Discussion Paper No. 12-089

Innovation Strategies of German Firms: The Effect of Competition and Intellectual Property Protection

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Non-Technical Summary

According to the Schumpeterian view, intellectual property (IP) protection policy and antitrust policy might affect firms' incentives to innovate in opposite directions. The former policy gives monopoly rights to innovators, thus, increasing incremental profits from innovation. The latter policy suppresses firms' market power decreasing incremental profits from innovation. This article contributes to understanding the interaction of IP protection policy and antitrust policy for stimulating firms' innovation. It takes into account that firms' innovation strategies can differ. Concretely, firms can choose whether to engage into imitative innovation improving already existing products or more radical innovation introducing market novelties.

Using a sample of 1253 German firms from manufacturing and services sectors. I analyze the impact of both the effectiveness of IP protection and competitive pressure on firms' innovation strategy choices. Three innovation strategies are considered: to abstain from innovation, to introduce products that are known in the market but new to the firm (imitation) or to introduce market novelties (innovation). I find that the effectiveness of patent protection perceived by firms positively affects firms' innovativeness, i.e. propensity of imitation and innovation. Having a small and a medium number of competitors also positively affects firms' innovativeness. However, this effect depends on the perceived effectiveness of patent protection. If the perceived effectiveness of patent protection is low or medium, both innovation and imitation are enhanced, whereas if it is high, only innovation is enhanced.

The results suggest that the two policies, IP protection policy and antitrust policy, can reinforce each other in promoting innovation. For instance, in markets with few competitors an increase in patent protection effectiveness perceived by firms might rather increase firms' incentives to introduce market novelties. By contrast, in markets where firms have almost monopoly power an increase in patent protection effectiveness might rather promote the introduction of improved products. Despite the common patent system in all industries the perceived effectiveness of IP protection by firms can be affected, for instance, through the courts' interpretation of novelty and non-obviousness.

Das Wichtigste in Kürze

Patenschutz und Wettbewerbspolitik können sich auf unterschiedliche Weise auf unternehmerische Anreize zu innovieren auswirken. Patentschutz stärkt die Marktmacht von Innovatoren, während Wettbewerbspolitik diese schwächt. Dieser Artikel zeigt, wie Patentschutz und Wettbewerbspolitik das Innovationsverhalten von Unternehmen beeinflussen können und wie sie dabei interagieren.

Anhand einer Stichprobe von 1253 deutschen Unternehmen aus Industrie- und Dienstleistungssektoren wird der Einfluss von Patentschutz und Wettbewerbspolitik auf die Innovationsstrategien der Unternehmen untersucht. Dabei werden drei Innovationsstrategien betrachtet: der Verzicht auf Innovationen, die Einführung von Produkten, die am Markt bekannt, aber für das Unternehmen neu sind (Imitation) und die Einführung von Marktneuheiten (Innovation).

Es zeigt sich, dass sich die von den Unternehmen wahrgenommene Wirksamkeit des Patentschutzes positiv auf die Innovationskraft, d.h. auf die Wahrscheinlichkeit zu imitieren oder zu innovieren auswirkt. Eine kleine oder mittlere Anzahl von Wettbewerbern kann sich ebenfalls positiv auf die Innovationsaktivität der Unternehmen auswirken. Dieser Effekt hängt jedoch wiederum von der von den Unternehmen wahrgenommenen Effektivität des Patentschutzes ab. Bei einer niedrigen bis mittleren Effektivität des Patentschutzes werden Imitation und Innovation begünstigt. Eine hohe Effektivität des Patentschutzes hingegen begünstigt nur Innovationen.

Diese Erkenntnisse zeigen, dass sich der Schutz des intellektuellen Eigentums und die Wettbewerbspolitik bei der Begünstigung von Innovationen gegenseitig verstärken können. Zum Beispiel kann in Märkten mit wenigen Wettbewerbern eine Erhöhung der Patentschutz-Effektivität die unternehmerischen Anreize erhöhen Marktneuheiten einzuführen. In Märkten, in denen Firmen fast eine Monopolstellung haben, kann ein Anstieg der Patentschutz-Effektivität die Einführung verbesserter Produkte fördern. Trotz des gemeinsamen Patentschutzsystems in allen Branchen, kann die von den Unternehmen wahrgenommene Effektivität des Patentschutzes zum Beispiel durch gerichtliche Interpretation von Neuheit oder Nicht-Offensichtlichkeit variieren.

Innovation strategies of German firms: the effect of competition and intellectual property protection

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December, 2012

Abstract

This article analyzes how the perceived effectiveness of intellectual property protection and competitive pressure affect firms' innovation strategy choices, concretely, whether to abstain from innovation, to introduce products that are known in the market but new to the firm (imitation) or to introduce market novelties (innovation). Using a sample of 1253 German firms from manufacturing and services sectors I show that the perceived effectiveness of patent protection positively affects firms' propensity to imitate and to innovate. Having a small or a medium number of competitors positively affects firms' propensity to imitate and to innovate as compared to being a monopolist or having a large number of competitors. However, this effect varies with the perceived patent protection effectiveness. If the perceived patent protection effectiveness is low or medium, both innovation and imitation are enhanced, whereas if it is high, only innovation is enhanced.

JEL-Classification: C35, L13, O31, O34.

Keywords: Innovation; imitation; competitive pressure; intellectual property protection.

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†An earlier version of this paper has been presented at the XXVI edition of "Jornadas de Economía Industrial" (Spain) and Competition and Innovation Summer School (Turkey). I am very grateful to the participants of these meetings and especially to Reinhilde Veugelers, Cedric Schneider and Bettina Peters for their comments and suggestions. I also acknowledge data support from ZEW Mannheim and financial support from the Spanish "Ministerio de Ciencia e Innovación" under project ECO2010-17113.

1 Introduction

In the recent economic literature the impact of market structure on firms' innovativeness has received much attention. In particular, there are two major debates regarding the impact of intellectual property (IP) protection and competitive pressure. The first debate discusses the impact of IP protection on firm innovative performance. In line with it, two confronting views are present. According to the first view, IP protection is a necessary mechanism that provides incentives for firms to engage in R&D and encourages a technology transfer between firms. Therefore, the strong protection of intellectual property rights, for instance, broad and long patents, would be the optimal R&D policy (Arora and Gambardella, 1994; Gans and Stern, 2003; Gans et al., 2008; Boldrin and Levine, 2008). However, this view has recently been challenged by Aghion et al. (2001), Bessen and Maskin (2009) and Zhou (2009), who show that a higher level of spillovers can induce imitation and, thus, foster innovative efforts by incumbent firms. Therefore, the patent protection can block the future development of technologies. The second debate concerns the effect of a competitive pressure on the firm innovation. Some studies suggest a monotonic relationship between the competitive pressure and firm R&D expenditures, positive (Dasgupta and Stiglitz, 1980; Geroski, 1990; Blundell et al., 1999; Correa, 2012) or negative (Henderson and Cockburn, 1996; Zhou, 2009) , whereas others propose a non-monotonic inverted U-shaped (Aghion et al., 2005) or U–shaped relationship (Tishler and Milstein, 2009).

