms. Figure 1 shows a continuous increase in patent applications at the GPTO during the 1990s, whereas before and after this period the number of filings is relatively constant. With a national share of 83%, Germany was the largest applicant country at the GPTO in 2000. Germany is of considerable interest in the context of European patent policy being the largest European patent applicant at the European Patent Office (EPO) with about 20,000 filings in 2000.[3]

<Figure 1 about here>

In between 1990 and 2000, the number of Germany's patent applications increased by about 71% at the GPTO and at a similar rate of 68% at the EPO. Over the same period, Germany's R&D expenditure grew only by about 41%.[4] Since this disproportionateness of patent applications and the presumably most important production factor for knowledge can only partially be explained by technological progress, it raises questions regarding the importance of patenting for IP protection. Does patenting rather indicate strategic firm behavior, while IP is better protected by

[3]Patent data is taken from various annual reports of the GPTO. Patent applications are defined as direct applications and Patent Cooperation Treaty applications in the national or regional phase with effects in the Federal Republic of Germany. Note that German filings with the EPO are included in the GPTO data with a one-year lag caused by priority.

[4]Information on R&D expenditure is taken from the Stifterverband (2003/04).

secrecy?

This paper investigates the importance of patents and secrecy after the significant changes in patenting schemes took place in the 1990s. As previous studies focus only on firms' evaluation of the different IP tools to measure their importance, this study introduces the market success of inventions as a new measure of the importance of patents as opposed to secrecy for product innovating firms. The importance of inventions protected by patents and such protected by secrecy is distinguishable in the market phase, because patents and secrecy are mutually exclusive for an invention once it has entered the market. Inventions' market success is measured by the sales figure with new products. The focus is on product innovating firms in German manufacturing in 2000.

The remainder of the paper is organized as follows. Section 2 summarizes the recent literature, section 3 provides information on the data and descriptive statistics, section 4 discusses the estimation results, and section 5 concludes.

2 LITERATURE REVIEW

The literature on IP appropriation mechanisms was for a long time dominated by the statement of Friedman et al. (1991), according to which no rational individual with a patentable invention would fail to patent it. This attitude was reflected in theoretical model assumptions without leaving room for alternative instruments of IP protection.[5] The underlying economic background is the temporary monopoly a patent grants, which allows firms to secure monopoly profits by protecting patented IP against undesired adaption by competitors for a certain period of time. Thus, patents generate incentives to innovate. The central problem discussed in the theoretical literature is the trade-off between the inefficiency of the monopoly and the

[5]See e.g. Tandon (1982) or Scotchmer (1991) for theoretical models based on such assumptions. Scotchmer (2004) provides a more balanced view.

incentives to innovate.[6]

Mansfield (1986) empirically analyzes the relationship between patenting and innovation behavior within a random sample of 100 US manufacturing firms. He finds that a substantial fraction of patentable inventions is not patented. He further highlights large differences among industries. In some industry sectors, like the pharmaceutical or chemical industry, the effectiveness of the patent system is found to be substantial, and accordingly a large share of the patentable inventions, about 80%, is patented. In other industries, patents appear to be relatively unimportant. In the motor vehicle industry, for example, the share of patented invention is only about 60%. Mansfield (1986) concludes that "clearly, firms generally do not prefer to rely on trade secrecy protection when patent protection is possible".

A few theoretical papers focus on secrecy as an alternative IP protection tool (e.g. Horstman et al., 1985, and Anton and Yao, 2004). Analyzing the choice to patent or to keep an invention secret, Anton and Yao (2004) point out three important features for understanding the management of IP: First, incomplete information about the extent of an innovation; second, the limitedness of IP protection; and third, the fact that imitation is facilitated by disclosure. Horstman et al. (1985) and Anton and Yao (2004) develop information signaling models on the decision to patent or to keep an invention secret with respect to strategic aspects.

The fact that neither patents - appropriability in the monopoly situation is not perfect, nor is diffusion through public disclosure ultimate after the patent expires - nor secrecy, which may leak out, work perfectly as the theory suggests, present a demand for empirical investigation.

Levin et al. (1987) serve as pioneers in the field with the Yale I study, in which they analyze survey data on firms' appropriation activities in US manufacturing.

[6] Seminal studies are provided by Nordhaus (1969, 1972). Denicolò (1996) and Langinier and Moschini (2002) provide surveys on this theoretical literature.

They find that patents are not the most important mechanism of IP appropriation. Secrecy and learning advantages as well as sales and service efforts are more important. Furthermore, they detect significant inter-industry variation regarding the use of IP protection instruments. In the chemical and pharmaceutical industries, patents are most often used and are considered to be more effective than in other industry sectors. A further result is that product innovations are better suited to patent protection than are process innovations.

Cohen et al. (2000) add a consecutive study (Carnegie Mellon survey) for US manufacturing. Their findings confirm the results found by Levin et al. (1987): Patents are the least emphasized instrument of IP protection (compared to secrecy, lead time advantages, and the use of complementarity marketing and manufacturing capabilities) for the majority of the sampled firms. Further, they point out that the reason behind patenting in general is not IP protection but strategic arguments, like bargaining power, cross-licensing, and reputation. Their results also underline the significance of industry differences, separating industries that usually introduce a 'discrete' product (a new substance in the chemical industry, for example) from industries that usually develop 'complex' products (such as a new product in the electronics sector). Cohen et al. (2000) show that most patents are filed by the chemical and pharmaceutical industries, and further that product innovations are better suited to patent protection than process innovations. These results confirm the findings of Levin et al. (1987).

