

Working Paper Nr. 95

**Patent Management in High Technology Companies
- A First Look**

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Dezember 2003

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Abstract

This article analyses the scope and impact of patent management in high technology companies. The exploratory empirical study is based on a conceptual framework, which relates patent management to firm performance by taking various contingent factors into account. The empirical analyses give a detailed descriptive overview about patent management in high technology firms. Further, differences in patent management between young and established high technology companies and special characteristics of biotechnology firms are examined. Finally, preliminary insights regarding the impact of patent management on firm performance are gained. The empirical findings have implications for improving patent management in high technology firms.

I. Introduction

Value creation is increasingly achieved through the use of knowledge-intensive products, processes, and services. Because of increasing costs for acquiring knowledge, its exclusive utilization is crucially important for creating a sustainable competitive advantage (Kurz, 2000; Smith and Parr, 1994; Sullivan, 1998). The exclusivity of knowledge use can be secured through various instruments. In the field of industrial property rights, the patent is the most important instrument for achieving the exclusive utilization of technical knowledge (Ernst, 2002; Harabi, 1995). The growing importance of patent protection is reflected, in particular, in the worldwide increasing number of patent applications (Bowonder, Yadav and Kumar, 2000; EPA, 2001; Kortum and Lerner, 1999). This patenting trend is attributable to motives beyond the basic intention of patent protection, which is to create barriers for the competition and to avoid fast imitation. Further important motives are to foster the external commercialization of the firm's existing technological capabilities in order to generate additional financial returns, for example, by means of licensing, and to get access to important externally available technological knowledge, for example, by means of cross licensing or the formation of R&D alliances (Bessen and Maskin, 2000; Grindley and Teece, 1997).

Intellectual property protection has become very important for many established companies (Grindley and Teece, 1997; Sullivan, 1998). A prominent example is Microsoft. After the creation of its patent department in 1995, the number of patent applications only in the U.S.A. increased to 1.576 between 1996 and 2000 in contrast to 115 patent applications between 1986 and 1995 (USPTO, 2001). The protection of intellectual property is of particular importance for start-ups and young high tech companies. This explains the high growth rate of the number of patent applications in the U.S.A., particularly of early-stage companies in the fields of software, e-business and biotechnology (Kortum and Lerner, 1999).

To establish themselves in the market and to be able to compete against larger, well-established competitors, young high technology companies must secure their technological competitive advantage through patent protection (Spero, 1990). The firm Qualcomm is a good example. Founded in 1985 by two professors from the University of California at San Diego, Qualcomm developed a new technology for the next

generation of mobile telecommunication (CDMA technology) and protected that technology through numerous patents. After a long series of legal battles with established competitors, Qualcomm settled a dispute with Ericsson in March 1993. Ericsson and later other large telecommunication firms decided to license the Qualcomm technology. Afterwards, Qualcomm's stock price rose (adjusted by a stock split) almost 2,700% by the end of the year. Initially valued at US\$5 billion, Qualcomm was valued as high as US\$132 billion (Erdell, Haug, and Higgins, 2001). Besides Qualcomm, there are examples of numerous other young high technology companies in which the value of the company is determined almost exclusively by its patent portfolio (Fox, 1998; Parr, 1999).

Empirical findings show a positive correlation between the quality of a patent portfolio and firm performance, both in young and established companies (Ernst, 2001; Lerner, 1994; Shane, 2001). It must be, therefore, a central objective of patent management to build a high quality patent portfolio which then leads to increased commercial performance. Until now, no extensive empirical study has been undertaken to examine either the structure or the impact of patent management on firm performance in high technology companies. This paper examines these two central points in an exploratory empirical study. The first part of this paper introduces a conceptual framework linking core elements of patent management to firm performance (section 2). The findings of the empirical study are presented in section 3. The article ends with a synopsis of the fundamental insights gained from the empirical results and recommendations for future research in section 4.

