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PROTECTING INNOVATION THROUGH PATENTS AND TRADE SECRETS: DETERMINANTS AND PERFORMANCE IMPACTS FOR GERMAN FIRMS

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Executive Summary

The European Observatory on infringements of Intellectual Property Rights (the Observatory) was created at the European Commission to improve the understanding of the role of Intellectual Property and of the negative consequences of IPR infringements. It was transferred to the EUIPO[1] by Resolution 386/2012 in June 2012.

In a study carried out in collaboration with the European Patent Office (EPO)[2], the EUIPO, acting through the Observatory, calculated that 39% of total economic activity in the EU is generated by IPR-intensive industries, and approximately 26% of all employment in the EU is provided directly by these industries, with a further 9% of jobs in the EU stemming from purchases of goods and services from other industries by IPR-intensive industries.

Another study compared economic performance of European companies that own IPRs with those that do not, finding that IPR owners´ revenue per employee is 29% higher on average. Although only 9% of SMEs own registered IPRs, those that do have almost 32% more revenue per employee than those that do not.

Building on this work, the Observatory is now seeking to enhance its understanding of the role and contribution of trade secrets within the IP portfolio of firms. In collaboration with the Centre for European Economic Research in Mannheim (ZEW), the Observatory has examined the determinants and performance impacts of protecting innovation through the use of patents and trade secrets for German firms. This is a pilot study in preparation for a more comprehensive, EU-wide study that is currently in progress.

Starting from propositions of theoretical models on the interaction between patenting and secrecy, a number of factors that are thought to influence the use of the two protection mechanisms are investigated. Particular emphasis is placed on preferences for either patents or secrecy, and the factors affecting the choice of a protection strategy.

By analysing data from the Community Innovation Survey (CIS) for Germany, this study tests a number of hypotheses on the use and effectiveness of patents and trade secrets to protect innovation. While previous analyses have often treated the two as substitutes, this work seeks to examine the complementary role of the two protection methods.

In general, analysis at the individual innovation level is not possible with CIS data. However, in the case of Germany, information about the number of different innovations introduced by the firm during the period in question was available. This provided the opportunity to investigate the interaction of patenting and secrecy and the performance impacts of the chosen protection strategy not only on the level of the firm but also on the level of the individual innovation. This was done by carrying out

[1] The name of the Office was changed from OHIM to EUIPO with the entry into force of the trade mark reform package on 23 April 2016. In this document, the new name is used also when referring to the period prior to that date.
[2] "Intellectual Property Rights intensive industries; contribution to economic performance and employment in the European Union", September 2013.

supplementary analyses on a subset of the dataset, containing only firms with a single innovation and thereby ensuring that their answers to the relevant survey questions applied to that particular innovation.

Three main findings emerge from the analysis of the CIS German data:

1. Innovating firms are more likely to combine patents with secrecy, as Intellectual Property law becomes stronger and as technology uncertainty increases.
2. Patents are more likely to be used (alone or in combination with secrecy), when innovations are new-to-market and in open innovation practices such as research cooperation.
3. The use of Secrecy is identified as being more important for process as opposed to product innovations.

It should be noted that as with all econometric analyses of this type a caveat must be made in respect of interpretation of the findings. The results in this study uncover relationships between certain characteristics of the companies and the markets in which they operate and their choice of protection strategy. However, this should not be construed as conclusive proof of cause-and-effect relationships. More in-depth research is required to more clearly identify the causal factors.

Nevertheless, the results of this study and the future EU-wide study will provide a basis for the policy-makers to further develop policies in this area following the adoption of the Trade Secrets Directive in 2016.

1. Introduction

The Oslo Manual[3] defines innovation as "*the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations."*

Furthermore, *"the minimum requirement for an innovation is that the product, process, marketing method or organisational method must be new (or significantly improved) to the firm. This includes products, processes and methods that firms are the first to develop and those that have been adopted from other firms or organisations."*

Innovations can be evolutionary or revolutionary. The first can be brought about by incremental advances in technology or processes, while the latter refer to innovations which are often disruptive and can even be associated with the creation of new markets.