The PACE report (Arundel et al., 1995), as the European counterpart of the Carnegie Mellon survey, focuses on the European Union's 840 largest manufacturing and industrial firms located in Germany, the UK, Italy, Belgium, the Netherlands, Luxembourg, Spain, Denmark, and France. The findings of the PACE report confirm important industry variations regarding the effectiveness of IP protection tools for European firms. For Europe and the US, patents play an outstanding role in the pharmaceutical and chemical industries for both product and process inventions. In addition, Arundel et al. (1995) find that patents and lead-time advantages are most important in protecting product inventions, whereas secrecy is most important in protecting process inventions in most industries. Arundel et al. (1995) also report differences regarding the importance of IP protection methods among EU countries. In general, German firms consider a range of IP protection tools as effective compared to the other EU countries. Consequently, Germany shows the highest patent rate.

In 1992, the Community Innovation Survey (CIS) of the European Commission started dealing with questions of IP protection. Unlike the PACE study that focuses on the largest European firms, the CIS takes SMEs into account. The CIS I wave (1992) asked the firms to evaluate several legal and non-legal methods of IP protection with regard to product and process innovations separately. Respondents scored the importance of the different IP protection tools on a five-point Likkert scale. Only a few studies have analyzed this information so far.

Arundel (2001) focuses on the relative effectiveness of patents and secrecy using the CIS I survey for six EU countries. He estimates ordered logit models on the relative efficiency of patents and secrecy. This approach has the advantage of taking into account unobserved firm heterogeneity. Arundel (2001) concludes that secrecy provides an effective alternative for IP protection. Moreover, he finds that firms rate secrecy even as more effective than patents, regardless of firm size.

König and Licht (1995) investigate the importance of patents compared to different, non-legal IP protection methods using the CIS I wave for German manufacturing. Their results confirm the findings of Levin et al. (1987) that non-legal IP protection instruments are more effective than legal tools. In contrast to the conclusion of Yale I, the study on Germany finds every non-legal IP protection tool more effective for protection of product innovations than patents. They further conclude that highly innovative firms rather rely on a bundle of IP rights than on patents only. Moreover, the results for Germany contrast with Arundel's (2001) analysis for several European countries by stating that patents are more important for larger firms than for SMEs. A drawback of the CIS I wave is that the firms were asked to evaluate the different IP protection tools regardless as to whether they had ever used the specific tools. Thus, the ratings of firms that had never used patents or secrecy are attributed the same weight as the scores of experienced firms. The CIS III wave, in contrast, asked the firms which IP protection methods they had used, and accepted ratings only from those firms that have actually used the respective IP protection tool. Unfortunately, the questions of CIS I and CIS III differ by such a high degree that a comparative analysis is impossible.

Hanel (2002) analyzes the use of IP protection in Canadian manufacturing, paying attention to a possible effect on firm profits. As a first step, he focuses on the propensity of innovative firms to protect their IP. He affirms Mansfield's (1986) results for Canada, which state that although firms do not trust in the protective effect of those instruments, most of them use at least one of them to protect their IP. Small firms use IP protection tools less often and world-first inventors use every kind of IP protection more frequently than other firms. The Canadian survey provides information on the impact of IP protection on profits. Firms rated this effect on a five-point Likkert scale. The scoring, however, is not related to particular IP protection instruments. Hanel (2002) finds that firms which protect their IP state that IP protection increased or maintained their profits.

A general drawback of firm level studies on IP protection tools arises from the fact that firms typically have more than one invention and, furthermore, tend to bundle different IP protection tools (e.g. Levin et al., 1987). It is thus impossible to determine what exactly is protected by which IP protection instrument. This creates a blind spot for empirical research at the firm level, because there are many possible ways to combine different IP protection tools (Arundel, 2001). A prominent scenario involves patents and their frequent use for the protection of product inventions, which are more likely to become re-engineered than process inventions, while secrecy is preferably applied to protect process inventions (Levin et al. 1987, Cohen et al. 2000). Cohen et al. (2000) highlight different situations in which a combined use of IP protection tools is possible, even for a single invention. For example, different elements of a particular invention may be protected by more than one protection tool, a strategy that is widespread in the chemical industry (Arora, 1997). Moreover, different IP protection tools may be used at different stages of the innovative process. For example, secrecy may be applied in early stages of the innovative process and patents may be used to protect the invention as it is commercialized. After the invention has entered the market, however, patents and secrecy are mutually exclusive for a particular invention because of the patent disclosure requirement.

Theoretical models focus on the invention level and are thus able to tackle the question of which IP tool is most suitable for a particular invention. However, empirical research at the firm level cannot tell whether patents and secrecy are used for one or more particular inventions, focusing instead on the use of patents and secrecy by firms in general.

This study analyzes the importance of patents and secrecy in terms of invention success in the market at the firm level using the CIS III survey data. The database allows identification of those firms that have actually applied the particular protection tools, which is a clear advantage compared to the CIS I wave. Going beyond an investigation of the relationship between the use of different IP protection tools by particular firms, this study analyzes the relationship of patents, secrecy - their rating in terms of importance for IP protection as a second specification - and sales with new products. The effectiveness of different IP protection tools is measured in terms of the protected inventions' market success at the firm level. Are the most promising inventions protected by patents or is it rather true that silence is golden?