II. Conceptual framework linking patent management and firm performance

Please insert Figure 1 about here

Figure 1 illustrates the conceptual framework that links patent management and firm performance. The framework consists of four primary components, each operationalized by further variables. The patent portfolio of a company is in the center of this framework. Two elements define the value of a patent portfolio: a) the number of patent applications and b) the quality of these patent applications. It is particularly important to include patent quality because a positive correlation between patents and firm

performance was only found when the quality of patents was measured (table 1). The quality of a patent can be quantified through the number of citations, the international and technological scope of the patent application, as well as whether or not the patent is granted by the patent office (Ernst, 1996; Ernst, 2003). This type of information, which is relevant to assess patent quality, can be determined for each patent and compiled into a single construct of overall patent quality. The weight for each indicator of patent quality can be determined by analyzing the respective sales or profit contribution of the individual patent in a regression analysis (Ernst, 2003).

Please insert Table 1 about here

The quality of a patent portfolio should depend on the effectiveness of patent management in a company (figure 1). Patent management pursues two primary goals within the scope of technology management: (1) the improvement of decision quality within technology management through the systematic analysis of patent information and (2) the attainment of a strong patent position that maximizes the yield from the internal and external utilization of technological knowledge (Ernst, 2003). In this sense, patent management supports technology management that focuses on managing the process of acquiring, storing and utilizing technology both internally and externally most effectively and efficiently (Brockhoff, 1999; Ernst, 2003). Figure 2 illustrates the tasks of patent management within the concept of technology management.

Please insert Figure 2 about here

Through the analysis of technical, legal, and strategic patent information, competitive intelligence and technological analyses can be performed (Field I in figure 2), which results in better decisions on the firm's R&D (Research and Development) strategy (Brockhoff, 1999; Ernst, 1998; Ernst and Soll, 2003). These analyses also enable the efficient identification and evaluation of potential options for the external acquisition of technologies (Field II in figure 2). In order to store technological knowledge (Field III in figure 2), patent data can be used to identify technological experts - so-called "key inventors" - who should be retained to keep their outstanding technical competency in the firm (Ernst, Leptien and Vitt, 2000). These tasks of patent management pertain to the information function of patents (Ernst, 2003; Fields I, II and III in figure 2).

Patents support the internal and external exploitation of technological knowledge through their protection function (Fields IV and V in figure 2). On the one hand, the effective use of patents enables a company to secure a strong competitive advantage, directly affecting the financial returns from R&D investments (Field IV in figure 2). On the other hand, patents offer the opportunity to commercialize technological knowledge externally, for example, through selling or licensing patent rights (Field V in figure 2). Licensing generates additional and immediate revenues, it helps to establish technological standards and it can provide the basis for accessing relevant technologies from other sources, for example, by means of cross licensing (Bessen and Maskin, 2000; Grindley and Teece, 1997). The ability to access a patented technology developed by a competitor often depends upon the attractiveness of the company's own patents. In this way, cross licensing combines the external processes of acquiring and utilizing knowledge (Fields II and V in figure 2).

The communication function of patents is a combination of the information and protection function of patents. Patents can signal the technological competency of a company (Ernst and Schnoor, 2000). More specifically, customers and investors can learn objectively about the technological potential of a company. The positive relationship between patents and the market valuation of companies, established in empirical studies, is evidence for the strong communication function of patents (Austin, 1993; Lerner, 1994). The communication function of patents is, therefore, especially relevant for young high technology companies for attracting financial capital from investors.

The preceding remarks demonstrate that patent management should affect firm performance either directly or indirectly (figure 1). Unfortunately, the existing literature does not provide a comprehensive list of generally accepted components of patent management. A not fully complete list of relevant variables was identified for this study based on a screening of the relevant literature on patent management and interviews with industry experts. This list includes variables such as the firm's patent strategy, various organizational aspects of patent management, the utilization of patent information, resources for patent management and licensing management. These

components of patent management are explained in more detail in the empirical part of this paper (section 3).

The relationship between patent management, patent portfolio and firm performance is influenced by three types of contingency factors (figure 1). These are company-, industry-, and system-specific contingency factors. Company-specific aspects are, for example, the business and technology strategy, the level of R&D expenditures, firm size and the age of the company. Empirical studies, for example, find that, in comparison to large companies, small companies file patents more selectively, they attach more significance to their patents and they have a higher share of patents in use to protect products (EPA, 1994; Ernst, 1996; Täger, 1989). Furthermore, patent management in smaller companies is less formalized. Consequently, the structure of patent management as well as its impact on firm performance varies with firm size.