One of possible reasons for such contradictory findings is that most of the above mentioned studies assume that firms' innovation strategies are homogeneous meaning that all firms invest in R&D and innovate symmetrically. However, empirical evidence suggests that most markets are characterized by heterogeneous innovation activities within as well as across markets. This heterogeneity arises as the result of firms' decisions to engage in R&D or to abstain from own R&D and imitate the outcomes of innovators. Furthermore, policy interventions, such as competition policy or intellectual property protection, might affect firms' innovation strategies and, consequently, the outcomes of firm innovation. A theoretical study by Aghion et al (2001) suggests the existence of a potential complementarity between competition (antitrust) policy and patent policy. It shows that, in the presence of imitation, an increase in competition is always positive for innovation incentives of firms. At the same time, for any given level of competition a little imitation is innovation-enhancing, whereas too much imitation discourages innovation incentives. However, this study assumes exogenously innovating and imitating firms, although in reality firms can switch from imitative to innovative strategy choosing the potentially most profitable strategy. Therefore, potential complementarities in the effect of both factors, intellectual property protection effectiveness and competitive pressure, on firm innovation strategies choice should be analyzed.

The present study is novel in two ways. First, it empirically analyzes firms' innovation strategy choices. The dependent variable represents a firm's innovation strategy choice among the following alternatives: to abstain from innovation, to introduce improved products (imitation) and to introduce market novelties (innovation). Therefore, a discrete choice model (stereotype logit) is employed. Second, it includes explanatory variables that were not considered together in previous studies. These are internal firm characteristics (firm size, human capital quality, capital and export intensity and the geographical scope of the market) and external factors, concretely, the perceived effectiveness of IP protection by patents and trademarks, competitive pressure measured by the number of main competitors and relative profit differences. The effectiveness of legal mechanisms for IP protection is measured as the scores of the success of legal protection mechanisms for innovations and inventions (patents and trademarks) reported by firms and averaged at an industry level.

The results suggest that firms' innovation strategy choices are tightly related to internal firm characteristics and external market factors. A larger firm size and more skilled human capital are positively associated with a firm's propensity to improve existing products (imitation) and to introduce market novelties (innovation), although the latter effect is higher in magnitude than the former. Geographical market size, namely, having access to European and worldwide markets is strongly positively associated to a firm's propensity to imitation and innovation. Regarding external factors, the results suggest that the perceived effectiveness of patent protection positively affects innovation and imitation for any level of competition. Its positive impact on innovation has a U-inverted shape decreasing when the number of competitors is high. The number of competitors has a U-inverted relationship with firms' propensities for imitation and innovation. Specifically, an increase in competitive pressure from 0 to few competitors (from 1 to 5 and from 6 to 15) and a decrease in competitive pressure from many (more than 15) to few competitors positively affect the propensity of firms to improve already existing products and to introduce market novelties. This effect varies with the perceived patent protection effectiveness. If the perceived patent protection effectiveness is low or medium, both innovation and imitation are enhanced, whereas if it is high, only innovation is enhanced. The indicator of relative profit differences suggests that a decrease in competitive pressure negatively affects both imitation and innovation. This effect weakly decreases for imitation and becomes insignificant for innovation when IP protection effectiveness perceived by firms increases.

The findings of this study suggest to look beyond overall R&D expenditures in the analysis of innovative performance in the markets because firms might choose different innovation strategies, and their choices in turn affect overall innovative performance in industries. Additionally, the present analysis derives a link between IP protection policy and competition policy. The two policies are usually considered to be substitutes because the former gives to a firm the market power over intellectual property whereas the latter is aimed at reducing the market power. However, these two policies can reinforce each other in promoting innovation. For instance, in markets with few competitors better patent protection might positively affect firms' incentives to introduce market novelties. On the contrary, in markets where firms have almost monopoly power an increase in patent protection can promote an introduction of improved products, i.e. incremental innovation, rather than the introduction of market novelties, i.e. radical innovation.

The rest of the article is organized as follows. Section 2 presents a relevant discussion in the literature. Section 3 describes the data for the empirical analysis and derives hypotheses to be tested. The econometric methodology is presented in Section 4. Section 5 discusses the results. Finally, Section 6 derives some policy implications and concludes.

2 Background discussion

This article is related to a large literature on the relationship between market structure and innovation strategy. Since it focuses on the effect of competitive pressure and intellectual property protection on firms' innovation strategies, it is related to two strands. The first strand analyzes how firms' R&D investments are affected by market competition. Pioneer works in this field are those of Schumpeter (1934 and 1942) who argues that, on the one hand, market pressure may foster firms' innovation, but, on the other hand, it may decrease firms' R&D investments because monopoly power of larger firms acts as a major accelerator of technological progress. Actually, there is still no accordance on the Schumpeterian debate in theoretical and empirical studies. For example, some authors argue that more intensive market competition decreases firms' incentives for innovation because when advantages from innovation are temporary, only sufficient market power guarantees that firms invest in R&D (Arrow, 1962; Futia, 1980; Gilbert and Newbery, 1982; Reinganum, 1983; or Zhou, 2009). This argument is supported by empirical studies, which find that market concentration increases the pace of innovative change. For instance, Henderson and Cockburn (1996) show that large firms in the US pharmaceutical industry perform R&D more efficiently, as they can enjoy scale and scope economies. On the other hand, market concentration is also argued to have a dampening effect on innovation because more intensive competition acts as an important incentive for firms to innovate (Dasgupta & Stiglitz, 1980). Again, these theoretical arguments are supported by empirical evidence (Geroski, 1990; Blundell et al., 1999).

These contradictory results led to the hypothesis that the effect of market competition on firms' innovative efforts is non-monotonic. For example, Boone (2000) finds that when competition is weak, the incentives to innovate increase for less efficient firms. When competition becomes more intense, however, the incentives to innovate increase for more efficient firms. Aghion et al. (2005) suggest the existence of an inverted-U relationship. Both, a low or high level of competition provide low incentives to innovate whereas a medium level of competition fosters innovation of firms operating on a similar technological level ("neck-and-neck firms"). Recently, this finding was challenged by Correa (2012) who finds a structral break in the data and, after controlling for that, a positive effect of competition on innovation. On the contrary, Tishler and Milstein (2009) find that R&D investments decrease with competitive pressure. However, at a certain level of competition firms engage in "R&D wars" and spend excessively on R&D.

The above mentioned literature assumes that firms' innovation behavior is homogeneous, that is, that all firms innovate by spending on R&D. However, empirical evidence suggests that firms' innovative activity is heterogeneous within markets. For instance, using data of Italian firms, Cefis and Orsenigo (2001) and Cefis (2003) find that in most markets there is a core of firms that are persistent innovators while other firms innovate only occasionallly. Czarnitzki et al. (2008) find that, depending on a firm's role in the market, competitive pressure might have a different effect on innovative effort. So, whereas entry pressure decreases the average investment per firm, it increases innovative effort of market leaders. Vives (2008) analyzes the effect of the number of competitors on process introduction aimed at reducing production costs and product innovation aimed at new product introduction. For process innovation, an increase in the number of competitors decreases cost-reduction expenditures, whereas the results are ambiguous for product innovation.