3 DATA AND DESCRIPTIVE STATISTICS

The underlying database is the Mannheim Innovation Panel (MIP), a survey conducted yearly by the Centre for European Economic Research (ZEW) on behalf of the German Federal Ministry of Education and Research (BMBF) since 1992. With its focus on firms' innovation behavior, the MIP is the German part of the Community Innovation Survey (CIS) of the European Commission. The CIS survey has been conducted every four years since 1992. This paper is based on the CIS III wave that poses the question of what instruments the firms had used over the past three years to protect their IP. In addition, patent information provided by the GPTO is used. The GPTO database contains all filings with the GPTO since 1979.

The resulting sample consists of 626 observations of manufacturing firms in Germany from the year 2000. As the need for IP protection depends on (successful) R&D activities, the sample includes only R&D conducting firms. Moreover, as the importance of patents and secrecy is measured in terms of sales with new products, only product innovators receive focus. 60% of those firms also conduct process innovations. Table 1 shows descriptive statistics of the variables of interest.

<Table 1 about here>

3.1 Patenting, secrecy and firm characteristics

More than half of the firms had used patents (56%) in 1998-2000 in order to protect their IP. A somewhat larger part of the firms had used secrecy (61%) for IP protection in 1998-2000.[7] 41% of the sample firms had employed patents and secrecy; 24% reported using neither patents nor secrecy.[8]

[7] The percentage of secrecy users may seem to underestimate the use of secrecy, considering the fact that, in principle, every invention is kept secret in the very first phase of the innovative process. On the other hand, the question of whether the firms applied secrecy rather than a number of other IP protection tools addresses those firms that applied secrecy consciously to protect their IP when another means of protection could have been used alternatively.

[8] The variables *patent* and *secrecy* are defined based on question 14.3 of the German CIS III questionnaire, where firms are asked for a "yes" or "no" response to 'have made use of any of these methods (patent, registered design, trade mark, copyright, secrecy, complex design, or temporary head start) to protect their innovations or inventions in the period 1998-2000'.

In order to estimate the success of the differently protected inventions in the market, the sales figure of new products is used as the endogenous variable. The CIS III asked the firms to disclose their cumulative sales with new products in the past three years. On average, the sample firms' new products had sales of about DM 18 million[9], which corresponds to 12% of their total sales. The censoring of firms without sales with new products is about 30%. Excluding them, the average sales with new products increases to about DM 26 million, corresponding to 17% of their total sales. To take the skewness of the innovation sales figure into account, the logarithm is used in the regressions.[10]

An important regressor is the firms' R&D expenditure as the presumably most important input factor for innovation production. In the current sample of about one-third of SMEs, the average product innovating firm spends DM 8.9 million on R&D activities. R&D intensity is calculated as R&D expenditure in terms of employment and reflects the relative importance of innovative activities to the respective firm. Firm size, measured by the number of employees, is another important variable. Large firms not only have the capability to conduct more R&D than smaller companies; they also have better organizational structures and suffer less financial restraints. Those firms are thus more likely to use IP protection tools and to have higher sales with new products than small firms. The average sample firm has 645 employees. Since the distribution of firm size shows a considerable skewness, the logarithm of employment is used in the regressions.

Another important regressor is the non-R&D innovation expenditure. Containing every innovation expenditure which is not R&D, this variable covers marketing costs as well as further costs associated with the market entry of a product. Again, the

[9]The exchange value of the DM is: DM 1 = €0.51129188.

[10]It would be desirable to have panel data on the sales figure of new products to take into account a possibly larger lag between IP protection and the commercialization of the invention. Unfortunately, the MIP is a highly unbalanced panel: Only a small share of the sampled firms responded in later years.

logarithm of the variable is used to take the skewness of the distribution into account.

Moreover, the lagged patent stock is used as an instrumental variable in two of the econometric specifications (see section 4 for details). The patent stock is highly correlated with current patent activities, but is supposed to have no impact on the error terms, as it is controlled for other relevant factors driving the sales figure with new products. Firms' patent stocks are calculated on the basis of the GPTO patent data as follows:

$$patstock_{i,t} = patstock_{i,t-1}(1 - \delta) + patent\ applications_{i,t},$$

where δ is a constant depreciation rate of knowledge, which is set to 0.15 as is common in the literature (see e.g. Hall, 1990, and Griliches and Mairesse, 1984). The patent stock is used with a three-year lag as an appropriate instrumental variable for patent activities in 1998-2000. To take the skewness of the distribution into account, the patent stock is measured in terms of employment. Furthermore, the logarithm is used. Zero values are set to the sample minimum. An average firm in the current sample has a patent stock of 0.04 patents per employee. Ignoring the 290 firms without any patents, the average patent stock is slightly larger at 0.07 patents per employee.

Furthermore, firm location is taken into account using a dummy variable that takes the value one for firms located in Eastern Germany and zero for firms in Western Germany. Eastern Germany was a planned economy until 1989 and its transition into a market economy is still ongoing. Firms in Eastern Germany are found to be still less innovative and less productive than their Western German counterparts (Czarnitzki, 2005). One-third of the firms in the sample is located in Eastern Germany.

The Hirschman-Herfindahl Index (HHI) is used to control for intra-industry competition. The HHI represents the domestic seller concentration at the three-digit NACE industry level. In the econometric model, the HHI is lagged by three years to avoid simultaneity problems. The HHI is divided by 1,000 to get the model coefficients into one range. Industry effects measured by 14 dummies turned out to be not statistically significant after controlling for firm size, R&D intensity, and innovation strategies (see next subsection). Thus, they are not taken into further account.