Moreover, industry-specific factors must be taken into account in this framework. Numerous empirical studies show that the effectiveness of patent protection depends strongly on the type of industry (Ernst, 1996; Levin et al., 1987; Mansfield, 1986). Patent protection is of particular importance in the pharmaceutical and biotechnology industries (Levin et al., 1987; Thumm, 2001). The effectiveness of patents depends mainly on how well a technology can be protected and thus how long imitation can be delayed (Levin et al., 1987). Other important industry-specific factors are, for example, the intensity of competition, the importance of technology for achieving competitive advantage and the dynamics of technological change. The importance of patent protection is lower in dynamic technological areas because the period in which the protected technical knowledge can be utilized is shorter (Brockhoff, 1999).

Finally, it is important to consider system-specific contingency factors. These include country-specific aspects of the respective patent systems as well as cultural factors with regard to the fundamental value placed on patents. The latter aspect is evident, for example, in Japan. Japanese inventors and companies ascribe a high importance to patent protection (Granstrand, 2000). This leads to international differences in patenting behavior with immediate effects on how patent management is performed in companies (Granstrand, 2000; Wyatt, Bertin and Pavitt, 1985). The legal framework in a particular country is critically important for the effectiveness of patent protection. A current

example is that patents for business methods are awarded much more frequently in the U.S.A than in Europe (Berkowitz, 2000). Similar discrepancies have also been observed in the fields of software and biotechnology (Gerstenberger, 1992; Kortum and Lerner, 1999). It is obvious that patenting has great economic and political importance in promoting new technologies as well as in establishing businesses in new fields. Furthermore, incentive systems required by national law such as the *Arbeitnehmererfindergesetz* to remunerate inventors in Germany, can have an impact on patent management (Leptien, 1996).

In sum, it can be said that the relationship between patent management, the quality of the patent portfolio and firm performance should ideally be analyzed in a path model as shown in figure 1. We are, however, limited to the measurement of selected aspects of the model in this paper (figure 1; gray arrows). A description of patent management in high technology companies is a prime motivation of this paper. Further, differences in patent management are examined with regard to important contingent factors such as age, size and industry. Finally, the relationship between patent management and firm performance is examined.

III. Empirical analysis

3.1 Data collection

Several industries were selected for the empirical study. All industries are characterized by a high propensity to patent (Arundel and Kabla, 1998; Brouwer and Kleinknecht, 1999), which is measured by the percentage of patentable inventions for which patents are actually filed (Mansfield, 1986). The companies in the sample come from the electrical engineering (19%), mechanical engineering (19%), micro-mechanical engineering (10%), chemical (14%), and biotechnology (22%) industries as well as from other industries (16%) in Germany. The data were collected by means of a survey, which was discussed and pre-tested with competent individuals from industry and academia. In 69.3% of the cases, the survey was filled out by the company's managing director or a member of the board of directors. In 19.4% of cases, the head of the patent department completed the survey, and in 11.3% of the cases it was completed by another employee, very often the head of the R&D department.

3.2 Findings

(1) Patent management in high technology firms

Table 2 displays descriptive statistics about various aspects of patent management and some contingent factors. On average, firms spend 23% of their total sales on R&D. This indicates that the sample consists mainly of high technology firms that have a strong focus on R&D. The obtainment of technological competitive advantage is regarded as very important. This explains why patents are viewed as more important than other intellectual property rights. The effectiveness of patents, compared to that of secrecy, is higher for products than for processes. It is, however, important to mention that approximately 36% of all patents held by the firms protect processes. This confirms the findings of earlier works that show that patents are regarded as more important for product inventions, but that companies also file process patents when these are attainable (EPA, 1994; Mansfield, 1986). On average, patent protection delays imitation by one year. In the absence of patent protection, the price level of existing products would on average drop by more than 20%. The average life span of a granted patent used in products on the market is nine years.

Please insert Table 2 about here

Top management attaches a high degree of importance to patents. Furthermore, patent management is frequently organized in a centralized unit and patent-related issues are systematically integrated into the development process. Patent management does not seem to be organized in a very formal way and firms balance the level of outsourcing patent-related matters with their own internal patenting activities.

