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## **A look at both sides of the coin: Investigating the protective and the disclosure effect of patenting**

**Diana Heger**

Industrial Economic and International Management  
dianaheger@gmail.com

**Alexandra Karin Zaby**

Fachbereich Wirtschaftswissenschaft  
alexandra.zaby@uni-tuebingen.de

### **Abstract**

This paper presents an empirical investigation of the effects of patenting. On the one hand a patent has the positive effect of temporarily mitigating competition, on the other hand it has the negative effect that the information disclosed through the patent application may enhance competition. Testing the theoretical results provided by Zaby (2010) we find that (i) in industries which are characterized by high unintended knowledge spillover the extent of the technological lead of an inventor has a positive effect on the propensity and that (ii) the intensity of patent protection mitigates the competitive threat the patentee faces.

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### Abstract

This paper presents an empirical investigation of the effects of patenting. On the one hand a patent has the positive effect of temporarily mitigating competition, on the other hand it has the negative effect that the information disclosed through the patent application may enhance competition. Testing the theoretical results provided by *Zaby* (2010b) we find that (i) in industries which are characterized by high unintended knowledge spillover the extent of the technological lead of an inventor has a positive effect on the propensity to patent and that (ii) the intensity of patent protection mitigates the competitive threat the patentee faces.

Keywords: patenting decision, disclosure requirement, patent scope, vertical product differentiation, IPC codes

JEL Classifications: L13, O14, O33, O34

## 1 Introduction

The fact that not every innovation is patented has long since been discussed in economic literature (see e.g. *Horstmann et al. (1985)*, *Anton, Yao (2004)*). Empirical evidence points in the same direction: *Arundel (2001)*, relying on data from the 1993 European Community Innovation Survey (CIS), explicitly analyzes the relative importance of secrecy versus patents and finds that most firms rate secrecy as more valuable than a patent. As *Cohen et al. (2000)* find, one major reason for the firms to refrain from patenting is the disclosure requirement that is linked to a patent. Thus it is the loss of a technological leadership caused by the required disclosure of proprietary knowledge which drives the propensity *not* to patent: The patentee has to fear that the transfer of enabling knowledge induced by the publication of the patent application may benefit his rivals by facilitating a rapid catch-up.

In this paper we empirically investigate these two opposing impacts of patenting: the *disclosure* and the *protective effect*. For this purpose we build on the theoretical model presented in *Zaby (2010b)*. In line with patent law, *Zaby* assumes that a patent requires the full disclosure of all technical details concerning a patented discovery. This transfer of enabling knowledge benefits a non-inventor instantaneously so that on the one hand, due to the *disclosure effect* of patenting, the profits of the innovator will decrease.<sup>1</sup> On the other hand, patenting secures the inventor a temporary monopoly and thus has a positive *protective effect*. Overall the patenting decision of an inventor has to balance the tradeoff between the benefits of temporary monopoly power, and the drawback of the complete disclosure of enabling knowledge. Naturally, the positive effect may be enhanced by stronger property rights while the negative effect is subject to the impact of the disclosure requirement.

In *Zaby (2010b)* the patenting decision of a successful inventor is introduced into a market with vertically differentiated products. She considers two firms which are asymmetric in their capabilities to adopt a new technology. The first adopter of a new product realizes monopoly profits offering the innovative technology at a relatively low quality up to the point in time when a rival firm enters and offers a product which incorporates the new technology in a higher quality. Subsequently, both firms compete in an asymmetric duopoly. Preceding the adoption decision the inventor faces the choice be-

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<sup>1</sup>Note that actually the impact of such a *disclosure effect* is subject to the implemented patent law. While in Europe a statutory research use exemption exists which allows the use of patented knowledge for research purposes, in other countries, such as the U.S. or Australia, a research use exemption does de facto not exist. In terms of the underlying theoretical model the lack of a research use exemption would mitigate the impact of the *disclosure effect*.

tween a patent and secrecy to protect his discovery. A patent protects a given quality range from the entry of a rival. At the same time the patentee faces the drawback of the disclosure requirement linked to the patent which may enable the competitor to accomplish the follow-up innovation at an earlier point in time.

The main result of *Zaby* (2010b) is that the inventor will patent his invention whenever his technological headstart is moderate and that he will rather rely on secrecy whenever his technological headstart is high. The latter is due to the fact that in this case the positive *protective effect* of a patent is outweighed by its negative effect of the required disclosure.

The crucial requirement for the empirical implementation of this theoretical model is the combination of information on innovative activity of firms (including intellectual property protection strategies) with information on the competitive environment as perceived by the firms. Such data is provided by the Mannheim Innovation Panel (MIP), which is the German part of the Community Innovation Survey (CIS). Several questions concerning the competitive environment were included in the MIP starting in the year 2005. To reflect the strength of the *protective effect*, the theoretical model uses varying degrees of patent scope. Due to the recentness of the data used, relying on patent citations – a common empirical implementation of patent scope – is not possible. Instead, following *Lerner* (1994), we constructed a measure for patent scope based on the International Patent Classification (IPC) codes assigned to every patent. This information provided by the European Patent Office (EPO) was then merged with the MIP data.

Our empirical analyses show that the common economic intuition that the propensity to patent increases with the size of an innovation, i.e. the extent of the technological leadership of an inventor, can only be confirmed for industry sectors which are characterized by high unintended knowledge spillover. In this case an inventor's technological headstart is reduced whenever he relies on secrecy. This fact leads to an increase of the propensity to patent as the positive *protective effect* of patenting gains weight. Furthermore, we find evidence that the strength of patent protection has a detrimental effect on the market entry threat perceived by the inventor, so stronger patents may lead to an increasing propensity to patent.

Several empirical studies aim at analyzing the propensity to patent. Using the first wave of the German part of the CIS, *König, Licht* (1995) investigate the importance of patents compared to non-legal appropriation methods of research output. They conclude that firms rather rely on a bundle of legal and non-legal appropriation mechanisms instead of solely patenting. In a direct comparison of the use of patents versus secrecy, *Hussinger* (2006) finds that patents are effective to protect innovations, i.e. commercialized inventions,

while secrecy is rather important for inventions which are in the pre-market phase.

*Arundel, Kabla* (1998) calculate the sales-weighted patent propensity rates for 19 industries using data from the PACE survey of Europe’s largest industrial firms. They find that only four industry sectors reveal patent propensities which exceed 50 %.

We contribute to this literature by explicitly “looking at both sides of the coin” as we divide the impact of patenting into a *protective* and a *disclosure effect*. Accounting for the consequences that patenting has on the competitive environment further allows us to gain deeper insights on the driving forces behind the decision to patent.

The rest of the paper is organized as follows. In Section 2 we present a brief version of the underlying theoretical model. Section 3 then states the hypotheses summarizing the theoretical results and presents their empirical implementation. The following Section 4 describes the data set and our proceeding in restricting the data sample and defining the variables. Section 5 presents our empirical results, Section 6 concludes.