The second strand of the literature, to which the present article is related, distinguishes between firms that innovate or imitate the outcomes of innovators' activity. Theoretical studies have analyzed the impact of ease of imitation (or the extent of spillovers) on innovative incentives in two frameworks, economic growth models (Grossman & Helpman, 1991; Aghion & Howitt, 1992) and oligopolistic competition models (Zhou, 2009). In some studies, imitation is shown to foster the innovation activity of technological leaders. In fact, strong IP protection may slow down the technological development and decrease the welfare and consumer surplus (Helpman, 1993; Bessen & Maskin 2009; Che et al., 2009; Fershtman & Markovich, 2010). In other studies, IP protection is shown to be a necessary mechanism that provides incentives for firms to engage in R&D and encourages technology transfer between firms. Therefore, Gans and Stern (2003), Gans et al. (2008), Boldrin and Levine (2008) suggest strong protection of intellectual property rights as the optimal R&D policy. Additionally, Braguinsky et al. (2007) show that the relationship between innovation and imitation might depend on other factors such as the maturity of an industry. When the industry is young and small, innovators have no incentives to prevent imitation. But when the industry expands, innovative effort decreases because of imitation pressure, therefore, innovators benefit from intellectual protection mechanisms.

Most of this literature assumes that innovators and imitators are exogenously determined. Exceptions in the theoretical literature are Segestrom (1991), Takalo (1998) and Amir and Wooders (2000). Applying an economic growth model, Segestrom (1991) allows firms to participate in both innovative and imitative R&D races. In the steady-state, firms' equilibrium innovation strategies depend on the distribution of previous R&D outcomes and the relative price of imitation. Firms are found to benefit more from imitation in industries with a single leader, whereas in industries with several leaders innovation is a more profitable strategy. In a standard oligopoly framework, Amir and Wooders (2000) show that, in equilibrium, firms choose their innovation strategies asymmetrically. This gives rise to a market with one innovating and one imitating firm. Finally, Takalo (1998) shows that under endogenous imitations short patents are optimal.

Regarding the empirical literature, until now few attention has been paid to the impact of competitive pressure and intellectual property protection due to poor data availability. Link and Neufeld (1986) examine the effect of market competition on the firms' choices to innovate or to imitate. Using cross-sectional data they analyze firms' strategy choice as a function of firm size, market share, and industry concentration. The present article is similar to their study in that it explores how market competition affects firms' choice between innovation and imitation. However, it extends competition measures considering various indicators such as the number of competitors and relative profit differences and takes into account IP protection effectiveness perceived by firms, which is important for firms' incentives for product innovation. Moreover, this article explores how competition measures affect firms' innovation strategy choices given different levels of IP protection effectiveness in the industry.

Despite the extensive existing research on firm innovativeness, empirical studies have following drawbacks. During the last decades they discussed the determinants of R&D activity mainly based on internal firm characteristics such as firm size, appropriability of the outcomes of innovation, access to international markets, cooperation with customers, suppliers and others (Patel and Pavitt, 1992; Crépon et al., 1998; Loof and Heshmati, 2002; Veugelers and Cassiman, 2005). Less attention has been paid to external factors because their measurement raises certain problems. For example, the intensity of market competition has been proxied with concentration measures, such as concentration ratios or Herfindahl-Hirshman index, based on industry level data (Geroski, 1990; Blundel et al., 1999; Aghion et al., 2005). The problem with this approach is that the product market, in which firms compete, can hardly be identified by an industrial sector. So, firms within one sector might not compete at all if their products meet different consumer needs. Another problem is the measurement of spillovers. The average spillover level has been measured with industry data as an average of firm R&D expenditures in the industry (Bloom et al., 2007; Czarnitzki and Kraft, 2007). However, firms can protect the outcomes of their R&D activity by using legal protection mechanisms as well as by secrecy. So, this indicator might wrongly reflect the spillover level in the industry or in the market. The common problem with the measurement of these variables is that market characteristics such as the firm's market position or the level of knowledge protection are not directly observable. The Mannheim

Innovation Panel (MIP), a survey used in this study, allows to take an alternative approach to the measurement of external market factors. In this survey, firms provide information about these factors according to their own perceptions of market characteristics, such as the number of main competitors and the effectiveness of legal mechanisms for intellectual property protection. These perceptions are tightly related to their innovation strategy choices.

3 Data and hypotheses

To investigate the determinants of firms' innovation strategy choices, the data from the Mannheim Innovation Panel (MIP) are used.[1] This survey is conducted by the Centre for European Economic Research (ZEW) as part of the Community Innovation Survey (CIS) for Germany on a yearly basis. It covers a sample of German firms in manufacturing and service sectors during the period 1995-2012. The data includes information regarding the introduction of new products, services and innovation processes within firms. The database has a cross-sectional structure such that survey questions differ across waves. Only the 2005 innovation survey, which is the 13th wave of the MIP, provides the necessary data for the purposes of this study. In this survey, firms were asked about both internal and external factors that affect their commercialization and innovation decisions during the period 2002-2004. Enterprises with 5 or more employees are covered. The drawing probabilities are disproportional with higher drawing quotas applied for large enterprises, enterprises from Eastern Germany and from sectors with a high variation in labour productivity. Whereas the independent variables are drawn from the 2005 survey, the dependent variable is drawn from the 2007 survey to decrease a potential simultaneity bias.

The dependent variable of the analysis represents a firm's innovation strategy choice. It is a categorical variable that indicates if, between 2004 and 2006, a firm did not conduct innovations (the value 0), introduced a product that is new for the firm but known in the market (the value 1) or introduced a product that is new for the market (the value 2). The questions in the survey that allow to distinguish between innovators and imitators refer only to product innovations, therefore, implications derived in the present study are applied, mainly, to product innovation. This dependent variable can also be interpreted as the degree of innovation. Then, the value 1 refers to an incremental

[1] This data are provided by ZEW Research Data Centre, http://kooperationen.zew.de/en/zew-fdz/home.html.

innovation (an improvement of already existing products) and the value 2 refers to a radical innovation (an introduction of a new product, which did not exist in the market before). In addition, firms that haven't introduce any new products because they aborted or did not complete innovation during the period of observation are excluded from the sample. This allows to exclude from consideration those factors that impede innovation success despite a firm's willingness to innovate.

As it is common in the economic literature, we interpret the introduction of a product that is new for the market as innovation whereas the introduction of a product that is new for the firm (but not for the market) as imitation. This interpretation is supported by Link and Neufeld (1986), who surveyed 76 R&D active US manufacturing companies. The vice presidents were asked whether their firm's overall R&D strategy was innovative or imitative and whether this classification is meaningful. All of them reported that although their firms operated in several lines of business, one dominant strategy characterized the overall R&D effort. However, the dependent variable of their analysis has an important drawback. It is based on the subjective vision of vice presidents of the companies and has a retrospective nature. Therefore, in the regression analysis with contemporaneous market characteristics the problem of endogeneity arises. On the contrary, the dependent variable of the present article allows to identify the outcome of the strategy chosen by a firm. The independent variables are drawn from the earlier survey. This allows to decrease the direct endogeneity due to the simultaneity in observations.