Licensing management seems to play on average only a subordinate role in the sample firms. This is shown by the low average number of patents licensed to third parties or cross-licensed with a third party. The standard deviations and the maximum values for these two variables, however, point to the fact that some companies pursue aggressive licensing strategies. The same observation can be made for the on average rather less frequent use of patent information. This finding confirms earlier studies, which show that companies hardly use this sources of information (EPA, 1994; Lange, 1994).

The high importance of patent protection across companies is reflected by the fact that the average company files for patents for approximately 64% of all patentable inventions and actively uses about 54% of all patents. In decreasing order of importance, companies have the following motives when filing for patents: protecting against imitation (average rank of 2.0 on a rank scale of 1 to 7), deterring competitors (3.2), establishing prior art (3.7), opening-up licensing opportunities (4.1), and attracting investors (4.6). On average, the companies spend 8% of their R&D budget on patents and patent management. This seems to be a relatively high amount. Despite the high importance of patent protection, it is important to note that not all companies have explicit patent strategies matching their respective business strategies. Additionally, patent infringements are not always prosecuted. The high variance in the data shows that the significance of patent protection and the way patent management is performed vary between companies.

Table 3 provides an overview of various success measures for assessing the impact of patent management. It is remarkable that the profit margin for patent-protected products is, on average, higher than the company's average profit margin. Furthermore, the contribution of patent-protected products is higher for profits and sales growth than for sales. This shows that patent-protected products contribute significantly more to profits and growth than unprotected products. It is also apparent that patent protection can serve to generate additional licensing revenues, to attract investors and to prevent the imitation by the competition. The high standard deviations again suggest that the effect of patent management on firm performance varies substantially between companies.

Please insert Table 3 about here

(2) Characteristics of young high technology firms

The companies in the sample are, on average, 38.3 years old and they have 1.206 employees. Based on age, they can be classified as young (up to 10 years old, $n = 23$) and established (10 or more years old, $n = 39$) companies. The young companies in the sample are, with an average of 24 employees, small businesses, while the established companies employ on average 1.903 employees. The correlation coefficient between age and the number of employees is .81 ($p < .01$). The biotechnology companies ($n =$

12) differ significantly from the other young companies (n = 11). Young biotechnology companies are therefore considered separately later in the text.

Please insert Table 4 about here

Table 4 summarizes the variables for which significant differences between young and established companies were found (excluding biotechnology companies). The percentage of R&D as of total sales is significantly higher for young companies. This strong technological orientation explains that patent protection is of substantial importance to this group of firms. The propensity to patent of young firms is not significantly lower than that of older companies. Likewise, insignificant differences between young and old firms are found for the systematic integration of patent-related criteria in the development process, the alignment of patent and business strategy and the importance that top management places on patents. These findings show the high importance of patent management in young companies. The high importance of patent management in young companies is further reflected by the significantly higher share of sales of patent-protected products and by the higher share of patents with high commercial importance, compared to established companies (table 4). These findings are in agreement with those of other empirical studies that have observed a high number of high-quality patent portfolios in young technology companies (Ernst, 1996).

Young companies, however, report a significantly lower share of blocking patents. Blocking patents are used to build a fence around the basic patent, which should improve the protection of the core patent. A possible explanation for the less frequent use of blocking patents in young companies could be that different goals are pursued with patent applications. The goal of 'protection against imitation' has a significantly lower importance for young companies (average rank of 3.1) than for established companies (average rank of 1.6). The use of patents for attracting investors is significantly more important for young companies. Young firms are, in contrast to the group of established companies, more interested in the communication function and less interested in the protection function of patents. In addition, just 17% of the established companies - but over half of the young companies - say that the establishment of prior art or the prevention of competitors' patents is the most important reason for filing patent applications. Obviously, young companies use patents more defensively in order

to safeguard their existing activities. A further indicator is that young companies prosecute patent infringements less frequently than established firms (table 4).

The assessment of the business environment by respondents from young companies can explain the defensive use of patents. They indicated that the delay of an imitation of the initial product innovation, which can be achieved with patents, is on average 2.4 months. This number is significantly lower compared to established companies (on average 14.1 months). The price decline for products without patent protection as well as the average length of utilization of patent-protected inventions is significantly lower in young companies compared to established firms. Thus, younger companies regard the effectiveness of patent protection lower than do established companies. Accordingly, an aggressive use of the patent portfolio by these companies is, in their judgment, less attractive. It could be that these companies rely on their ability to innovate faster than their competitors in markets with short product life cycles. However, patent protection could take some pressures of these firms to shorten product life cycles by fast innovations and to increase the return period of innovations.