3.2 Innovation strategies

Innovation strategies are supposed to be an important issue when focusing on firms' innovative output. If a firm's innovation activity aims at gaining market power or competitive advantages, the firm's sales with new products are likely to be high, because the firm has to compete internationally and inventions must cope with high technological standards. Other firms innovate to decrease production costs. This innovation strategy is likely to have no direct effect on the sales figure of new products.

Different innovation strategies are identified by means of the effects of firms' innovations in 1998-2000. Firms ranked the importance of their inventions with respect to several options on a four-point Likkert scale, where "3" corresponds to a high effect of their innovations on the respective task and "0" indicates that there had been no effect on that task at all. The possible effects of inventions are separated into three groups. The first group is related to innovations' effects on products and services:

- diversification of products or service offerings (mean: 2.31/std.dev.: 0.78)
- entry into new markets or enlargement of market share (2.12/0.80)
- quality improvement of products or services (2.26/0.79).

The second group of effects targets process and procedure related effects of innovations:

- enhancement of product flexibility (1.61/1.10)

- expansion of capability (1.73/1.05)
- decrease in personal costs (1.48/1.04)
- decrease in material and energy costs (1.24/0.98).

The third group describes further effects of innovations:

- improvement of environmental and health conditions (1.17/1.04)
- achievement of regulatory and standard conditions (1.24/1.08).

The sample means of innovations' importance for the different product and process related improvements as well as for the achievement of regulatory, environmental and health conditions are between one and two. Firms' innovations thus have, on average, a positive impact on all targets from the firms' point of view. Innovations are most important for the first group of tasks, namely entry into new markets, achievement of larger market shares, and quality improvements of their products and services. For those options that aim at improving firm performance in competition with rival firms, the mean importance is between two and three, the latter of which is the maximum value of importance.

To detect innovation strategies underlying the effects of firm innovations, standard factor analysis is conducted. Factor analysis allows reduction of the dimensionality of the survey questions above by bundling the underlying information according to variance analysis. Table 2 shows the result.

<Table 2 about here>

It turns out that three dimensions capture most of the variance in the scorings, corresponding to the three groups of innovation effects defined in the survey. The first factor is highly correlated with the second group, the process improvement related effects of innovations. Innovation activities aiming at higher product flexibility, at increased capability, and at lower factor input costs can be interpreted as an internal

or *process improvement strategy* for innovating. The second dimension captures the third group of innovation effects. Firms conduct innovation projects to comply with environmental and health conditions as well as with regulatory and standard conditions. Those firms follow a *compliance strategy* for innovating. The third dimension shows a correlation between diversification of product or service offerings and entry into new markets or enlargement of market share caused by innovations. Those firms innovate in order to increase or maintain market power. For the following analysis, the term *new markets strategy* for innovating will be applied.
The different innovation strategies are supposed to have an impact on firms' innovative success in the market. Firms that develop innovations for competitive reasons (*new markets strategy*) are supposed to have higher sales with new products than other firms. Three score variables corresponding to the estimated factors are included in further regressions to take into account the different innovation strategies.

Furthermore, 'industry strategies' are focused on to account for sectoral heterogeneity. In some industries, like basic metals, inventions are often based on relatively general principles of mechanical engineering and will therefore not be patented, whereas in other industries, like pharmaceuticals, chemicals, or high technology, IP protection is more important (Arundel, 2001). The fraction of firms that applied patents and secrecy on the three-digit NACE level is taken into account to control for industry preference for the respective IP protection tools.

3.3 Importance of patents and secrecy

The CIS III contains a question on the importance of the applied IP protection tools.[11] Those firms which actually applied the particular means scored its importance for IP protection on a three-point Likkert scale ranging from "very important" to "not important". A fourth group containing those firms which have "not used" the particular instrument is defined. This group is supposed to contain the firms

[11]See question 14.3 in the German CIS III questionnaire.

with the lowest valuation of the respective protective instrument. Figure 2 shows the average importance of patents and secrecy for the sample firm with respect to their sales figures with new products. The table below provides some statistics.

<Figure 2 about here>

<Table 3 about here>

Figure 2 shows that the number of firms that have not applied patents or secrecy is the largest among product innovators without any sales with new products. Moreover, it is apparent that those German firms which actually applied patents and/or secrecy rank those tools as important for IP protection - the conditional average rating of patents and secrecy is always between "2" (important) and "3" (very important). This finding is in line with Arundel et al. (1995), who conclude that German firms tend to uprate IP protection tools compared to other EU countries. It also turns out that patents are rated as more important for IP protection than secrecy, independent of their sales figure with new products (Table 3). However, the difference in distributions is not statistically significant.

4 EMPIRICAL ANALYSIS

The empirical part of this paper analyzes whether patents and secrecy have a positive impact on firms' sales figures with new products to address the question of whether either of them is more important for protecting inventions in their market phases. The econometric specification is:

$$log(sales_i^{new\ products}) = \beta_0 + \beta_1 patent_i + \beta_2 secrecy_i + \gamma X_i + u_i. \quad (1)$$

The logarithm of sales with new products, $log(sales_i^{new\ products})$, is the endogenous variable. The most important regressors are two dummy variables, one controlling for patenting, *patent*, and the second for application of *secrecy*. X presents a vector of control variables, like firm size, R&D expenditure and firm strategy. u_i is the

error term. In the following, this specification is referred to as model (I).
In order to establish a more direct link between the firms' innovation sales and the effectiveness of patents and secrecy for IP protection, an alternative specification is estimated where the binary variables *patent* and *secrecy* in equation (1) are replaced by six binary variables that map the ranking in effectiveness from the firms' point of view as defined in Figure2. This specification is referred to as model (II).