## 2 The Theoretical Model

The model presented in this section is a condensed version of the model presented in *Zaby* (2010b) which introduces the patenting decision into a model of dynamic vertical product differentiation as proposed by *Dutta et al.* (1995). We focus on the theoretical aspects crucial for our empirical investigation. *Zaby* (2010b) analyzes the patenting decision of a successful inventor and the market entry decisions of the two considered firms in a three stage game. On the first stage the inventor, denoted by subscript  $i$ , chooses the protection method for his discovery. His strategy can either be to protect it by a patent or to keep his invention secret. On the second stage firms choose whether to market a product of low quality or a product of high quality given the inventor’s protection decision. On the third stage firms compete in prices. The game is solved by backward induction. One crucial assumption of the model is the dynamic evolution of product quality.

Following *Dutta et al.* (1995) and *Hoppe, Lehmann-Grube* (2001) *Zaby* assumes that investing more time in research activities suffices to improve the quality of the new technology over time. More precisely, the quality of the invention,  $x$ , increases by one unit in every period without involving any further research costs. Thus, the inventor’s research time is given by

$$t_i(x) = x, \tag{1}$$

implying that the inventor has to invest  $t_i(\bar{x}) = \bar{x}$  periods of time in order to reach a certain quality level  $\bar{x}$ . Thus, the adoption date  $t_i(\bar{x})$  obviously defines the adopted quality level,  $\bar{x}$ . To capture the fact that the inventor has a technological headstart compared to his rival, it is further assumed that at the date of the invention ( $t = 0$ ) he has a technological lead in height of  $\gamma$  which is common knowledge. This means that the non-inventor will have to invest  $\gamma$  periods more than the inventor to reach the same quality level, so that his research time can be specified by  $t_j(x) = x + \gamma$ . Whenever the inventor patents, he loses his lead which means that technically speaking  $\gamma = 0$ .

Regarding the asymmetric research capabilities of the firms in the case of secrecy, a further important aspect is taken into account: the existence of spillover effects. To measure the spillover of information *Zaby* (2010b) introduces the exogenously given spillover parameter  $\lambda$ . Whenever the invention is marketed, the knowledge spillover can be interpreted as the easiness of reverse engineering. Due to the existence of a spillover effect, *Zaby* (2010b) distinguishes the *initial* headstart of the inventor,  $\tilde{\gamma}$ , from his *effective* headstart,  $\gamma$ , where the latter accounts for a positive spillover effect. Whenever the inventor chooses secrecy, the extent of his technological lead at any point in time  $t > 0$  will differ from his *initial* headstart if  $\lambda > 0$ . The extent of the inventor's *effective* technological lead is thus defined by  $\gamma \equiv \tilde{\gamma}(1 - \lambda)$ . Thus the non-inventor profits from the spillover of information as his research time is shortened by  $\lambda\tilde{\gamma}$ . For  $\lambda > 0$  it is given by

$$t_j(x) = x + \tilde{\gamma} - \lambda\tilde{\gamma} = x + \gamma. \quad (2)$$

Proceeding with the theoretical model, we will give a brief outline of the derivation of the subgame perfect Nash equilibrium.

## 2.1 Price Competition

Subsequent to the protection decision on the first stage and the quality decisions of the firms on the second stage of the game, firms compete in prices. The market structures that may prevail in the chosen model setting are either monopolistic or duopolistic.<sup>2</sup> During the temporary monopoly the first adopter earns monopoly profits  $\pi_m$  per period. The entrance of the late adopter changes the market structure to an asymmetric duopoly where the firm offering the lower quality, i.e. the first adopter, earns  $\pi_l$  per period and the firm offering the higher quality, i.e. the late adopter, realizes profits  $\pi_h$  per period, with  $\pi_m > \pi_h > \pi_l$ .

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<sup>2</sup>We omit the explicit derivation of profits (see *Zaby* (2010b) for details).

Moving one stage backwards both firms will make their strategic quality decisions given the inventor's protection decision on the first stage where he either (a) chooses to protect his invention by a patent or (b) chooses to keep his invention secret.

## 2.2 Quality Choices

On the second stage of the game the late adopter  $H$  has to decide when to adopt the new technology after the early adopter  $L$  has already adopted the low quality  $x_l$ . The crucial aspect in deriving the optimum quality choices is the distinction of the respective research time functions of the inventor and the non-inventor in the respective scenarios (i) and (ii). In scenario (i) the inventor  $i$  is the early adopter and his rival, the non-inventor firm  $j$ , is the late adopter. Thus the respective research time functions are  $t_i(x_l^i) = x_l^i$  and  $t_j(x_h^{j*}) = x_l^i + 1/r + \gamma$ .

This changes in scenario (ii) where the non-inventor is the first adopter. Now the research time functions change to  $t_j(x_l^j) = x_l^j + \gamma$  for the non-inventor and  $t_i(x_h^{i*}) = x_l^j + 1/r$  for the inventor as late adopter.

As *Zaby* (2010b) shows, the actual quality choices of the inventor and his rival crucially depend on the inventor's protection decision on the first stage of the game. If he chooses to patent his invention, a given range of quality levels will be protected by the patent with the consequence that the non-inventor can only enter the market with a quality that exceeds the protected range. This positive aspect of the patent is accompanied by the drawback that the inventor loses his technological lead due to the disclosure requirement. If he chooses secrecy he maintains his headstart but misses the benefits of patent protection. Proceeding with the second stage of the game, the subgames *secrecy* and *patent* have to be distinguished.

### ***Subgame "secrecy"***

Whenever the inventor decides to keep his invention secret on the first stage of the game, the strategy space concerning the non-inventor's quality choice is not constrained. *Zaby* (2010b) comes to

**Result 1** *If the inventor chooses to keep his invention secret the subgame secrecy has a preemption equilibrium where the inventor adopts first offering the lower quality and the non-inventor is the late adopter offering the higher quality.*

### ***Subgame "patent"***

If the inventor patents his basic invention on the first stage of the game the non-inventor is deterred from adopting the new technology up to a certain quality level which is characterized by the height of the patent,  $\phi$ .

To avoid confusion henceforth choice variables will carry the superscript  $S$  if the inventor chooses secrecy and the superscript  $P$  if he patents his invention. The inventor has an incentive to patent in every situation where he is not able to adopt his profit maximizing quality level. This is due to the fact that a patent mitigates the threat of entry perceived by the inventor: With a patent a given range of product space is protected from the entry of a rival so that the inventor can postpone his entry long enough to realize a higher product quality. Note though, that this positive effect of patenting is opposed by the negative effect of the required disclosure which may invalidate the positive effect completely.

*Zaby* (2010b) distinguishes three patent types according to their protectional degree: *weakly protective* patents, *strongly protective* patents and *delaying* patents. *Weakly protective* patents have the positive effect of protecting the quality range up to  $\phi$ . *Strongly protective* patents allow the inventor to reach his profit maximizing quality. Both patent types modestly mitigate the threat of entry as they still admit the non-inventor to follow his best differentiation strategy. The strongest protectional degree is reached with *delaying* patents. Additionally to the *protective effect* they affect the differentiation strategy of the non-inventor: he is forced to postpone adoption further into the future so the mitigating effect on the threat of entry is very high.