Significant differences between young and established companies also exist with regard to the use of patent information (table 4). Young companies use technical and legal patent information less frequently. The mean value also shows that strategic patent information is used less frequently, although the difference here is not significant. Strategic patent information refers to the early identification of changes of competitors' technological strategies, of new technological trends, and of licensing opportunities (figure 2). This type of information is especially helpful for small firms, which have to make good decisions in technology management to use scarce resources most effectively and efficiently. Obviously, the more frequent use of patent information offers a potential for young firms to improve their technology management.

Young companies are, on average, less successful in commercializing knowledge externally. Although licensing is an important reason for young companies to file patents, they license less patents than established companies. The share of patents in their patent portfolios licensed to third parties is significantly lower than in established firms (table 4). This may be a consequence of the above observed infrequent use of patent information to systematically identify licensing options. None of the young

companies in the sample had entered into a cross licensing agreement, but over 33% of the old companies had. Young companies presumably have the potential to increase the financial and strategic returns from their patent portfolios through a better external utilization of their patents.

Strategic patent management in young companies appears to focus primarily on passive protection (establishing "prior art") and on increasing their attractiveness for investors. Because of these objectives, other important options of patent management are only partially utilized. Young companies should be able to become more profitable through a more active and professional patent management because the share of sales generated from patent-protected products is high.

(3) Characteristics of biotechnology firms

Table 5 provides an overview of the significant differences between the patent management of young biotechnology and other young technology companies. With an average of 80.6%, the propensity to patent is significantly higher for biotechnology than for other young companies. Biotechnology companies file patents significantly earlier in the development process. Biotechnology companies view the effectiveness of patents to be significantly higher in comparison to other intellectual property rights. The significance of patents is further highlighted by the fact that biotechnology companies on average invest over 70% of their sales in R&D. Biotechnology is an especially knowledge-intensive industry, even compared to other industries where technological competitive advantages are also of high importance. Respondents from the biotechnology industry estimate the delay of imitation caused by patents to be significantly longer - 14 months - in comparison to the other young companies. Further, the price decline caused by the imitation of a product innovation is significantly higher for biotechnology products.

Please insert Table 5 about here

In comparison to secrecy, patent protection has a higher significance in biotechnology companies: 66% of the biotechnology companies, but only 20% of the other young companies, estimate the decline in revenue caused by a loss of patent protection to be

higher than the decline in revenue from making public all the inventions that they keep secret. Young biotechnology companies represent a group of technology companies with the highest commercial value of patents relative to secrecy. This may stem from the high importance of external technology utilization as well as the lower effectiveness of secrecy as a protective tool due to the technological nature of the biotechnology industry.

Clear differences between biotechnology and other young firms also exist regarding the extent of licensing activities. Biotechnology companies license a significantly higher percentage of their patents to third parties and they also license considerably more patent from third parties. This points to a very high importance of external technology utilization and acquisition. While the other young companies do not pursue cross licensing, the percentage of cross-licensed patents is on average 8.9% for young biotechnology companies (table 5). The percentage of licensing revenue as a portion of total sales is, at 16%, significantly higher in biotechnology firms than in other young companies (1.3%) and in established companies (0.9%). The ability to license their inventions is on average the biggest motivation for young biotechnology companies to file for patents (average rank value of 2.6). Establishing prior art is, in contrast, less important for these companies (average rank of 4.5). This is also an indication of a less defensive use of the patent portfolio in biotechnology firms. With an average rank of 2.8, increasing attractiveness for investors is more than one rank higher for biotechnology companies in comparison to other young companies. Empirical studies show that biotechnology companies are valued higher by investors if they have high quality patent portfolios (Lerner, 1994).

Young biotechnology companies use patent information significantly more frequently than other young companies. This can be attributed to the higher level of licensing activity and the higher relevance of patents in the biotechnology industry (table 5).