To take the censoring of the endogenous variable into account both specifications are estimated using a tobit model. The first column of Table 5 shows the estimation results for specification (I); the third column does so for specification (II). It turns out that there is a positive, statistically significant relationship between patenting and sales with new products, whereas there is no effect for secrecy. This also holds for the effectiveness of patents and secrecy. Firms that state that patents are important or very important for IP protection have significantly higher innovation sales. In both models, the coefficients of secrecy are much smaller than the patent coefficient, and the t-statistics are fairly low.

However, the econometric model given by equation (1) ignores that patenting in model (I) and the patent ranking in model (II) may be endogenous with respect to sales with new products. In that case, the error term in equation (1) would be correlated with the patent decision (or the respective patent ranking respectively) and the sales figure with new products at the same time, which would lead to a non-zero expectation value of the error term conditioned on X_i and, thus, to biased estimation results.
To take suspected endogeneity into account, instrumental variables (IV) regression is applied as a check for robustness of the positive results for patenting and the patent rating if endogeneity is controlled for. IV estimation requires at least one appropriate instrumental variable Z_i to identify the putative endogenous variable. Z_i has to provide a significant correlation with the endogenous variable and must

also not be fully or approximately fully explained by the regressors in the outcome equation.

In application, the suspectedly endogenous regressors are replaced by their expected value conditioned on the instrumental variables Z_i and control variables X_i. The econometric specification becomes:

$$log(sales_i^{new\ products}) = \beta_0 + \beta_1 \widehat{patent}_i + \beta_2 secrecy_i + \gamma X_i + u_i, \tag{2}$$

where $\widehat{patent}_i$ is the expected value of the patent dummy conditioned on Z_i and X_i in specification (I) and the conditional expected value of the patent ranking in specification (II). For model (I), $\widehat{patent}_i$ is obtained by conducting a first-step probit regression of the patent dummy on Z_i and X_i (see Gourieroux, 1991, pp. 226-29):

$$patent_i = \alpha_0 + \theta Z_i + \delta X_i + v_i, \tag{3}$$

where v_i presents the error term of the model. For specification (II), the binary variables "patents are important" and "patents are very important" have to be instrumentalized. An LR-test shows that the coefficients for those variables do not differ significantly (LR-χ^2=.20, prob> χ^2=.65). This allows to use one variable "patents are important or very important" instead of two. This variable is instrumentalized using a first-step probit model. Equation (2) is estimated using a tobit model for both specifications as before. The firms' patent stock in the year 1997 is used as instrumental variable. This variable has a significant impact on current patent activities and the current patent rating, but is not statistically significant when included in equation (1). The same holds for the shares of firms using patents and secrecy in an industry. Those variables serve as further instruments. In industries where patenting is widely-used, firms may be forced to file patents to protect their IP independent of their expected innovation sales from the respective innovation. In the presence of fierce technological competition, firms may have to win patent races in order to survive or maintain competitiveness in the market. In contrast, in industries characterized by a low patent propensity, like basic metals, there might be no reason for a single firm to file a patent. Analogue argumentation applies to the share of firms that use secrecy within an industry.

<Table 4 about here>

Table 4 shows the results of the first step regression for models (I) and (II). It turns out that the lagged patent stock has a positive impact on patent propensity as well as on the propensity to find patents important. Firms apparently commit themselves to patenting. The persistence in patenting shows that patents are an appropriate instrument for IP protection, for strategic issues or both from the patent holders' view. Model (II) proves that product patentees value patents as important for IP protection.

Model (I) shows that there is a strong correlation between patent propensity and the use of secrecy. Firms tend to apply both IP protection instruments. This result confirms the common finding of previous studies that firms tend to bundle different IP protection tools (Levin et al., 1987, Cohen et al., 2000, König and Licht, 1995, and Arundel et al., 1995). Moreover, product innovators rate their patents' protective value higher than others, and there is a positive correlation of the valuation of patents and secrecy as model (II) shows. One should keep in mind that German firms are found to evaluate any kind of protection tool as more important compared to other European countries (Arundel et al., 1995). It also turns out that firms that state that secrecy is not important for IP protection are more likely to find patents important.

Industry preferences for either instrument turn out to have a strong impact on the use of patents and their importance for IP protection. The percentage of firms in an industry that uses patents measured on the three-digit NACE level has a large positive impact on the decision to patent and also on the positive patent rating. The share of secrecy users has a negative impact in both models. These variables capture industry heterogeneity. The fact that patents' importance varies across industries is a common finding of previous studies. In some industries, like basic metals, inventions tend to be based on general engineering principles that are not patentable, whereas in high-technology industries as well as in chemicals and the pharmaceutical industry, patents are supposed to be much more important. If industry preferences for patents and secrecy are included, there is no further effect of industry dummies, even if they are highly aggregated with respect to their technology intensity.[12] Innovation strategies at the firm level also have no effect in both models. A possible effect might also be captured by the industry preference for either of the instruments.

Firm size has a positive impact on patent probability and positive patent rating. Large firms usually conduct more R&D, which enables them to file more patents. In addition, large firms are likely to have their own legal departments and do not suffer financial constraints to the same degree as small firms. This is of great value in the case of infringement. Infringement costs constitute a significant barrier to patenting for small, financially bound firms.