The sample of 1253 German firms used for this study shows that the rate of innovating and imitating firms varies across industries. The total number of non-innovating, imitating and innovating firms for manufacturing and services sectors in the year 2007 is, correspondingly, 631 (53%), 313 (26%) and 238 (20%). The highest rate of non-innovating firms can be observed in manufacturing sectors including mining (81%), wood / paper (75%), glass / ceramics (73%), metals (77%), and many services sectors. On the other hand, most firms are innovators in sectors such as chemicals (31%), medical instruments (40%) and electrical (40%) and transport equipment (42%).

To study firms' innovation strategy choices, the two categories of independent variables are included into the empirical model: variables that measure internal and external factors. As commonly used in firm-level studies, our internal factors are: firm size (*lsize*), the quality of human capital (*hc*), capital intensity (*capint*), export intensity (*expint*), a dummy for firms' membership in a group of companies (*group*), the geographical size of the market, to which a firm has access (*geo*), and, specific to our data, firm location in the territory of former Eastern Germany (*east*).

Most studies on firm innovation control for firm size because larger firms are supposed to more efficiently conduct innovation due to economies of scale and scope (Henderson and Cockburn, 1996; Shefer and Frenkel, 2005). In the present study *lsize* measures the log-number of employees to control for non-linearities in the effect of firm size on the firms' innovation strategy choices. Regarding the *group* dummy, previous studies suggest that firms, which belong to a group, have more incentives and resources for innovation. *geo* is used as a proxy for a firm's market size. We create 4 dummies to distinguish between geographical scope of markets that firms have access to: local or regional markets, the German (i.e. nation-wide) market, the market of EU, EU candidates and EFTA member countries and the world market. Following previous studies, a positive effect of *geo* on a firm's propensity to engage in R&D is expected.

Apart from the traditional internal factors mentioned above, the literature stresses the importance of the so called "absorptive capacity" for firms' innovation activity. According to Cohen and Levinthal (1989), this term stands for a firm's ability to identify, assimilate and apply new knowledge given the firm's experience, human capital skills, and organizational procedures' flexibility and relevance. Firms that have more advanced human capital skills are expected to dispose of more capability for R&D. There is a number of ways to measure a firm's human capital quality. Given the cross-sectional structure of our data, *hc* is measured as a firm's proportion of employees with at least university degree. As firms' performance depends on the employees skills, the general level of education, experience and training of employees, this seems to be a good proxy for a firm's human capital quality and is expected to positively affect firms' innovativeness. A more sophisticated approach (see Vega-Jurado et al, 2008) extends the notion of absorptive capacity to technological opportunity, appropriability conditions and internal technological competences that affect firms' innovation strategies. Finally, I use the dummy variable *east* to control whether a firm is located in former Eastern Germany. Historically, firms that belong to the western and the eastern part of Germany were affected by different policies (subsidies, taxes, institutions). As a consequence, there might exist a systematic difference in the innovative performance of firms located in these regions.

Regarding the external factors, the variables used are the perceived effectiveness of intellectual property rights protection by patents (*pat*) and trademarks (*tm*), and competitive pressure, measured by the number of main competitors (*com*) and relative profit differences (*rpd*). The effectiveness of legal mechanisms for IP protection, *pat* and *tm*, is measured as the success scores of legal protection mechanisms for innovations and inventions, patents and trademarks, reported by firms. In order to obtain the information on the effecttiveness of legal protection mechanisms, each firm was asked to evaluate to what extent patents and trademarks protect intellectual property. Firms' evaluations are represented in the form of a Likert scale ranging from 0 ("not at all") to 3 ("highly"). To deal with the possible endogeneity of these indexes, following Schmidt (2006), for each firm I calculate the average index value across the NACE 3-digit industry code excluding the firm in observation. A higher value of this index for each IP protection mechanism means that this mechanism achieves better intellectual property protection in the firm's market. A priori, patents and trademarks effectiveness in the industry are expected to positively affect firms' incentives to imitate and to innovate. Nevertheless, the effect on imitation might be smaller and would be rather indirect by encouraging innovation.

The categorical variable *com* measures the number of main competitors reported by a firm: 0 competitors, from 1 to 5, from 6 to 15 or more than 15. Since a firm has a better vision of its own market structure, this indicator measures closer the intensity of market competition. For the estimation 4 dummies are created (com_i, $i = 0, ..., 3$) , where $i = 0$ indicates that a firm has no competitors, $i = 1$ from 1 to 5 competitors, $i = 2$ from 6 to 15 competitors, and $i = 3$ more than 15 competitors. Because theoretical and empirical results in the literature are ambiguous, I don't have any expectations regarding the effect of the number of competitors on firms' innovativeness.

Finally, I consider an additional measure of competitive pressure, relative profit differences (*rpd*). It was originally proposed by Boone (2008) and defined as follows. For every three firms with different efficiency levels $n'' > n' > n$ the index $[(\pi(n'') - \pi(n))] / [\pi(n') - \pi(n)]$ raises when the competitive pressure becomes more intense, where $\pi(n)$ is the profit of a firm with the efficiency level n. This measure is robust to the theoretical specification and is convenient for the empirical analysis due to its computational simplicity and data requirements. Specifically, it is sufficient to use only the sample of firms in the industry such that the key property of this index holds. It is important that firms interact in the markets with relatively homogenous goods and that firms are symmetric so that equally efficient firms get equal profits. The measure of *rpd*, which is applied in the present empirical analysis, is modified, following Schiersch and Schmidt-Ehmcke (2011). Firms in the industry (at NACE 4-digit level) are ordered according to their normalized efficiency $(n - \underline{n}) / (\overline{n} - \underline{n})$, where $\underline{n}$ and $\overline{n}$ are the efficiencies of the least and the most efficient firm in the industry, correspondingly. The efficiency level is approximated by average variable cost defined by the sum of material and labour cost normalized by firms' turnover, as proposed by Boone (2008). In order to avoid dividing by zero for the case $n = \underline{n}$ the inverse of the original *rpd* index is used and firms' profits are normalized by turnover. Therefore, the applied index *rpd* is given by:

$$rpd\,(n) = \frac{\pi\,(n)\,/sales\,(n) - \pi\,(\underline{n})\,/sales\,(\underline{n})}{\pi\,(\overline{n})\,/sales\,(\overline{n}) - \pi\,(\underline{n})\,/sales\,(\underline{n})}$$

A higher level of *rpd* index is associated to a lower level of competition experienced by a firm in an industry.

Regarding industry dummies, following OECD taxonomy for NACE Rev.1 codes, I include dummies for 25 aggregated industry sectors. This allows to control for unobserved heterogeneity in innovative performance across sectors. The industry effects on firms' innovation strategy choice might be twofold. On the one hand, industry dummies might capture the technological complexity of knowledge in the industry. The fact that the technology is more advanced in the industry can impede introduction of improved and new products. On the other hand, industry dummies might indicate the level of spillovers from rivals' innovation in the industry. Thus, in industries with high rate of innovation firms can be more disposed to conduct innovation resulting in the introduction of improved and new products. In addition, the interaction terms of *pat* and industry dummies are included to control for different impact of the effectiveness of patent protection in the specific industry. The effectiveness of patents might depend on the underlying knowledge base, i.e. on the extent to which the new ideas and knowledge can be codified in terms of universal categories for a given industry. If this is the case, the object and scope of patent can be defined with more precision.