(4) Impact of patent management on firm performance

At this point, the relationship between the elements of patent management and firm performance, as measured by the firms' operating profit margin, should be examined. To avoid a bias due to the age of the company, the correlation analysis is based exclusively on data from the established companies that provided information about their profit margin ($n = 26$). Furthermore, biotechnology firms were excluded from the analysis. The analysis leads to the following significant results:

The systematic consideration of patent-related criteria in the development process has a positive and significant impact on firm performance ($r = .62$; $p < .00$). Thus, it is important to ensure that the patent department is intimately involved in the development projects and that patent-related tasks are clearly specified for each phase and milestone of the development process. The integration of patent management and new product development lead to the creation of an effective patent position that protects the company's products from imitation and establishes a basis for the external commercialization of technological knowledge. The alignment of business and patent strategy ($r = .45$) as well as top management support for patent management ($r = .50$), correlates significantly ($p < .05$) and positively with firm performance. Top management support is crucially important for an effective patent management in many ways. It ensures the strategic coordination of business and patent strategy, it demonstrates the importance of patenting within the company and it is able to allocate sufficient resources required for a professional patent management. Finally, there is a significant ($p < .10$) and positive relationship between the utilization of legal ($r = .37$) and strategic ($r = .36$) patent information and firm performance. This finding supports the initial argument that the use of patent information can effectively support decision making in various fields of technology management (figure 2).

IV. Conclusion

This paper introduced a conceptual framework that describes the relationship between patent management, patent portfolio and firm performance while taking important contingent factors into account. We examined specific elements of the conceptual framework based on a sample of 62 German high technology companies from industries

with high propensities to patent. It was shown that patent protection and hence patent management are important. Motives, structures, and effects of patent management vary depending on the company's age and its industry. Patent protection is particularly important for young biotechnology companies. This is reflected in the professional patent management in these firms. For other young technology companies, patent protection is hardly less important. In this group of firms, however, there is room for improving patent management, particularly with regard to the external utilization of patents and the more aggressive use of patents to prevent imitation by competitors. The importance of effective patent management is highlighted by the fact that patent-protected products account for significantly higher sales growth and profits compared to unprotected products. The findings of the final correlation analysis show a significant and positive impact of certain elements of patent management on firm performance. The systematic integration of patent-related criteria in the new product development process, the alignment of business and patent strategy, top management support and the frequent use of legal and strategic patent information offer good starting points to improve the effectiveness of patent management and to increase firm performance.

This paper's limitations create numerous suggestions for future empirical research in this area. If information about the patent portfolio was available, the relationship between patent management, patent portfolio and firm performance could be examined in a path model. In doing so, one should collect data on the quality of the patent portfolio (Ernst, 2003). Moreover, it is necessary to test more contingent relationships. This requires a large sample of firms. Finally, this research could be extended to other industrial property rights, in particular trademarks. Trademarks have become particularly important for the protection of services in many industries (Miles et al., 2000).