R&D intensity as a measure of the importance of innovative activity to the firms turns out to have no impact on patent propensity. However, there is a significant impact of R&D intensity on the importance of patents for IP protection for product innovators. These findings confirm the results of Arundel et al. (1995).

Firms located in Eastern Germany that lag behind Western German firms with respect to their innovation activities and output are less likely to file a patent than others. However, there is no significant difference between Eastern and Western German firms with respect to the positive patent rating. Having controlled for industry preference and firm size, no effect of the concentration index (HHI) is observable.

After having obtained the instrumentalized counterparts of the variables of interest, the focus is now on the impact of patents and secrecy (and their ratings) on sales figures with new products. The first and third column of Table 5 show the estimation results for models (I) and (II) obtained from the tobit regressions; the second and fourth columns show the respective results for the IV regressions. Here, the patent

[12] The same holds for industry interaction terms with patent history and the R&D intensity of the individual firms.

dummy and rating are replaced by the estimated variables obtained from the first step regressions. The results are quite robust with respect to the different estimation approaches and specifications. However, the instrumentalized regressors decrease in significance because their standard errors increased through instrumentalization.

<Table 5 about here>

Patent propensity and a positive patent rating turn out to have a statistically significant impact on sales with new products. The positive result of both variables is confirmed when endogeneity is controlled for. The correlation between patenting and innovation sales figures is in line with the hypothesis that patenting indicates valuable inventions. Moreover, it may indicate that patents are filed when the expected monopoly profits are large. However, the result from specification (I) may be driven by the fact that firms that applied for patents may have developed more advanced innovations, which then led to higher innovation sales shares. In this case, patenting may proxy the quality of a firm's innovations and technological capabilities. Model (II) employs a more direct link that allows the conclusion that patents are ranked as more important than secrecy for IP protection among product innovating firms. The shift towards a more strategic use of patents that has taken place over the past decades has thus not replaced the patent's value as a means of IP protection for German firms.

Secrecy seems to play no role at all in the inventions' market phases. How can this be reconciled with a 61% share of sample firms that used secrecy? One explanation is that firms use secrecy to protect their inventions in early phases of the innovative process where the research outcome is still uncertain, rather than once the inventions have entered the market. A lead endogenous variable of the sales figures with new products, which was, unfortunately, not available for this study, could take the early state of the inventions into account. Another possible explanation is that firms use secrecy to protect their process inventions rather than their products. Remember that 60% of the sample firms also conduct process innovations, the success of which is not captured by the sales figures with new products.[13]

Further, it turns out that firm size, mapping the capability of firms to conduct R&D, as well as R&D intensity, which measures the importance of R&D to the respective firm, have a positive impact on sales with new products based on the tobit results. However, the firm size effect is not robust. If the impact of size on patent activities is taken into account via IV regression, the firm size effect disappears. The importance of R&D, however, is an important predictor for the usage of patents and their positive rating for IP protection. This result is in line with Arundel et al. (1995), who find a positive correlation between R&D intensity and the importance of patents for product inventions. Innovation strategies turn out to have no impact on innovation sales if the R&D intensity of the firms' is controlled for. Thus, the aims of firms' innovation activity does not necessarily influence innovation sales. Non-R&D innovation expenditure turns out to have no significant impact on sales with new products, which is robust for the different specifications.

Eastern German firms turn out to have significantly fewer sales with new products than their Western German counterparts. Innovative activities of Eastern German firms rather lead to catching up with the recent standards than to releasing products that are new to the market. There is no effect of intra-industry competition measured by the Hirschman-Herfindahl Index (HHI).[14]

The empirical results confirm previous findings regarding the tendency of firms to bundle different IP protection tools and the relationship between patents, firm size, and R&D intensity for product innovators.

In contrast to prior studies that measure the effectiveness of different IP tools by the firms' valuation of those tools, this paper focus on the success of inventions in the market, measured by sales figures with new products. It turns out that there

[13] Including a dummy variable for process innovating firms does not change the results, and the estimated coefficient is not statistically significant.

[14] An LR-test showed that 14 industry dummies were not statistically significant.

is a strong positive correlation between the patenting activities of the firms and the market success of their inventions, whereas there is no effect for secrecy at all. This result is confirmed if the patents' rating in importance for IP protection is taken into account, and is robust when possible endogeneity of patenting is controlled for.

5 CONCLUSION

In the 1990s, patenting schemes changed in many respects: Technological and institutional conditions altered, upcoming new technologies accelerated the shift from price competition towards competition based on technological inventions, and strategic patenting became important. At the same time, a worldwide surge in patenting took place. These developments raise the question of whether patents are still used to protect valuable inventions or if they rather indicate strategic firm behavior while alternative methods are used for the protection of intellectual property (IP).

Patents constitute legal instruments used to protect IP by granting the patent holder a temporary monopoly position including the right to sue for infringement. However, patents bear the disadvantage that patenting firms have to disclose the patented technology. This leads some firms to prefer secrecy as a mutually exclusive IP protection tool.

In the early 1990s, empirical research found secrecy to be more effective for IP protection than patents from firms' point of view. These studies use firms' evaluation of the different IP tools to measure their importance. This study introduces a new measure of the importance of patents as opposed to secrecy for product innovating firms focusing on the inventions' success in the market, where patents and secrecy are mutually exclusive due to the disclosure requirement of patenting. Inventions' market success is measured by sales figures with new products.