Given that the inventor patents his invention, *Zaby* (2010b) finds three alternative unique Nash equilibria in the subgame *patent* depending on the strength of protection:<sup>3</sup>

**Result 2** *If the inventor chooses to patent his invention the subgame patent has three alternative unique and stable Nash Equilibria.*

- (i) *With a weakly protective patent the inventor cannot reach his profit maximizing quality while the non-inventor can follow his profit maximizing strategy. The perceived threat of entry is modestly mitigated.*
- (ii) *With a strongly protective patent the inventor adopts his profit maximizing quality while the non-inventor can follow his profit maximizing strategy. The perceived threat of entry is modestly mitigated.*
- (iii) *With a delaying patent the inventor adopts his profit maximizing quality the non-inventor is forced to wait until he reaches the quality  $\phi + \epsilon$ . The perceived threat of entry is strongly mitigated.*

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<sup>3</sup>The stated result corresponds to Proposition 2 in *Zaby* (2010b).

Note that the influence a patent has on the perceived threat of market entry can only be measured indirectly by comparing the early adoption dates the inventor can realize with secrecy or with a patent. From the above result it can be concluded that with strong patents, patenting reduces the threat of entry perceived by the inventor.

Equipped with the results from the analyses of the subgames “secrecy” and “patent” the subgame perfect Nash equilibrium of the three stage game can be derived by comparing the inventor’s alternative payoffs subject to the chosen protection mechanism.

### 2.3 The Patenting Decision

On the first stage of the game the inventor decides whether to patent or to keep his invention secret.

The positive *protective effect* of a patent can be described by the difference between the inventor’s profit with and without a patent, thereby ignoring the *disclosure effect* so that  $\gamma > 0$  continues to hold. By patenting the inventor is able to choose the higher quality  $x_i^P$ , while with secrecy he realizes  $x_i^{i,S}$ , naturally by definition  $x_i^P > x_i^{i,S}$  always holds. This defines

$$\Delta^+ = L_i(x_i^{i,P})|_{\gamma>0} - L_i(x_i^{i,S})|_{\gamma>0} \quad (3)$$

as the positive *protective effect* of patenting. This positive effect is opposed by the negative *disclosure effect*. Due to the disclosure requirement linked to a patent the inventor loses his lead which means that technically speaking the technological headstart of the inventor,  $\gamma$ , becomes zero. Consequently, as the non-inventor is now able to enter at an earlier point in time,  $t_j^P(x) = x$ , instead of  $t_j^S(x) = x + \gamma$ , the duration of the monopoly of the patent holder is narrowed. This negative patent effect can be measured by the difference between the profit of the inventor with and without a technological lead,

$$\Delta^- = L_i(x_i^{i,P})|_{\gamma>0} - L_i(x_i^{i,P})|_{\gamma=0}. \quad (4)$$

Combining the *protective* and the *disclosure effect* yields the overall effect that patenting has on the profit of the inventor,  $\Delta_P = \Delta^+ - \Delta^-$ . Inserting equations (3) and (4) this total patent effect can be derived as

$$\Delta_P = L_i(x_i^{i,P})|_{\gamma=0} - L_i(x_i^{i,S})|_{\gamma>0}. \quad (5)$$

Whenever the total patent effect  $\Delta_P$  is positive, the *protective effect* overcompensates the *disclosure effect* and the inventor has an incentive to patent as this increases his overall profits.

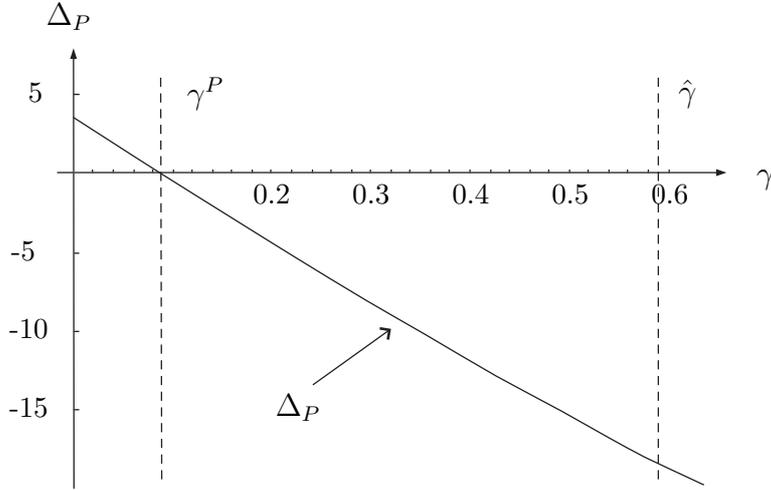


Figure 1: Total patent effect for  $\phi = x_l^{i*}$

Figure 1 is taken from *Zaby* (2010b) and depicts the total patent effect for strongly protective patents. As we can see the total patent effect  $\Delta_P$  takes positive as well as negative values. The intersection point of the  $\Delta_P$ -curve with the x-axis defines a critical value of the technological lead,  $\gamma^P$ . For  $\gamma = \gamma^P$  the *protective effect* and the *disclosure effect* cancel each other out so the total patent effect equals zero. If the technological lead is small,  $\gamma < \gamma^P$ , the *protective effect* dominates the *disclosure effect* and the inventor profits from patenting his basic invention. If the technological lead exceeds the critical value  $\gamma^P$  the *disclosure effect* outweighs the *protective effect* so that the total patent effect is negative and the inventor prefers to keep his invention secret. In *Zaby* (2010b) the unique and stable subgame perfect Nash equilibrium of the considered three stage game is stated in the central Proposition 3, which is summarized in the following result.

**Result 3** *The patenting decision of the inventor crucially depends on the extent of his technological headstart. He will choose to*

- (i) *patent if a preemption equilibrium would prevail with secrecy and his technological lead is small  $\gamma^P \geq \gamma$ ,*
- (ii) *keep his invention secret if a preemption equilibrium would prevail with secrecy and his technological lead is high,  $\gamma^P < \gamma$ .*

Naturally the value of the spillover parameter influences this result. Actually, as Zaby (2010b) shows, an increase of the spillover of information,  $\lambda$ , leads to an increasing propensity to patent as the effective technological lead,  $\gamma = \tilde{\gamma}(1 - \lambda)$ , declines in the absence of patent protection.<sup>4</sup> Thus a firm operating in an industry sector where unintended knowledge spillover are a substantial threat will rather choose to patent than rely on secrecy as even a large initial technological headstart will diminish due to the high value of the parameter  $\lambda$ , i.e. the *protective effect* of the patent will then more likely outweigh the *disclosure effect* as the latter is weakened due to the high value of the spillover parameter. This leads the inventor to patent his invention whenever the unintended spillover of information is high.

Intuitively, intensifying the strength of patent protection should have the same effect of increasing the inventor's propensity to patent.<sup>5</sup>

### 3 Hypotheses and their empirical implementation

Building on these theoretical results we now turn to the empirical investigation of the decision to patent.<sup>6</sup> In a first step we will condense the proposed interdependencies into three hypotheses which we will then test empirically. The formulated hypotheses reflect the twofold effects of patenting. On the one hand patenting may intensify the competitive threat perceived by the inventor through the required disclosure of information (*disclosure effect*), on the other hand patenting may mitigate the competitive threat by its *protective effect*.