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Figures and Tables

Figure 1: A Framework Linking Patent Management and Firm Performance

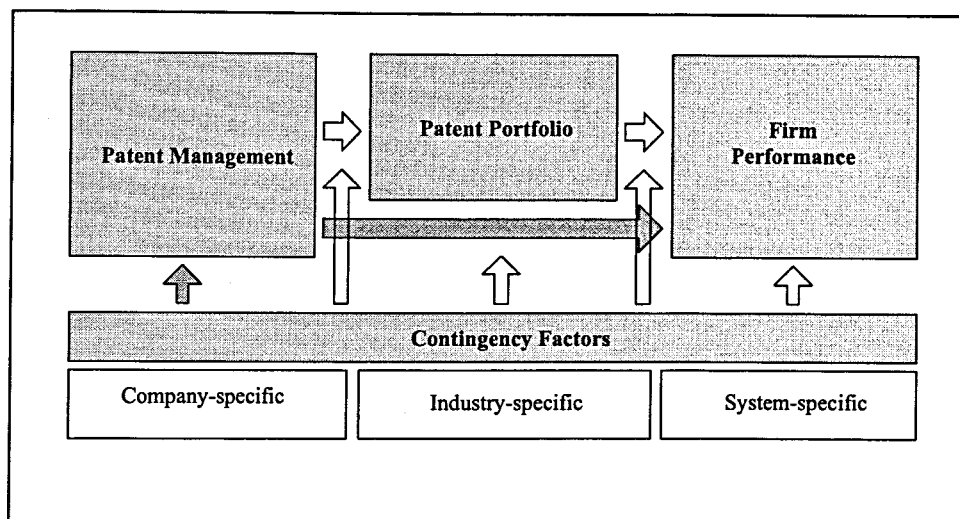


Figure 2: Tasks of Patent Management

	Technology Creation	Technology Storage	Technology Use
Patent Functions	Information		Protection
Internal	Support of R&D Investment Decisions (Competitor Monitoring and Technology Assessment)	Human Resource Management in R&D and Knowledge Management	Effective Protection of Products, Processes and Services from Imitation
External	Identification and Assessment of Sources for External Technology Creation (e.g. M&A; Alliances)	-	Strategic (e.g. Cross-Licensing) and Operational (e.g. Patent Sale) Value Maximization of the Patent Portfolio

Source: Ernst (2003), p. 234

Table 1: Recent Findings Regarding the Impact of Patents on Performance

Author	Sample	Core Findings
Austin (1993)	20 biotechnology companies (U.S.A.)	Positive influence of granted patents on market value; stronger influence of key patents
Deng, Lev, Narin (1999)	388 companies (pharmaceuticals, chemicals, electronics)	Positive influence of frequently-cited patents on market value
Ernst (2001)	50 mechanical engineering companies (Germany)	Patent applications lead to significant increases in sales with a time-lag of 2-3 years. The effect is greater for high-quality patents (wide international scope)
Ernst (1996)	50 mechanical engineering companies (Germany)	Companies with active, systematic patent strategies and a high quality patent portfolio (construct of patent quality) are more successful than companies that are inactive and unsystematic with regard to patents (low quality patent portfolios)
Hall, Jaffe, Trajtenberg (1999)	4.000 companies from various industries (U.S.A.)	Positive influence of frequently-cited patents on market value
Lerner (1994)	535 financing rounds of 173 VC-financed biotechnology companies (U.S.A.)	Firms with a large number of high quality patents (wide technological scope) receive higher valuations by investors
Shane (2001)	1.397 patents awarded to the Massachusetts Institute of Technology (U.S.A.)	High quality patents (wide technological scope, frequent citations) are more likely to be commercialized (start-up or licensing)

Table 2: Characteristics of Patent Management in High Technology Firms

Variable	N	Mean	Std Dev	Min	Max
Context Factors					
R&D expenditures as a percentage of sales ^a	55	22.6	27.0	0	125
Importance of technological competitive advantages ^c	62	4.1	.7	2	5
Average degree of innovativeness of inventions ^b	62	3.4	1.0	1	5
Average length of utilization of patented inventions the company has introduced in the market (in years)	57	8.9	4.3	2	20
Percentage of patents covering processes ^a	57	36.2	31.2	0	100
Importance of patents in comparison with other industrial property rights ^c	62	3.9	1.0	2	5
Effectiveness of patents in comparison to trade secrets for the protection of products ^c	61	4.0	1.0	1	5
Effectiveness of patents in comparison to trade secrets for the protection of processes ^c	60	2.7	1.2	1	5
Delay of imitations of product innovations caused by patents (in months)	40	12.2	12.3	0	48
Decline of price level caused by the imitation of a product innovation (scale of 1 (0-10%) to 5 (> 41%))	46	2.3	1.1	1	5
Organization					
Systematic integration of patent-related criteria in the development process ^b	61	3.5	.90	2	5
Degree of formalization of patent management ^b	62	2.7	1.1	1	5
Degree of centralization of patent management ^b	62	3.8	1.6	1	5
Top management support of patent management ^b	62	3.9	1.1	1	5
Outsourcing of patent-related tasks to external parties, e.g. patent attorneys (scale from 1 (only internal) to 5 (only external))	62	3.0	1.0	1	5
Licensing					
Share of licensed patents ^a	50	6.1	14.4	0	70
Share of cross-licensed patents ^a	44	3.3	9.9	0	60
Patent Information					
Use of technical patent information ^d	61	3.0	1.2	1	5
Use of legal patent information ^d	61	2.7	1.3	0	5
Use of strategic patent information ^d	61	2.4	1.1	0	5

Table 2: Characteristics of Patent Management in High Technology Firms (contd.)