Focusing on product innovating firms in German manufacturing in 2000, after significant changes in patenting schemes have taken place, a strong positive correlation between patents and sales with new products emerges, whereas there is no effect for secrecy. This finding indicates that patent's are used to protect valuable invention, although the patents' importance as a strategic tool has significantly gained in importance. However, the result may correlate with the quality of firms' patented inventions and technological capacity. A second model specification focusing on the importance of patents and secrecy for IP protection shows that the positive relationship between patenting and innovation sales figures also holds for patent rating. This shows that patents are ranked as more effective for IP protection by firms as opposed to secrecy. Secrecy rather may be applied for early-state inventions that will enter the market in a later period. Another explanation for the frequent use of secrecy among the sample firms might be that firms use this instrument in order to protect process inventions, which is not captured by sales figures with new products. For further research on the effectiveness of patents and secrecy, data at the invention level would be desirable.

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Figures

Figure 1: Filings at the GPTO

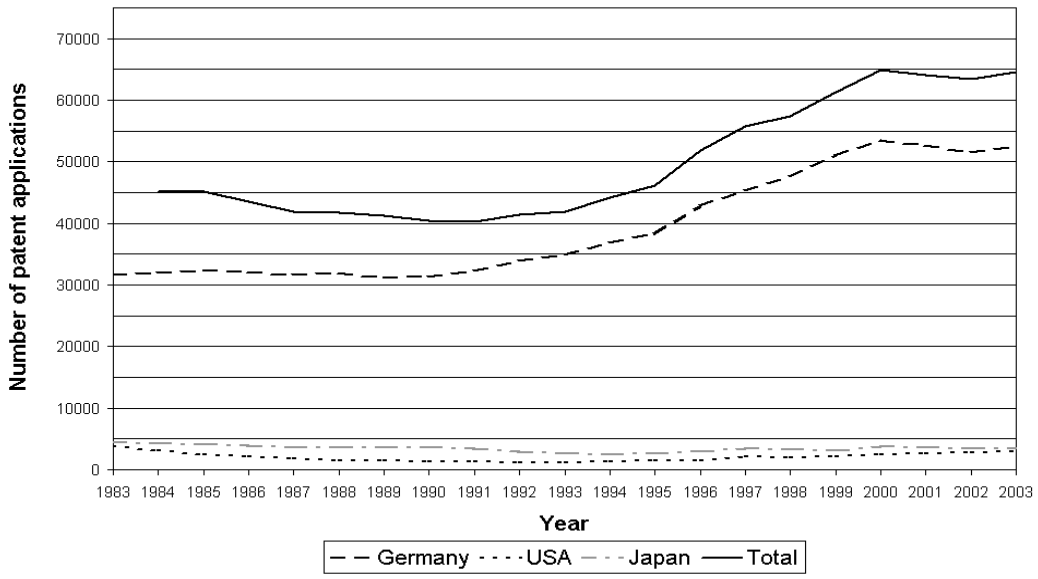
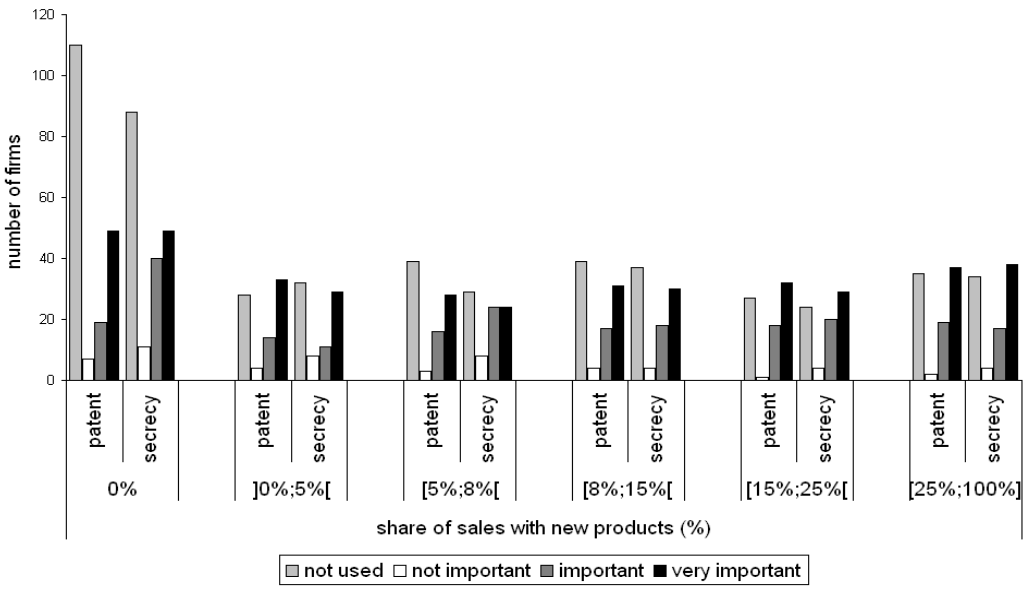


Figure 2: Effectiveness of Patents and Secrecy for IP Protection



Tables

Table 1: Descriptive Statistics

variable	unit	mean	std. dev.
patent	[0/1]	0.56	0.50
secrecy	[0/1]	0.61	0.49
sales new products	DM mio	18.06	124.54
if >0 (437 obs.)	DM mio	25.93	148.59
employment	persons	644.74	3,494.48
R&D expenditure	DM mio	8.93	83.44
R&D intensity	DM mio per emp.	9.83	15.73
non-R&D innovation exp.	DM mio	2.55	35.31
$patstock_{1997}$	patents per emp.	0.04	0.15
if >0 (337 obs.)	patents per emp.	0.07	0.19
Eastern Germany	[0/1]	0.33	0.47
HHI/1000	]0;10,000]	0.06	0.08
number of observations		626	