Naturally it is not possible to completely disentangle both effects in the real world, so our analysis is to be understood as distinguishing situations in which both effects have an impact, but one overcompensates the other. Our approach can thus be specified as follows: we will first empirically investigate the driving factors behind the impact of the *disclosure effect* on the patenting decision (Hypotheses 1 and 2) and will then examine the theoretically proposed results regarding rival's timing of market entry, i.e. the threat of entry the innovator faces which is driven by the *protective effect* of a patent (Hypothesis 3).

Recall the results on the first stage of the three-stage game: a firm decides to patent if profits generated by the *protective effect* exceed the reduction of profits by the *disclosure effect*, otherwise it is better off appropriating

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<sup>4</sup>See Corollary 1 in Zaby (2010b).

<sup>5</sup>This interdependency is confirmed analytically in Corollary 2, Zaby (2010b).

<sup>6</sup>The empirical analyses presented here in some parts build on chapter 3 of Alexandra Zaby's dissertation, see Zaby (2010a).

the results of its R&D activities by secrecy. Both effects are driven by the three parameters *extent of the technological lead*,  $\gamma$ , *unintended spillover of information*,  $\lambda$ , and *intensity of patent protection*,  $\phi$ .

It is straightforward to assume that the spillover parameter may vary throughout different industry sectors. At the same time there is strong empirical evidence that some industry sectors are characterized by higher patenting rates than others. Take, for example, the industry sector *pharmaceuticals* where the patenting rate is rather high, whereas in an industry sector such as *precision instruments* the patenting rate is found to be rather low (*Arundel et al.* (1995)). Obviously some industry specific differences have to exist, which account for the difference in patenting rates. Providing an explanation for this empirical evidence is a crucial part of our analysis. To achieve this we use the fact that in the theoretical model, the technological headstart of a successful inventor is linked to the industry specific parameter  $\lambda$ , reflecting the unintended spillover of information. Following the argumentation proposed by *Zaby* (2010b), it could be due to differing degrees of knowledge spillover throughout industries that the effectiveness of appropriating the returns from innovation by secrecy varies. Recall that the propensity to patent will be high whenever high knowledge spillover weaken the alternative appropriation strategy “secrecy”. Summarizing the theoretical results concerning the impact of the *disclosure effect* on the patenting decision, we derive the following hypotheses:

**Hypothesis 1** *Whenever the protective effect of mitigating the threat of entry overcompensates the disclosure effect, the inventor chooses to patent. As the impact of the disclosure effect increases with the extent of the technological lead of the inventor while the protective effect remains unchanged, the relationship of the countering effects eventually is reversed. Thus, the higher the technological lead, the lower is the inventor’s propensity to patent.*

**Hypothesis 2** *In industry sectors characterized by unintended knowledge spillover the technological lead is disseminated without patenting. As this weakens the appropriation strategy “secrecy” the propensity to patent is high whenever unintended spillover are high.*

Proceeding, we will implement these hypotheses into one estimation equation. From above we know that the effective technological lead consists of the initial headstart of the inventor which is potentially decreased by an industry-specific spillover effect:

$$\gamma = \tilde{\gamma}(1 - \lambda) = \tilde{\gamma} - \lambda\tilde{\gamma}.$$

As stated in Hypotheses 1 and 2, the decision to patent is mainly driven by the initial headstart and its potential reduction. We thus translate the theoretical result into the following empirical equation:

$$P = \beta_1 + \beta_2 TL + \beta_3 KS + \beta_4 TL * KS + Controls, \quad (6)$$

where  $P$  denotes the patenting decision,  $TL$  the (initial) technological lead and  $KS$  the unintended knowledge spillover. In line with the theoretical findings we conjecture a negative influence of the technological lead ( $TL$ ) and a positive effect of the interaction term of  $TL$  and  $KS$ . As in the theoretical model the spillover of information has no direct effect on the propensity to patent, we expect to find no significant effect of  $KS$  empirically.

The fact that the *disclosure effect's* strength is subject to the technological lead of the inventor allows us to capture the impact of the *disclosure effect* on the propensity to patent indirectly by focussing on the influence of the initial technological lead (and its potential reduction) on the propensity to patent.

This leaves us to analyze the positive effect of patenting. From the theoretical model we know that a strong *protective effect* can overcompensate the negative *disclosure effect* in which case patenting becomes the profit maximizing strategy of an inventor. The strength of the *protective effect* is subject to the extent of protection, i.e. the scope of a patent.

From the theoretical model we can conclude that the *protective effect* mitigates the threat of entry perceived by the patentee. Naturally this effect should be stronger, the higher the level of patent protection is. As we are not able to partially exclude the impact of the *disclosure effect* in our empirical analysis, note that the threat of entry can only decrease whenever the *disclosure effect* is overcompensated by the *protective effect*. Consequently, whenever the perceived threat of market entry is reduced this can be equivalently interpreted as an increase of the inventor's propensity to patent. Thus we propose the following Hypothesis.

**Hypothesis 3** *The threat of entry decreases with the intensity of patent protection, i.e. patent scope. Thus the propensity to patent increases when patent scope increases.*

From Result 2 we know that the threat of entry is weakened with either a *weakly* or a *strongly protective* patent and that the threat of entry is strongly mitigated with a *delaying* patent. This translates into the following empirical model

$$TOE = \beta_1 + \beta_2 TL + \beta_3 KS + \beta_4 TL * KS + \beta_5 DP + \beta_6 SP + \beta_7 WP + Controls,$$

where  $TOE$  is the threat of entry,  $DP$  reflects *delaying* patents,  $SP$  *strongly* and  $WP$  *weakly protective* patents. For a definition of  $TL$  and  $KS$  see the previous equation. The technological lead,  $TL$ , should now have a negative effect on the threat of entry, i.e. the time until a rival firm is able to enter increases with the extent of the technological headstart. The interaction term with knowledge spillover should again reveal a positive effect while the sole effect of  $KS$  should not be significant. In accordance with the theoretical model, a *delaying* patent should have a negative effect on the perceived intensity of the threat of entry, while *strong* and *weak* patents should have a negative or an insignificant effect.

## 4 Data set

The basis for the empirical analysis is the Mannheim Innovation Panel (MIP) of the year 2005. The MIP is an annual survey which is conducted by the Centre for European Economic Research (ZEW) Mannheim. The aim of the survey is to provide a tool to investigate the innovation behavior of German manufacturing and service firms. Regularly – currently every two years – the MIP is the German contribution to the Community Innovation Survey (CIS). Our empirical investigations are based on about 740 firms.

In the year 2005, the survey additionally contained an investigation of firms' perception of their competitive situation. Thus questions regarding the characteristics and the importance of specific competitive factors like price or quality as well as questions concerning the perceived competitive situation were included.

To capture patent scope we merge this data with information provided by the European Patent Office (EPO).<sup>7</sup> By this we condense the EPO data to the firm level. Hence, we now observe firms holding various numbers of *delaying*, *strongly* and/or *weakly protective* patents. We identified only few firms that stated to hold a patent in the MIP survey but had no equivalent entry in the EPO data set. Due to the missing information we dropped these observations.