In the sample of 1253 German firms over 24% of firms introduced product innovations that were new to their market by 2005, whereas 29% of firms introduced products that were already known to their market but new for the firm. 47% of firms abstained from innovation. Table 1 presents the descriptive statistics.The average firm in the sample has 453 employees, among which, on average 20%

of employees have at least higher education. 31% of firms are group members, and 34% of the firms are from Eastern Germany. The similar shares of firms have access to markets of different geographical sizes: 29% to local or regional markets in Germany, 29% to German national market, 17% to European and 25% to the worldwide market. 25% of firms reported that they have more than 15 competitors in their markets. Similarly, 23% of firms reported to have 1-5 main competitors, whereas only 9% are monopolists in their markets. Most of firms (43%) have claimed to have 6-15 competitors. The average perceived effectiveness of patent protection (0.53) is higher on average than the perceived effectiveness of protection by trademarks (0.44). A detailed description of the variables is provided in Table 3.

4 Empirical model

The statistical model that analyzes firms' innovation strategy choices as a function of firm characteristics and external market parameters should take into account that firms' innovation strategy choices can be threefold: no innovation, imitation and innovation. Given a set of regressors x_{ij}, where $i = 1, ..., I$ indexes firms and $j = 1, ..., J$ indexes regressors, the combination of variables $\sum_{j=0}^{J} (x_{ij}\beta_j)$ is used to distinguish between the K categories of the outcome variable. Due to the nature of the dependent variable, a discrete choice model should be employed and the choice of the model is determined by the relationship between the categories of the dependent variable.

Recall that the introduction of products new to the firm is defined as an imitation or an incremental innovation, whereas an introduction of products new to the market is defined as a radical innovation. The previous studies (Link & Neufeld, 1986; Vinding, 2006) suggest that the choice of a firm's innovation strategy, an imitation or an innovation, depends on the amount of resources that it is willing to spend on R&D and on the expected profitability of each strategy. Concretely, the amount of resources that is needed to improve already existing products is smaller than the amount of resources needed for the maintenance of an R&D laboratory and a radical innovation. Therefore, the choice categories reflect the degree of firms' involvement into an innovation activity. Vinding (2006) suggests the existence of a natural ordering of the dependent variable categories according to the degree of firms' "innovativeness" and proposes an econometric specification based on an ordered logit.

This model is based on two important assumptions. First, it assumes that the same combination of independent variables can be used to distinguish between all levels of the outcome variable. Second, the odds ratio for being in a category k or higher, relative to being in a category $k-1$ or lower, is assumed to be the same for all k, $2 \leq k \leq K$. This assumption is also known as the parallel regression assumption. In the context of our analysis this means that the effect of regressors on the decision to imitate instead of not to innovate is the same as on the decision to innovate instead of to imitate. Since this assumption is not fulfilled, the ordered logit is not applied for the present analysis[2].

Another potentially applicable model for categorical dependent variables is a multinomial logit. It relies on the assumption that the choices between categories are independent on the set of available alternatives. This assumption is known as IIA (Independence of Irrelevant Alternatives) and it states that the relative probability of choosing one category instead of another does not depend on the set of other available (”irrelevant”) alternatives. For instance, the relative probability of engaging in imitation or innovation does not change in the absence of the alternative ”not to innovate”. This approach is used by Vega-Jurado et al (2008) who use the same dependent variable as the present article. Traditionally, application of the multinomial logit model is contrasted by Hausman and Small-Hsiao tests for the IIA assumption. The results of these tests are often contradictory. Therefore, the general advice when using the multinomial logit model is to rely on underlying meaning of the categories of the dependent variable. Despite the fact that in the analysis some tests show an evidence supporting IIA when using the multinomial logit model, the present study adopts a more appropriate econometric specification. It allows to estimate the parameters for each of the alternatives and then to test the existence of ordering nature in the dependent variable.

A compromise between the two models described above, a multinomial and an ordered logit, is a stereotype logistic regression proposed by Anderson (1984). This model imposes ordering constraints on the multinomial model. In the multinomial logistic model $K-1$ parameters $\widetilde{\beta}_k$, $k = 1, ..., K-1$ are estimated. The stereotype logistic model imposes restriction on the multinomial model by estimating D parameter vectors, where $1 < D < min\,(K-1, j)$. The relationship between coefficients of stereotype model $\beta_d, d = 1, ..., D$ and the multinomial model's coefficients is $\widetilde{\beta}_k = \sum_{d=1}^{D} \phi_{dk}\beta_d$. The parameters

[2]For the dataset the LR-test for the pallel regression assumption (Wolfe and Gould, 1998) and a Wald test (Brant, 1990) are performed. Both tests reject the parallel regression assumption at 0.01 level.

ϕ_{dk} are estimated together with parameters β_d. Denote $\eta_k = \theta_k + \sum_{d=1}^{D} \phi_{dk}\mathbf{x}\beta_d$[3], where $\mathbf{x}$ is a row vector of covariates and θ_k are unrestricted constant terms for each equation. The probability of observing outcome k is:

$$\Pr(y_i = k) = \begin{cases} \frac{\exp(\eta_k)}{1+\sum_{k=1}^{K-1}\exp(\eta_k)} & k < K \\ \frac{1}{1+\sum_{k=1}^{K-1}\exp(\eta_k)} & k = K \end{cases}.$$

Using the data of 1253 German firms from manufacturing and services sectors the one-dimensional stereotype logistic model ($d = 1$) is specified as:

$$\eta_k = \theta_k + \phi_k \left(\begin{array}{c} \beta_1 lsize + \beta_2 hc + \beta_3 capint + \beta_3 \exp int + \beta_4 group + \sum_{i=0}^{3} \beta_{5i} geo_i + \beta_6 east \\ +\beta_7 pat + \beta_8 tm + \sum_{i=0}^{3} \beta_{9i} com_i + \beta_{10} rpd03 + indust.dummies + inter.terms \end{array} \right).$$

In this model, the estimated relationship between rescaling parameters ϕ_k indicates the appropriability of the categories ordering. If $\phi_1 \leq \phi_2 \leq ... \leq \phi_K$ holds, the nature of the dependent variable is indeed ordered. For model identification, we must impose the following restrictions on θ_k and ϕ_k: $\theta_0 = \phi_0 = 0$ and $\phi_1 = 1$. Cluster-robust standard errors (clustered within NACE 3-digit industries) are computed for stereotype logistic regression. The algorithm assumes an independence of the error terms over clusters and a correlation of the error terms within clusters. As mentioned above, the stereotype logistic model has a number of advantages as compared to previously used models. First, it relaxes the proportional regression assumption of an ordered logit. Second, it does not impose an ordering restriction on categories, but rather allows to test the appropriability of ordering. Third, it relies on maximum likelihood estimation of different coefficients for each alternative (multinomial logistic model) and, then, reparameterizes the coefficients. Therefore, it highlights the ordering of categories and reduces the number of parameters for interpretation, without reducing significantly the appropriability of the fit.

[3]Originally, Andreson (1984) introduced the model as $\eta_k = \theta_k - \sum_{d=1}^{D} \phi_{dk}\mathbf{x}\beta_d$. The minus sign in front of ϕs makes the interpretation confusing, therefore here the model is rewritten with a plus sign in front of ϕs. The signs of estimated parameters β are reversed correspondingly.