Table 2: Effects of Innovation and Innovation Strategies

factor loading matrix (varimax rotation)

	factor 1	factor 2	factor 3
product related effects:			
broader range of products/services	0.10	0.02	0.50
new markets/ larger market share	0.15	0.08	0.51
quality improvements of prod./serv.	0.28	0.28	0.17
process related effects:			
higher product flexibility	0.71	0.16	0.10
increased capability	0.77	0.17	0.04
lower personal costs	0.78	0.13	0.06
lower material and energy costs	0.62	0.32	0.08
other effects:			
improved environmental/health conditions	0.29	0.64	0.02
achieved regulatory/standard conditions	0.23	0.61	0.06

Table 3: Importance of Patents and Secrecy from the Firms' Point of View

sales share with new products		0%	]0%;5%[	[5%;8%[	[8%;15%[	[15%;25%[	[25%;100%]
number of observations		190	81	87	93	80	95
conditional mean[a]	patents	2.56	2.57	2.53	2.52	2.60	2.60
	secrecy	2.38	2.43	2.29	2.50	2.47	2.58
conditional median[a]	patents	3	3	3	3	3	3
	secrecy	2	3	2	3	3	3

*** (**) indicate a significance level of 1% (5%).

[a] Mean and median are calculated for only those firms that have applied and scored the respective IP protection tool.

Table 4: First Step Probit Regressions

	(I)	(II)
endogenous variable	patent dummy	patents "important" or "very important"
	coef. z-stat[A]	coef. z-stat[A]
$\log(\text{patent stock}_{1997})$	0.14***	0.13***
	(6.74)	(5.84)
secrecy	0.62***	
	(4.17)	
secrecy "not important"		0.59**
		(2.09)
secrecy "important"		0.79***
		(4.29)
secrecy "very important"		0.83***
		(5.10)
share of patent users in industry	11.18***	9.95***
	(6.03)	(5.25)
share of secrecy users in industry	-5.32***	-5.57***
	(-2.63)	(-2.78)
process strategy	-0.01	0.04
	(-0.07)	(0.52)
compliance strategy	-0.09	-0.12
	(-0.61)	(-0.48)
new markets strategy	0.09	0.23
	(0.64)	(1.20)
log(employees)	0.27***	0.28***
	(5.20)	(4.95)
R&D intensity	0.01	0.01*
	(1.44)	(1.73)
HHI	-0.32	-1.05
	(-0.44)	(-1.32)
Eastern Germany	-0.33**	-0.20
	(-2.35)	(-1.48)
constant	-1.14***	-1.41***
	(-3.02)	(-3.51)
number of obs.	626	626
Pseudo-R^2	0.31	0.31
Log-likelihood	-294.67	-300.10

*** (**,*) indicate a significance level of 1% (5%, 10%).
[A] The t-statistics are based on bootstrapped standard errors.
200 replications of the entire estimation procedure are used.

Table 5: Success of Firms' Innovation in the Market

	(I)		(II)	
endogenous variable	log(sales with new products)			
model type	tobit	IV regression	tobit	IV regression
	coef.	coef.	coef.	coef.
	(t-stat)	(t-stat)	(t-stat)	(t-stat)
patent	1.28***			
	(3.18)			
patent propensity		0.48*		
		(1.65)		
secrecy	0.49	0.41		
	(1.22)	(1.03)		
patents "not important"			-.01	-0.89
			(-0.01)	(-0.87)
patents "important"			1.69***	
			(3.13)	
patents "very important"			1.35***	
			(2.97)	
patents "important" or				0.57*
"very important" propensity				(1.77)
secrecy "not important"			-.19	-0.26
			(-0.24)	(-0.33)
secrecy "important"			-0.05	-0.14
			(-0.09)	(-0.23)
secrecy "very important"			0.42	0.28
			(0.86)	(0.54)
process strategy	0.12	0.12	0.10	0.09
	(0.56)	(0.56)	(0.44)	(0.41)
compliance strategy	0.25	0.26	0.28	0.30
	(0.95)	(0.69)	(0.76)	(0.75)
new markets strategy	0.60	0.58	0.51	0.43
	(1.41)	(1.35)	(1.26)	(1.00)
log(employment)	0.35**	0.28	0.33*	0.25
	(2.04)	(1.39)	(1.95)	(1.23)
R&D intensity	0.03***	0.03**	0.03***	0.03***
	(2.91)	(2.37)	(2.99)	(2.49)
log(non R&D inno. exp.)	0.14	0.17	0.15	0.17*
	(1.36)	(1.61)	(1.39)	(1.64)
Eastern Germany	-1.24***	-1.19***	-1.30***	-1.29***
	(-3.10)	(-2.58)	(-3.06)	(-3.33)
HHI	-1.38	-1.26	-1.70	-0.46
	(-0.61)	(-0.56)	(-0.28)	(-0.20)
constant	-3.81***	-2.76***	-3.57***	-2.23*
	(-3.76)	(-2.29)	(-3.36)	(-1.81)
number of obs.	626	626	626	626
censoring	30%	30%	30%	30%
Log-likelihood	-1,452.76	-1,437.96	-1,451.16	-1,455.79

*** (**,*) indicate a significance level of 1% (5%, 10%).
The t-statistics are based on bootstrapped standard errors. 200 replications of the entire estimation procedure are used.