### 4.1 Sample definition

Recall that some crucial assumptions were made in setting up the theoretical model. Most importantly the world in which the model and its results are valid is one of innovative firms and vertically differentiated products, i.e. the

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<sup>7</sup>The merge was conducted by Thorsten Doherr, ZEW, Mannheim, using a computer assisted matching algorithm on the basis of firm names.

firms compete in quality. Thus, in order to test our hypotheses, we first of all need to restrict our sample to innovative firms, i.e. we exclude firms which did not launch a new product or process within the period 2002 to 2004. Furthermore the fact that the theoretical model is designed for vertically differentiated products, i.e. the competitive situation is characterized by quality competition, has to be taken into account. In the 2005 survey, one question was included which refers to a characterization of the competitive situation on the main product market as perceived by the questioned firm. The firms were asked to rank the following choices according to their importance: quality, price, technological advance, advertisement, product variety, flexibility towards customers. In our sample we keep all observations where firms indicated that quality is the most, second or third most important feature of their competitive situation.

The first part of the empirical analysis deals with the propensity to patent and investigates the question whether it depends on the technological leadership of the inventor (Hypotheses 1 and 2). In the theoretical model, patenting and secrecy are excluding categories: A firm can either patent or keep its R&D results secret. For the empirical implementation, this assumption needs to be treated carefully. In the data set, we find several examples of firms which use both, patenting and secrecy. Hence, we observe that firms may have more than one innovation and that these may be treated differently. In the following we assume that firms which indicate patents as highly important use patenting as their main IP protection strategy, and we ignore all other protection strategies. Furthermore, all firms which use other formal mechanisms like trademarks are dropped even if they indicate that they use secrecy.

## 4.2 Variable definition and descriptive statistics

In the following we will describe how we define the core variables of the two estimations. For reasons of clarity, we do this for both estimations separately. Recall that Hypotheses 1 and 2 deal with the propensity to patent and the disclosure effect and that Hypothesis 3 refers to the theoretical results concerning the strength of patent protection, thereby focussing on the protective effect. We set off with the variable definitions and descriptive statistics for the propensity to patent-estimation.

### *Propensity to patent-estimation*

Let us start with the dependent variable of this estimation. We measure *patenting* as a dummy variable indicating whether an inventor uses patenting to protect his intellectual property. In our data set about 60% of the firms

applied for a patent in the relevant period (see Table 1).

Table 1: Descriptive statistics for propensity to patent-estimation

	Mean	Std. Dev.	Min	Max
<i>patent</i>	0.595	0.491	0	1
<i>technological lead</i>	0.589	0.492	0	1
<i>knowledge spillover</i>	0.684	0.465	0	1
<i>tech. lead * know. spill.</i>	0.382	0.486	0	1
<i>complexity</i>	0.378	0.485	0	1
<i>log(employees)</i>	4.563	1.696	0.693	9.077
<i>human capital</i>	0.267	0.266	0.000	1.000
<i>R&amp;D intensity</i>	0.066	0.130	0.000	1.100
<i>strong competition</i>	0.132	0.339	0	1
<i>medium competition</i>	0.209	0.407	0	1
<i>EU</i>	0.673	0.469	0	1
<i>non_EU</i>	0.491	0.500	0	1
<i>subsidy</i>	0.419	0.494	0	1
<i>customer power</i>	0.303	0.460	0	1
<i>obsolete</i>	0.089	0.285	0	1
<i>tech. change</i>	0.465	0.499	0	1
<i>cooperation</i>	0.453	0.498	0	1
<i>diversification</i>	0.658	0.241	0.003	1.000
<i>east</i>	0.292	0.455	0	1
<i>No. of observations</i>		740		

Next we define the explanatory variables. The central variables of the propensity to patent-estimation are technological leadership and the unintended spillover of information. Both constructs are not straightforward to implement empirically. In MIP 2005, *technological leadership* is defined by the variable temporal headstart over competitors. Hence, we create a dummy variable indicating whether the importance of technological leadership is high. About 60% of all firms state that technological leadership is a substantial characteristic of the competitive environment in their main product market.

The other theoretical concept that has to be transformed into empirical terms is the unintended spillover of information which can also be interpreted as the easiness of reverse engineering. As stated in *Arundel et al. (1995)*, reverse engineering is a characteristic of the industry and not of the firm. We construct a dummy variable which has unit value if a market is characterized by easy-to-substitute products. Hence, we assume that if a firm's most important product is easy to substitute, knowledge spillover prevail in the respective industry and thus reverse engineering is easily possible. In our data set almost 70% of the innovating firms operate in a market where unintended knowledge spillover prevail.

From the theoretical model we know that the technological leadership of a firm may be reduced by unintended knowledge spillover. To implement this fact in our empirical analysis we create an interaction term (*tech. lead \* know. spill.*).

From Table 1 we know that 38% of all innovating firms state that their competitive environment is characterized by a high relevance of technological leadership and at the same time knowledge spillover play an important role. Furthermore, we control for several factors that may influence innovation activities. Firm size is represented by the number of *employees* in the year 2002, *human capital* by the share of employees holding a university degree. Market structure is reflected by two dummy variables indicating whether the number of main competitors lies between 6 and 15 (*medium competition*) or exceeds 15 (*strong competition*). Finally, we describe the competitive situation with respect to the geographical dimension of the product market. We control for two world regions, *EU* and *non-EU* countries. Germany is considered separately as it serves as reference category in the regression. Thus it is not contained in the variable *EU*. *Customer power* refers to the fact that the share of sales by the three most important customers exceeds 50% of total sales.

In order to capture the fact that large investments in R&D may lead to a higher innovative output and thus may positively influence the propensity to patent, we control for *R&D intensity* defined as expenditures for in-house R&D activities per sales. If firms cooperate with others, e.g. competitors, customers and universities in conducting R&D this may influence their IP protection strategy. Therefore we include a dummy variable reflecting whether research *cooperations* take place. We also control for public R&D *subsidies* by either regional, national or European authorities.

The life cycle of a firm's products may also have an impact on the firm's use of patents as IP protection method, therefore we include an indicator whether a product becomes *obsolete* quickly. As the fact that a rapid change of production or service generating technologies may play an important role concerning the decision to patent and the perceived threat of market entry,

the respective indicator *tech. change* is included as control variable. Furthermore we control for the individual *complexity* of product design.<sup>8</sup> Additionally a firm's degree of *diversification* might be another impact factor in the propensity to patent-estimation so that we use a measure reflecting the share of sales originating from a firm's top-selling product or service. In order to capture regional and sectoral differences we include an indicator whether the firm is located in Eastern Germany (*east*) and define 11 *industry dummies*.

#### *Threat of entry-estimation*

Again let us start with the dependent variable of this estimation. To capture the *threat of entry* (TOE) as perceived by the inventor, we refer to a firm's statement whether its market position is threatened by the entry of new rivals, which is ranked on a 4-digit Likert scale.<sup>9</sup> This ordered variable is our indicator showing to what extent the *protective effect* of a patent influences the threat of market entry perceived by the inventor. We thereby assume that firms rank the *threat of entry* higher, the earlier they conjecture a rival to enter. Thus, if a firm expects that the time until a rival enters is rather short, it should rank the variable *threat of entry* higher than in a case where it assumes that the rival's market entry takes place at a relatively late point in time.