Strategy and Resources					
Share of patents actively used ^a	58	53.8	32.5	0	100
Existence of a patent strategy ^b	61	2.7	1.3	1	5
Alignment of patent and business strategy ^b	61	3.0	1.3	1	5
Share of blocking patents ^a	48	10.0	14.4	0	50
Systematic prosecution of patent infringements ^b	60	3.1	1.3	1	5
Propensity to patent (% of patentable inventions for which patents have been filed) ^a	55	63.5	34.3	0	100
Total cost of patenting (% of R&D expenditures) ^a	52	8.0	11.9	0	57.7
a = percentage; b = assessment from 1 (low/none) to 5 (high); c = scale from 1 (unimportant/ineffective) to 5 (very important/very effective); d = frequency from 0 (never) to 5 (daily); N = number of observations					

Table 3: Success Measures of Patent Management (Entire Sample)

Variables	N	Mean	Std Dev
Operating profit margin ^a	26	7.0	6.3
Relative (in relation to the average profit margin of the same firm) profit margin of patent-protected products ^b	43	3.4	0.9
Share of sales from products protected by patents (share of total sales) ^a	43	41.5	36
Share of sales growth from products protected by patents (share of overall sales growth) ^a	38	53.6	37.4
Share of profits from products protected by patents (share of total profits) ^a	34	47.3	36.4
Share of sales from products protected by licensed patents (share of total sales) ^a	36	7.2	17.7
Share of patents (within the patent portfolio) with high commercial importance ^a	43	43.9	29.9
Importance of patents for attracting investors ^c	59	2.9	1.6
Effects of patents on competitors ^c	58	3.1	1.2
a = percentage; b = scale of 1 (low) to 5 (high); c = assessment from 1 (low/none) to 5 (high); N = number of observations			

Table 4: Characteristics of Young High Technology Firms

	Firms up to 10 years old ⁺		Firms 10 or more years old	
	N	Mean	N	Mean
R&D expenditures as a percentage of sales ^{a***}	9	31	36	10
Average length of utilization of patented inventions the company has introduced in the market (in years) ^{***}	9	6.2	37	9.9
Share of blocking patents ^{a*}	11	3.6	27	11.8
Systematic prosecution of patent infringements ^{c***}	11	2	38	3.5
Share of licensed patents ^{a*}	10	2.0	30	3.9
Share of cross-licensed patents ^{a**}	8	0	27	2.3
Use of technical patent information ^{b***}	11	1.9	38	3.3
Use of legal patent information ^{b***}	11	1.4	38	3.1
Share of patents (within the patent portfolio) with high commercial importance ^{a**}	8	57.5	25	30,3
Share of sales from products protected by patents (share of total sales) ^{a**}	9	60.6	29	31.4
Importance of patents for attracting investors ^{c***}	11	3.9	36	2.2

a = percentage; b = frequency from 0 (never) to 5 (daily); c = assessment from 1 (low/none) to 5 (high); levels of significance (Mann-Whitney-U-Test): * = p < .10; ** = p < .05; *** = p < .01; + = without biotechnology companies; N = number of observations

Table 5: Characteristics of Biotechnology Firms

	Biotechnology Firms		Other Young Firms	
	N	Mean	N	Mean
R&D expenditures as a percentage of sales ^{a***}	8	72	9	31
Propensity to patent (% of patentable inventions for which patents have been filed) ^{a*}	9	80,6	10	51.5
Importance of patents in comparison with other industrial property rights ^{c**}	12	4.6	11	3.6
Phase of the development process when patents are usually filed ^{d*}	12	2	11	2.7
Share of licensed patents ^{a*}	10	17	10	2
Share of cross-licensed patents ^{a**}	9	8.9	8	0
Number of licensed patents ^{a**}	9	32.8	11	2
Use of technical patent information ^{b**}	12	3	11	1.9
Use of legal patent information ^{b**}	12	2.7	11	1.4
Use of strategic patent information ^{b**}	12	2.9	11	1.9

a = percentage; b = frequency from 0 (never) to 5 (daily); c = value from 1 (low/never) to 5 (high); d = scale of 1 ("in the conceptual phase") to 5 ("close to being introduced in the market"); levels of significance (Mann-Whitney-U-Test): * = p < .10; ** = p < .05; *** = p < .01; + = without biotechnology companies; N = number of observations

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