5 Results and discussion

Table 2 provides estimates (coefficients and average marginal effects) of the stereotype logistic regression. The average marginal effects indicate the average change in the probability that a firm engages in imitation or innovation with a unit change in the independent variable for given values of other regressors. Figure 1 plots the marginal effects at means of the categories of the number of competitors from 1 to 5 and from 6 to 15 and the effect of relative profit differences for a range of the patent protection effectiveness values. Figure 2 plots marginal effects at means of the patent protection effectiveness for each category of the number of competitors and for a range of relative profit differences.

The appropriability of the econometric specification is examined by the estimates of ϕ_k, which indicate the distance between categories of the dependent variable. We see that the parameters ϕ_k are monotonically increasing with respect to j, which means that the model is appropriate for the ordered dependent variable and the categories of the dependent variable are ordered in accordance with the impact of the independent variables on them. To see how the effect of market characteristics on firm' innovation strategy choice varies among adjacent categories, we compare $\widehat{\phi}_3 - \widehat{\phi}_2 = 0.791$ (innovation-imitation) and $\widehat{\phi}_2 - \widehat{\phi}_1 = 1$ (imitation-no innovation). This suggests that firm and market characteristics have a stronger impact on the odds of a firm's choice between imitation and no innovation than on the odds of the choice between innovation and imitation. Furthermore, Wald and LR tests are performed to check the distinguishability of the dependent variable categories (the equality of ϕ_k). Because the hypothesis that all parameters ϕ_k are equal can be rejected at 0.01 significance level, we conclude that the categories of the dependent variable are distinguishable. The overall predictive ability of the model is similar to that of full multinomial logit model and is over 58%.

Regarding internal firms' characteristics, firm size is found to have a positive but decreasing effect on the degree of firms' innovativeness. The quality of human capital and the intensity of capital expenditures also have a significant positive impact. Geographical market size has a significant positive effect for firms that have access to the European and worldwide markets. The location of a firm in former Eastern Germany after controlling for other factors, turns to be insignificant.

Remarkably, the estimation results suggest crucial importance of external (market) factors for a firm's innovation strategy choice. The success of legal IP protection mechanisms, especially patents, positively affects firms' choices to engage in imitative or innovative activity. This fact can have several explanations. First, the reduction of uncertainty about R&D outcomes and future profits due to patent protection plays an important role in the firms' decision to engage in imitation, or incremental innovation, as well as in radical innovation. Second, the positive effect on imitation can be indirect, through the increased incentives of innovators to license their technologies. Therefore, this result might provide support for the arguments of Arora and Gambardella (1994), Gans and Stern (2003), and Gans et al. (2008). Notably, this overall positive effect is significantly higher for the IT and Telecommunication servies. Finally, no significant effect of IP protection by trademarks is found. However, in industries such as glass and ceramics manufacturing, automobile retail services and transport the IP protection effectiveness by trademarks is significantly positively associated to firms' innovativeness. Surprisingly, there is a negative association between innovativeness and protection effectiveness by trademarks in sectors related to IT and Telecommunication services. Overall, the sectors that belong to IT and Telecommunication services indicate a high importance of patent protection effectiveness whereas the impact of trademark effectiveness is found to be lower than in any other industries.

Competitive pressure is measured by the number of main competitors and relative profit differences. The results show that the oligopolistic market structure with 1-5 main competitors is the one that favours most imitation and innovation. The category of having 6-15 main competitors also shows a slightly lower positive effect. Finally, the impact of having more than 15 competitors is lower and in some specifications even insignificant. This suggests a weak evidence for an "U-inverted" relationship between the number of competitors and firms' incentives to innovate and imitate. As compared to the firms that have no competitors, firms with a small or medium number of competitors are more propense to imitation and innovation. When the number of competitors grows higher, this positive effect vanishes. According to another indicator of competitive pressure, a lower level of competition measured by relative profit differences in the industries is related to a decrease in firms' propensity to imitate and innovate. This effect weakly decreases for imitation and becomes insignificant for innovation when IP protection effectiveness perceived by firms increases.

The marginal effects of the number of competitors calculated for a range of values of patent protection effectiveness are ploted on Figure 1. The results suggest that for low levels of patent protection effectiveness a small (from 1 to 5) or medium number of competitors (from 6 to 15) is positively related to firms' incentives for imitation and innovation. However, for high levels of patent protection effectiveness the effect of a small or medium number of competitors is even higher for the incentives to innovate whereas and lower for the incentives to imitate. This means that with a high effectiveness of intellectual property protection (or high appropriability of knowledge) more firms turn to introduction of market novelties rather than adopt products already existing in the market. Regarding relative profit differences, Figure 1 shows that the negative effect of lower competitive pressure diminishes for imitation and becomes insignificant for innovation when the perceived effectiveness of patent protection is high. This suggests that the innovation-enhancing effect of higher competition measured by relative profit differences in an industry diminishes for imitation and looses relevance for innovation with higher perceived IP protection effectiveness.

The positive effect of the perceived effectiveness of patent protection also varies with the level of competition. Figure 2 shows that for imitation this effect increases with increase in the number of competitors, although only for the categories 0 and 1. For the categories 2 and 3 this effect turns to be insignificant. For innovation, the positive effect of the perceived effectiveness of patent protection increases with the number of competitors with the maximum for 6 - 15 competitors, and then decreases. Therefore, we can observe a weak U-inverted shape between the number of competitors and the innovation-enhancing effect of the perceived effectiveness of patent protection.

The results of this article extend the previous findings on the firms' choice between innovation and imitation. First, this study uses a larger sample of firms from manufacturing and services sectors than the predecessors (Link and Neufeld, 1986; Vinding, 2006). Second, the results of previous studies are contradictory. Specifically, the former finds that market power is crucial for firms to engage into innovation and imitation. Conversely, the latter finds that an increase in competitive pressure enhances introduction of improved products and market novelties. The present study uses two measures of competitive pressure and suggests a non-monotonic effect of competitive pressure on firms' incentives to imitate and innovate for the number of competitors and a monotonic effect for relative profit differences. A small or medium number of competitors is found to have the highest positive impact on innovative performance of an industry in terms of new product introduction. In addition, the present results emphasize that the effect of competitive pressure might vary depending on the effectiveness of IP protection preceived by firms.

The present results are also related to several theoretical studies. They provide support to Boldrin and Levine (2008) who argue that IP protection is a good mechanism for enhancing innovation. The present article goes further analyzing how this effect depends on the level of competition a firm faces. Opposite to Vives (2008), empirical evidence for German firms suggests that an increase in market size has a non-ambiguous positive effect on the introduction of new products. Finally, the results contradict the theoretical results by Zhou (2009). Using a standard oligopoly framework he shows that intensified competition measured by an increase in the number of competitors always dampens innovation. Under an moderate level of competition, weak IP protection (or a high exogenously given level of spillovers) increases firms' incentives to innovate. This might result from the fact that in Zhou (2009) the model does not account for possible changes in innovation strategies chosen by firms (innovation and imitation) when it becomes more profitable to switch from the current strategy. When the level of spillovers is high (or the level of IP protection is weak), the former innovators might find it more profitable to switch to imitation, increasing competition among imitators. Contrary to Zhou (2009), the present article finds that a small or medium number of competitors can stimulate both product innovators and imitators. IP protection to a large extent affects a firms' choice to innovate and, indirectly, has a lower positive effect on product improvement by imitators through an increased activity of innovators. Therefore, when looking at the effect of competitive pressure and intellectual property protection, it is essential to model a firms' innovation strategy choice as endogenous.