For the investigation of the influence of the *protective effect* on the threat of entry (Hypothesis 3), we need to include patent scope in the data set. As the observation period 2002-2004 of our data is too recent to work with the common measure of patent citations we follow *Lerner* (1994) and refer to the International Patent Classification (IPC) codes to capture patent scope. Every patent is assigned at least one IPC code by a patent office official. The classification codes relate a patent into specific technology clusters which vary in their aggregational level, see the following table.

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<sup>8</sup>Note that we need to distinguish individual complexity and industry-specific complexity which can be described by the substitutability of products in the respective competitive environment of a firm.

<sup>9</sup>Respondents could choose between *fully applies*, *rather applies*, *hardly applies* and *does not apply*.

Table 2: International Patent Classification (IPC)  
Code of the European Patent Office

Section	Class	Subclass	Group	
			Main Group	Subgroup
A	01	B	33/0	33/08

*Lerner* (1994) argues that patent scope can be captured by a variation of the first four digits of the IPC codes assigned to a patent (see also *Austin* (1993)). He uses alternative approaches to validate this implementation. His argumentation mainly builds on a regression of the number of patent citations on the number of variations in the assigned IPC codes. Furthermore *Lerner* conducts interviews with 12 intellectual property attorneys. All validation procedures reveal that patent scope can be appropriately implemented by variations in the IPC codes.

To transfer the specific notions of patent scope from the underlying theoretical model into our empirical analysis we build on *Lerner*'s approach. For the empirical definition of *weakly*, *strongly protective* and *delaying* patents we need a more detailed differentiation than that proposed in *Lerner* (1994). In order to capture the different levels of patent scope we distinguish between variations of IPC codes at the class, the subclass or the group level.<sup>10</sup> The IPC Guide gives a quite clear statement on the relation between the IPC code and the scope of the respective patent.

In line with the IPC Guide (§68), since “*the class title gives an overall indication of the subject matter covered by its subclasses*” and as variations at the sectional level (including subsections), only “*very loosely indicate the scope*” of the respective patent, we define the alternative patent scopes *weakly protective*, *strongly protective* and *delaying* patents starting with variations at the class level. Thus we implement the alternative patent scopes from our theoretical model as follows: Whenever a classification symbol differs on the level of classes or subclasses, we characterize the respective patent as *delaying*. We define a patent as *strongly protective*, if the IPC codes vary in groups and as *weakly protective*, if the IPC codes differ in subgroups. Additionally all patents with a single IPC code are classified as *weakly protective* patents.

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<sup>10</sup>To examine whether this distinction of variations in the IPC codes is an appropriate measure for patent scope we use the regression-based robustness check implemented by *Lerner* (1994). We use patent data from 1995 and its citations up to 2005 to escape the problem of recentness. Our Poisson regressions reveal two significant effects: A strongly positive effect of our *delaying* patent indicator and a negative effect for the indicator of *weakly protective* patents.

Following this implementation of patent scope, in our data 16% of the firms hold at least one delaying patent, while only 10% hold a strong, and 18% a weak patent. Note that it is possible that a firm holds various patents belonging to different categories.

Again we control for several factors that may influence our dependent variables. Most of the control variables coincide with those of the propensity to patent-estimation. In the following we thus only refer to the variables which we additionally included in the threat of entry-estimation.

In order to capture whether a market is characterized by certain market entry barriers – a crucial factor when considering the threat of market entry – we additionally control for *capital intensity* defined as tangible assets per employee. Further, the intensity of the *threat of entry* may be strongly influenced by the fact that a product is *new* to the market. Therefore we include a dummy variable reflecting whether the responding firm has introduced such a product in the relevant time period. The estimation of the threat of entry further incorporates a control variable for the use of *secrecy* as an IP appropriation mechanism. As secrecy may provide the same protection as a patent without the drawback of mandatory disclosure, choosing this protection strategy may have a relevant impact on our dependent variable *threat of entry*.

## 5 Empirical results

Again, for reasons of clarity we present the results from both estimations successively.

### *Propensity to patent-estimation*

To test Hypotheses 1 and 2 which refer to the driving factors behind firms' patenting behavior, we estimate a probit model. We calculate the marginal effects evaluated at the sample means and obtain the standard errors by using the delta method. The calculation of the marginal effect of the interaction term is based on  $A_i$ , *Norton* (2003). All results of the propensity to patent-estimation are displayed in Table 3.

According to the theoretical results proposed in *Zaby* (2010b) one driving factor behind the propensity to patent is the technological lead of the inventor. Recall its analytical definition as  $\gamma = \tilde{\gamma} - \lambda\tilde{\gamma}$ . Building on this definition where  $\lambda$ , the unintended spillover of information, only appears as a multiplier of the technological headstart,  $\lambda\tilde{\gamma}$ , we only included the effect of  $\lambda$  in an interaction term with the technological headstart. For a correct empirical implementation of our theoretical model our estimation equation

nevertheless needs to contain the sole effect of  $\lambda$  which is implemented by the variable  $KS$ . Actually we find an insignificant effect of  $KS$ , so that our theoretical model is confirmed.

As a central result *Zaby* (2010b) comes to the conclusion that the patenting behavior is negatively influenced by an increase of the technological lead of the innovator. This is stated in Hypothesis 1. In line with the theoretical conjecture our empirical results correctly display a negative sign of the respective marginal effect, but it turns out to be insignificant. At first sight this is an unsatisfactory result as the insignificance means that whether there is a technological lead or not does not influence firms' patenting propensity if the industry is characterized by the absence of unintended knowledge spillover. Nevertheless, it should be pointed out that the theoretical model disregards several mandatory patentability requirements, e.g. a sufficiently high inventive step. Thus, while the model predicts that the propensity to patent is high whenever the technological lead is small, it actually may be the case that the respective extent of the technological headstart leading to a patent in theoretical terms, is de facto not eligible for patent protection as it does not incorporate a sufficient inventive step. Consequently, we ascribe the insignificance of the marginal effect of technological lead to the fact that the theoretical model disregards patentability requirements.

The other central result of *Zaby* (2010b) is that in industries, which are characterized by high knowledge spillover, the technological lead is reduced so that the propensity to patent is high (see Hypothesis 2). We implemented this effect empirically by the interaction term of technological lead and knowledge spillover. Our empirical findings confirm this theoretical result.

Turning to our control variables we can state that our results are in line with the stylized facts that the patenting behavior of firms is positively influenced by the size of a firm, its R&D intensity, by R&D subsidies as well as by the engagement of a firm in R&D cooperations. Interestingly, the control variables reflecting the strength of competition with respect to competitors, customers and regional dimensions are mainly insignificant for the patenting decision. One exception is a significantly positive effect for *non\_EU*. A possible explanation for this result is that firms which are inter alia active in non-EU markets tend to rate protection in their home-market as more important than firms operating solely in the German home-market. This effect may prevail due to the fact that those firms fear the entry of foreign firms with substitute products. Further we find that R&D cooperation has a positive significant effect on the propensity to patent whereas being located in Eastern Germany has a negative impact.

Generally empirical evidence based on firm-level surveys finds that the propensity to patent varies by industry sectors. Our industry dummies are jointly

significant hinting at structural differences between industry sectors. However, due to the fact that we explicitly include the main factors driving these differences in our estimation, e.g. knowledge spillover, complexity, technological change, we are not able to confirm significant differences between sectors.

Table 3: Results of the propensity to patent–estimation

	Marginal Effect	Standard Error
<i>technological lead</i>	-0.012	0.040
<i>knowledge spillover</i>	0.006	0.043
<i>tech. lead * know. spill.</i>	0.143*	0.085
<i>complexity</i>	-0.060	0.041
<i>log(employees)</i>	0.081***	0.015
<i>human capital</i>	0.128	0.109
<i>R&amp;D intensity</i>	0.781***	0.219
<i>strong competition</i>	-0.042	0.061
<i>medium competition</i>	-0.021	0.049
<i>EU</i>	0.030	0.050
<i>non_EU</i>	0.112**	0.045
<i>subsidy</i>	0.102**	0.050
<i>customer power</i>	-0.070	0.046
<i>obsolete</i>	0.000	0.072
<i>tech. change</i>	-0.042	0.041
<i>cooperation</i>	0.099**	0.047
<i>diversification</i>	-0.138	0.088
<i>east</i>	-0.110**	0.049
<i>industry dummies</i>	<i>included</i>	
<i>Log likelihood</i>	-382.08	
<i>McFadden's adjusted R<sup>2</sup></i>	0.235	
$\chi^2(all)$	235.05***	
$\chi^2(ind)$	42.33***	
<i>Number of observations</i>	740	

\*\*\* (\*\*, \*) indicate significance of 1 % (5 %, 10 %) respectively.

This table depicts marginal effects of a probit estimation regarding the determinants of the patenting decision. Marginal effects are calculated at the sample means and those of the interaction terms are obtained according to *Ai, Norton (2003)*. Standard errors are calculated with the delta method.

$\chi^2(all)$  displays a test on the joint significance of all variables.

$\chi^2(ind)$  displays a test on the joint significance of the industry dummies.

*Threat of entry-estimation* After the discussion of the driving factors behind the impact of the *disclosure effect* on the patenting decision (Hypotheses 1 and 2) we now turn to the investigation of the positive effect of patenting, the *protective effect* (Hypothesis 3). It relates to the theoretical finding that the propensity to patent increases with the intensity of patent protection, i.e. patent scope. As mentioned earlier we empirically implement this *protective effect* by estimating the effects of patent scope on the perceived *threat of market entry*.

We empirically implement the *threat of market entry* by using firms' statement on the importance of the threat of market entry by potential rivals. As this perceived threat of entry is measured on a four-point Likert scale we estimate an ordered probit model. Marginal effects are calculated at the sample means and standard errors using the delta method. For the calculation of the interaction effect we rely on *Mallick* (2009). The results are summarized in Table 4.

Regarding Hypothesis 3 the predictions of the theoretical model are confirmed by the empirical findings. To test the hypothesis we implemented three alternative measures for the intensity of patent protection. We find that the strongest level of protection, i.e. a *delaying* patent, has a significant negative effect on the threat of entry while lower intensities of patent protection, i.e. *weakly* and *strongly* protective patents, reveal no significant effect. Recall from our presentation of *Zaby* (2010b) that a *delaying* patent forces the patentee's rival to postpone his market entry beyond his optimum entry date, while *weakly* and *strongly* protective patents only slightly reduce the threat of entry as they still admit the rival to choose his first best entry date. Our empirical findings thus strongly support the theoretically proposed interdependency between the strength of patent protection and the perceived threat of market entry.

Additionally we find that for firms which operate in markets which are characterized by the absence of a technological lead, unintended spillover of information have a significantly positive effect on the perceived threat of market entry. This quite intuitive result confirms our earlier findings: If a firm's technological lead is small, unintended spillover of information emphasize the positive effect of patenting, while the negative effect – due to the absence of a technological lead – is small. Regarding the perceived threat of market entry, we find that high knowledge spillover intensify the competitive threat – which again makes patenting more attractive as it relaxes the threat of entry.

Concerning our control variables we find that firms' capital intensity, which can be interpreted as a barrier to market entry for competitors, has a negative significant effect on the threat of entry while the control variables reflecting

the number of competitors operating in a market show positive significant effects. This finding opposes the common conjecture that more intensive competition in a market decreases the intensity of the threat of entry an incumbent firm perceives. Our interpretation of this result is that the number of competitors operating in a market implicitly reflects a high demand potential. More competitors in the market may be an indicator for the fact that the market has the capability of absorbing even more firms. Furthermore it could also be an indicator for a market with low entry barriers. Naturally, whenever market entry barriers are low, firms perceive a high threat of further market entry.

In line with economic intuition the empirical results state that if services or products become obsolete quickly or production technologies change rapidly this has a positive significant effect on the intensity of the threat of entry. Further our estimation results show that the lower the level of diversification in a firm is, the higher this firm rates the intensity of the market entry threat.

Table 4: Ordered Probit for Threat of Entry Estimation

<b>threat</b>	<b>strong</b>	<b>medium</b>	<b>weak</b>	<b>no</b>
	<b>Marg. Eff. (Std. Err.)</b>	<b>Marg. Eff. (Std. Err.)</b>	<b>Marg. Eff. (Std. Err.)</b>	<b>Marg. Eff. (Std. Err.)</b>
<i>technological lead</i>	0.020 (0.016)	0.028 (0.022)	-0.029 (0.024)	-0.019 (0.015)
<i>knowledge spillover</i>	0.039** (0.015)	0.061*** (0.021)	-0.056** (0.022)	-0.043** (0.017)
<i>tech. lead * know. spill.</i>	0.009 (0.026)	0.000 (0.041)	-0.014 (0.037)	0.006 (0.031)
<i>delaying</i>	-0.040** (0.018)	-0.067* (0.036)	0.057** (0.025)	0.050 (0.031)
<i>strong</i>	-0.019 (0.023)	-0.029 (0.039)	0.027 (0.033)	0.021 (0.030)
<i>weak</i>	0.011 (0.024)	0.016 (0.031)	-0.017 (0.035)	-0.010 (0.020)
<i>complexity</i>	0.021 (0.017)	0.028 (0.022)	-0.030 (0.025)	-0.018 (0.015)
<i>secrecy</i>	-0.022 (0.016)	-0.031 (0.023)	0.032 (0.024)	0.021 (0.016)
<i>log(employees)</i>	0.005 (0.004)	0.007 (0.007)	-0.007 (0.006)	-0.005 (0.005)