6 Concluding remarks

The present article explicitly considers that firms may have different innovation strategies (innovate, imitate or abstain from innovation) and analyzes how IP protection and competitive pressure jointly affect firms' innovation strategy choice. The results show that the perceived effectiveness of patent protection positively affects firms' innovativeness, i.e. propensity to imitation and innovation. This effect varies with the level of competitive pressure measured by the number of competitors. The increase in the perceived effectiveness of patent protection enhances imitation only for a small number of competitors, whereas for innovation it has a U-inverted shape with the maximum effect for firms with 6 - 15 competitors. Similarly, the number of competitors and firm innovativeness are related in

U-inverted shape with the highest positive effect of a small and a medium number of competitors. However, this effect varies with the perceived patent protection effectiveness. If the perceived patent protection effectiveness is low or medium, both innovation and imitation are enhanced, whereas if it is high, only innovation is enhanced. The relative profit differences indicator suggests that a decrease in competitive pressure negatively affects both imitation and innovation, and this effect becomes weaker for imitation and stronger for innovation when IP protection effectiveness perceived by firms increases.

The findings of the article add to understanding the link between IP protection policy and competition policy. According to the Schumpeterian view, these two policies affect firms' incentives to innovate in opposite directions. Whereas the former policy gives monopoly rights to innovators, thus, increasing incremental profits from innovation, the latter policy suppresses firms' market power decreasing incremental profits from innovation. My results suggest that IP protection policy and competition policy can reinforce each other in promoting innovation. For instance, in markets with few competitors better patent protection might positively affect firms' incentives to introduce market novelties. On the contrary, in markets where firms have almost monopoly power an increase in patent protection can promote an introduction of improved products, i.e. incremental innovation, rather than the introduction of market novelties, i.e. radical innovation. Despite the common patent system for all industries the perceived effectiveness of IP protection by firms can be affected, for instance, through the courts' interpretation of novelty and non-obviousness. Therefore, these findings can be relevant for policy makers.

Once the factors that affect firm innovation strategy choice are identified, another question arises. Is it efficient to have much imitation in the markets or is it better to restrict imitation providing monopoly power to innovators? This question is addressed in recent theoretical studies. For instance, König et al. (2012) introduce the endogenous choice between innovation and imitation into an endogenous model of technological change, productivity growth and technology spillovers. Fostering only innovation increases the inequality in the industry, which lowers overall economic performance. Increased imitation in the absence of innovation doesn't contribute to productivity growth. Therefore, they suggest to enhance both in-house innovation and technology diffusion through imitation. However, further theoretical research is needed to analyze social welfare implications of the innovation / imitation balance under different market structures with endogenous innovation strategy choice.

Several limitations of the present study call for further research on this topic. First, due to data structure this study adopts a static perspective. An analysis with panel data would allow to account for firm-specific unobserved heterogeneity and would decrease the potentially existing bias due to omitted variables. Second, the analysis of sectorial patterns of innovation strategy choice is obstructed due to the small number of observations. Although implementation of sector-specific R&D policies is a difficult task, it would be especially valuable for industrial policy design. Third, firms' innovation strategies should be analyzed in more dimensions than exclusively the dimension adopted in this article. Future research should explore the other dimensions such as the internal or external sources usage for incremental and radical innovation. Finally, conditional on the innovation strategy chosen it is important to evaluate quantitatively the innovative effort of firms.

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Variable	Mean	Std.dev.	Med	Min	Max
Innovation strategy	0.441	0.725	0	0	2
Log N empl.	3.846	1.564	3.761	0	12.143
Human capital	19.904	23.713	10	0	100
Capital intensity	0.057	0.109	0.022	0	0.868
Export intensity	0.139	0.231	0.002	0	1
Belongs to a group of firms	0.305	0.461	0	0	1
East.Germany	0.338	0.473	0	0	1
Av. succ. pat. prot.	0.530	0.551	0.289	0	3
Av. succ. tradem. prot.	0.442	0.343	0.393	0	3
Rel. profit diff.	0.489	0.334	0.510	0	1
Variable	Categories				
	0	1	2	3	
Number of competitors	9.24%	22.63%	42.83%	25.29%	
Geographical market size	28.60%	29.45%	16.96%	24.98%	

Table 1: Descriptive statistics (1253 observations).

	Model 1		Av. marg. effects (Base model)		
	Coefficient	(Std. Err.)	No-Innovation	Imitation	Innovation
	Firm characteristics				
Log N empl.	0.258***	(0.061)	-0.053***	0.018***	0.035***
% Empl. with high ed.	0.015***	(0.003)	-0.003***	0.001***	0.002***
Capital intens.	0.676***	(0.258)	-0.139***	0.047**	0.091***
Export intens.	0.345	(0.286)	-0.071	0.024	0.046
Group (0/1)	0.096	(0.152)	-0.020	0.007	0.013
German market (0/1)	0.269	(0.200)	-0.052	0.021	0.031
European market (0/1)	0.524**	(0.207)	-0.108***	0.041**	0.067***
Worldwide market (0/1)	0.534**	(0.249)	-0.110**	0.041**	0.069**
Eastern Germany (0/1)	0.015	(0.108)	-0.003	0.001	0.002
	Market characteristics				
Eff.patent prot.	0.372*	(0.191)	-0.076**	0.026*	0.050**
Eff.patent prot. Food/Tobacco	-10.760*	(6.407)	2.205*	-0.754*	-1.451
Eff.patent prot. Sector IT/Telecom	5.295**	(2.614)	-1.085**	0.371**	0.714*
Eff.trademark prot.	0.301	(0.274)	-0.062	0.021	0.041
Eff.trademark prot. Glass/Ceramics	4.582***	(1.002)	-0.939***	0.321***	0.618***
Eff.trademark prot. Electr. Equipment	1.854**	(0.813)	-0.380**	0.130**	0.250**
Eff.trademark prot. Retail/Automobile	5.181**	(2.110)	-1.062**	0.363**	0.699**
Eff.trademark prot. Transport	2.237**	(1.056)	-0.458**	0.157**	0.302**
Eff.trademark prot. IT/Telecom	-4.392*	(2.281)	0.900**	-0.308*	-0.592*
1 - 5 competitors	1.366***	(0.486)	-0.280***	0.096***	0.184**
6 - 15 competitors	1.219**	(0.503)	-0.250**	0.085**	0.164**
more than 15 competitors	0.903*	(0.482)	-0.185*	0.063*	0.122*
Rel.profit differ.	-0.374**	(0.190)	0.077**	-0.026**	-0.050*
Industry dummies (joint significance)					
	χ^2 (25)				
$(\phi_1 = 0, \phi_2 = 1)$ ϕ_3	1.791***				
$(\theta_1 = 0)$ θ_2	-4.821***				
θ_3	-8.188***				
N obs.	1253				
Log-likelihood	-839.93				
Wald chi-squared	398.52				
% pred. prob.	58%				

Note: ***, * and ** indicate statistical significance at 10, 5 and 1% level.