Table continued on the next page

threat	strong	medium	weak	no
	Marg. Eff. (Std. Err.)	Marg. Eff. (Std. Err.)	Marg. Eff. (Std. Err.)	Marg. Eff. (Std. Err.)
<i>R&amp;D intensity</i>	0.026 (0.025)	0.036 (0.035)	-0.037 (0.036)	-0.025 (0.024)
<i>capital intensity</i>	-0.047** (0.022)	-0.066** (0.031)	0.068** (0.033)	0.045** (0.022)
<i>strong competition</i>	0.060** (0.025)	0.069*** (0.022)	-0.086*** (0.033)	-0.044*** (0.015)
<i>medium competition</i>	0.046** (0.022)	0.057*** (0.021)	-0.067** (0.030)	-0.037*** (0.014)
<i>new to market</i>	-0.019 (0.015)	-0.027 (0.021)	0.028 (0.021)	0.019 (0.015)
<i>subsidy</i>	0.012 (0.017)	0.016 (0.022)	-0.017 (0.024)	-0.011 (0.015)
<i>obsolete</i>	0.051* (0.031)	0.058** (0.029)	-0.072* (0.042)	-0.036** (0.018)
<i>tech. change</i>	0.034** (0.015)	0.047** (0.020)	-0.049** (0.022)	-0.032** (0.015)
<i>diversification</i>	0.063** (0.028)	0.089** (0.042)	-0.092** (0.041)	-0.060** (0.031)
<i>east</i>	-0.029 (0.015)	-0.029 (0.022)	0.029 (0.022)	0.020 (0.016)
<i>industry dummies</i>	<i>included</i>	<i>included</i>	<i>included</i>	<i>included</i>
<i>Log likelihood</i>		-417.94		
<i>McFadden's adjusted R<sup>2</sup></i>		0.037		
$\chi^2(all)$		65.21***		
$\chi^2(ind)$		8.72		
<i>Number of observations</i>		748		

\*\*\* (\*\*, \*) indicate significance of 1 % (5 %, 10 %) respectively.

This table depicts marginal effects for an ordered probit of the estimation of threat of entry. Marginal effects are calculated at the sample means and those of the interaction terms are obtained according to Mallick (2009). Standard errors are calculated with the delta method.

$\chi^2(all)$  displays a test on the joint significance of all variables.

$\chi^2(ind)$  displays a test on the joint significance of the industry dummies.

## 6 Conclusion

This paper provides a thorough empirical analysis of the decision to patent where the impact of a patent is divided into a positive *protective* and a negative *disclosure effect*. Our empirical approach is substantiated by the theoretical results and predictions obtained by *Zaby* (2010b). We condensed her theoretical results into three hypotheses reflecting the twofold effects of patenting. Hypotheses 1 and 2 refer to the *disclosure effect*, Hypothesis 3 to the *protective effect*. The underlying model came to the conclusion that while patenting on the one hand intensifies the competitive threat perceived by the inventor due to the mandatory disclosure requirement, on the other hand it mitigates the competitive threat by its *protective effect*. In the end the predominant effect overcompensates the other and thus determines the decision to patent.

We set off our empirical analysis with the investigation of the *disclosure effect*. Hypothesis 1 proposed that the higher the technological lead of an inventor, the lower is his propensity to patent. Hypothesis 2 stated that if unintended knowledge spillover prevail in an industry, the technological lead is reduced so that patenting becomes more attractive, i.e. the propensity to patent increases. To test these hypotheses we implemented an interaction term of technological lead and knowledge spillover. We could not find empirical evidence supporting Hypothesis 1, while Hypothesis 2 could be confirmed due to the fact that the effect of the interaction term is found to be positive and significant.

The second part of our empirical investigation aimed at analyzing the *protective effect* of patenting. Here we used the perceived *threat of market entry* as dependent variable. Our estimation provides evidence that the threat of market entry decreases with the intensity of patent protection, a result of the theoretical model formulated in Hypothesis 3. To implement the differences in patent scope empirically we built on previous work by *Lerner* (1994) and used the variations of IPC codes as a measure for the intensity of patent protection. The empirical results reveal that the broader the scope of a patent is, the lower is the competitive threat perceived by the innovator as the market entry by rivals is postponed.

Aside from the advancement of *Lerner's* measure for patent scope our main contribution is the containment of a stylized fact: we find that the common economic intuition that the propensity to patent is higher, the greater the technological advance an innovation embodies, actually only holds in industry sectors with high unintended knowledge spillover. Thus the theoretical finding by *Zaby* (2010b), namely that the propensity to patent decreases, the

higher the technological lead of an innovator is, does not contradict common intuition but constrains its validity to industry sectors where high unintended knowledge spillover prevail.

## References

- Ai, C., Norton, E. C. (2003): Interaction Terms in Logit and Probit Models. *Economics Letters* 80, 123–129.
- Anton, J. J., Yao, D. A. (2004): Little Patents and Big Secrets: Managing Intellectual Property. *RAND Journal of Economics* 35, 1–22.
- Arundel, A. (2001): The Relative Effectiveness of Patents and Secrecy for Appropriation. *Research Policy* 30, 611–624.
- Arundel, A., Kabla, I. (1998): What Percentage of Innovations are Patented? Empirical Estimates for European Firms. *Research Policy* 27, 127–141.
- Arundel, A., van de Paal, G., Soete, L. (1995): *Innovation Strategies of Europe's Largest Industrial Firms. Results of the PACE Survey for Information Sources, Public Research, Protection of Innovations and Government Programmes*. Final Report, MERIT, PACE Report, Brussels.
- Austin, D. H. (1993): An event-study approach to measuring innovative output: The case of biotechnology. *American Economic Review Papers and Proceedings* 83, 253–258.
- Cohen, W., Nelson, R., Walsh, J. (2000): Protecting Their Intellectual Assets: Appropriability Conditions and Why U. S. Manufacturing Firms Patent (or Not). *NBER working paper* 7552.
- Dutta, P., Lach, S., Rustichini, A. (1995): Better Late Than Early: Vertical Differentiation in the Adoption of a New Technology. *Journal of Economics & Management Strategy* 4, 563–589.
- Hoppe, H., Lehmann-Grube, U. (2001): Second-Mover Advantages in Dynamic Quality Competition. *Journal of Economics & Management Strategy* 10, 419–433.
- Horstmann, I., MacDonald, G. M., Slivinsky, A. (1985): Patents as Information Transfer Mechanisms: to Patent or (maybe) not to Patent. *Journal of Political Economy* 93, 837–858.
- Hussinger, K. (2006): Is Silence Golden? Patents versus Secrecy at the Firm Level. *Economics of Innovation and New Technology* 15, 735–752.
- König, H., Licht, G. (1995): Patents, R&D and Innovation: Evidence from the Mannheim Innovation Panel. *Ifo-Studien* 33, 521–543.

- Lerner, J. (1994): The importance of patent scope: An empirical analysis. *RAND Journal of Economics* 25, 319–333.
- Mallick, D. (2009): Marginal and Interaction Effects in Ordered Response Models. MPRA paper No. 13325, available at <http://mpra.ub.uni-muenchen.de/13325>.
- Zaby, A. K. (2010a): *The decision to patent*. Springer Heidelberg.
- Zaby, A. K. (2010b): Losing the Lead: The Patenting Decision in the Light of the Disclosure Requirement. *Economics of Innovation and New Technology* 19, 147–164.