Table 2: Stereotype logit regression for firm innovation strategy (at the firm level)

Variable	Label
Dependent variable	
str	A firm's innovation strategy by 2007: 0 = to abstain from innovation, 1 = to imitate, 2 = to innovate.
Independent variables	
Firm characteristics:	
lsize	A log-size of a firm in 2004, measured as a number of employees.
hc	A firm's human capital measured by the proportion of all employees who have a university degree or other higher education qualification in 2004.
capint	An intensity of capital expenditures in 2004, normalized by overall turnover in 2004.
expint	An intensity of export in 2004 measured by a turnover from export, normalized by overall turnover of a firm.
group	A dummy indicating if a firm belong to the group of firms: 0 = no; 1 = yes.
geo	A geographical size of the market availabe for the firm: 0 = local or regional market, 1=nation-wide market in Germany, 2 = European Union (EU), the European Free Trade Association (EFTA) countries and EU candidates, 3 = the worldwide market.
east	A dummy indicating if a firm is located in the former Eastern Germany: 0 = no, 1 = yes.
Market characteristics:	
pat, tm	The effectiveness of patents and trademarks as a legal protection mechanism for innovations and inventions evaluated as 0 = not applicable, 1= poor, 2 = medium, 3 = high. For each firm this value is calculated as an average effectiveness of patent and trademark protection in its NACE 3-digit industry code excluding the firm in observation.
com	The number of main competitors: 0 = no competitors, 1 = from 1 to 5 competitors, 2 = from 6 to 15 competitors, 3 = more than 15 competitors.
rpd	The relative profit difference between a firm and the most efficient and the least efficient firms in its NACE 4-digit industry code.

Table 3: Description of variables.

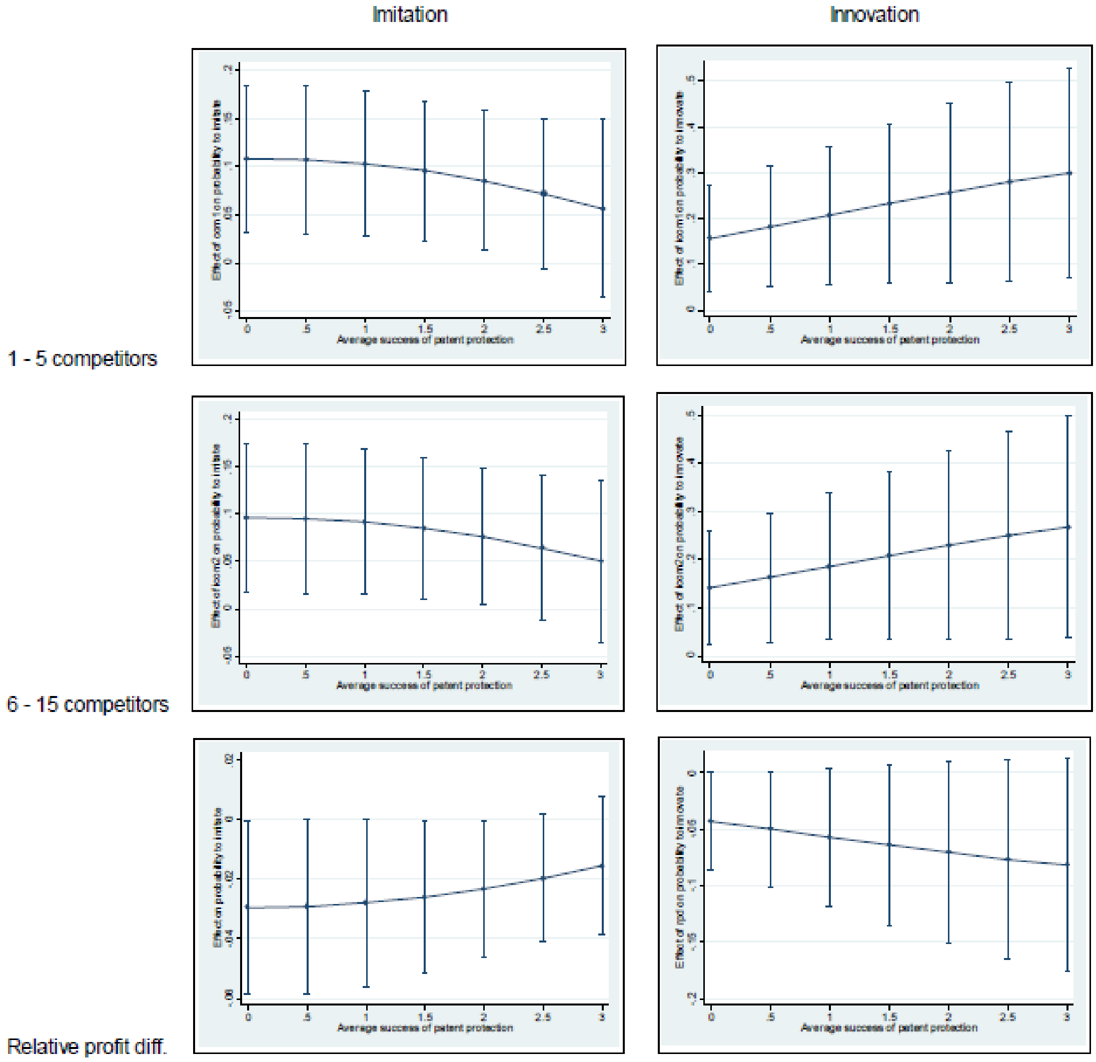

Figure 1: Average marginal effects of competitive pressure indicators.

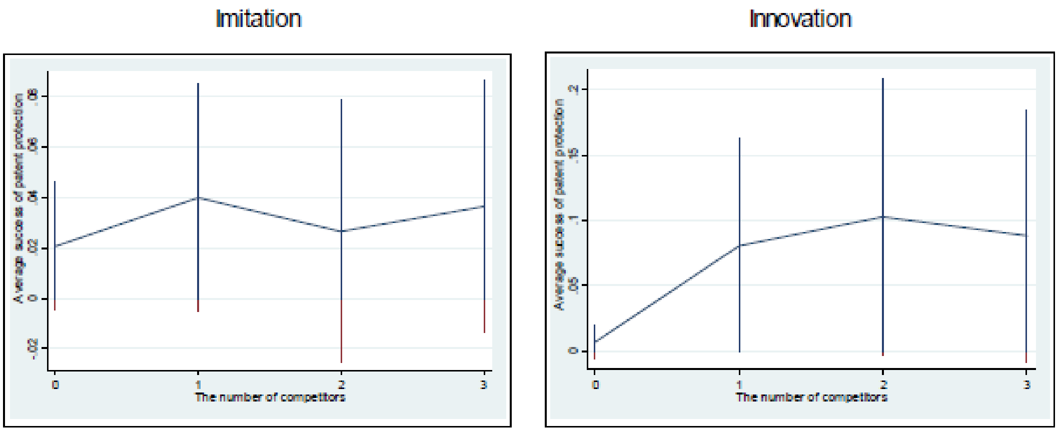

Figure 2: Average marginal effects of the perceived effectiveness of patent protection.