1.1. Protection of innovations and appropriability of returns from innovation

Nelson (1959) and Arrow (1962) highlighted that the main problem is appropriability and the semi-public good characteristics of knowledge. Appropriability refers to the different "tools" an economic agent may use to profit from its inventions or innovations by temporarily enjoying some exclusivity over the knowledge it creates. If inventors or innovators could not rely on some means to protect the knowledge they create, they would be at a disadvantage compared to their rivals that did not incur the costs of creating that knowledge. Such rivals could free ride on the innovation expenses of the innovators and imitate the new product/process at zero cost. Some kind of incentive is therefore required to incent private agents to devote resources to innovation activities.

Intellectual property rights (such as patents, trademarks, designs or copyright) are some of the appropriability mechanisms that may be used by innovators. However, there are other available mechanisms, including the exploitation of lead time advantage, complexity of design and trade secrecy. "Lead time advantage" is the practice to commercialise an innovation as fast as possible to benefit from so-called first-mover advantages. "Complex design" of a product impedes competitors from engaging in reverse engineering or "invent-around" strategies.

1.2. Trade secrets

An internationally agreed definition of trade secrecy can be found in Article 39 of the TRIPS Agreement (Agreement on Trade-Related Aspects of Intellectual Property Rights, 1994)[4]. This

[3] The Oslo Manual contains guidelines for collecting and using data on industrial innovation. The manual was the result of a joint effort of the European Union and the OECD. It is the basis for the construction of CIS and similar surveys for EU Member States as well as Norway, Iceland, Switzerland, Canada, Australia, New Zealand, Turkey and Japan.

definition is also used in Article 2 of the recently adopted EU directive on the protection of trade secrets[5]:

(1) 'trade secret' means information which meets all of the following requirements:

(a) is secret in the sense that it is not, as a body or in the precise configuration and assembly of its components, generally known among or readily accessible to persons within the circles that normally deal with the kind of information in question;
(b) has commercial value because it is secret;
(c) has been subject to reasonable steps under the circumstances, by the person lawfully in control of the information, to keep it secret.

The duration of trade secret protection is not limited to a set term as is the case with most registered IP rights.

Trade secrets can be technical in nature, such as drawings and designs, prototypes, manufacturing processes, non-patentable or non-patented inventions, know-how, formulae or recipes, genetic materials and fragrances. Commercial trade secrets may consist of customer and supplier lists, business methods and strategies, and cost and price information.

The EU directive on the protection of trade secrets explains the relationship between trade secrets and other types of IP as follows:

Businesses and non- commercial research institutions invest in acquiring, developing and applying know-how and information, which is the currency of the knowledge economy. This investment in generating and applying intellectual capital determines their competitiveness in the market and therefore their returns to investment, which is the underlying motivation for business research and development. Businesses have recourse to different means to appropriate the results of their innovative activities when openness does not allow for the full exploitation of their research and innovation investments. Use of formal intellectual property rights such as patents, design rights or copyright is one of them. Another is to protect access and exploit the knowledge that is valuable to the entity and not widely known. Such know-how and business information, that is undisclosed and intended to remain confidential is referred to as a trade secret. Businesses, irrespective of their size, value trade secrets as much as patents and other forms of intellectual property right and use confidentiality as a business and research innovation management tool, covering a diversified range of information, which extends beyond technological knowledge to commercial data such as information on customers and suppliers, business plans or market research and strategies. By protecting such a wide range of know-how and commercial information, whether as a complement or as an alternative to intellectual property rights, trade secrets allow the creator to derive profit from his/her creation and innovations and therefore are particularly important for research and development and innovative performance.

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[4] TRIPS is an international agreement administered by the World Trade Organization that sets down minimum standards for many forms of intellectual property regulation. The areas of intellectual property that it covers are copyright and related rights, trademarks, geographical indications, industrial designs, patents, including the protection of new varieties of plants, the layout-designs of integrated circuits and undisclosed information including trade secrets and test data.

[5] Proposal for a Directive of the European Parliament and of the Council on the protection of undisclosed know-how and business information (trade secrets) against their unlawful acquisition, use and disclosure. The directive was approved by the European Parliament on 14 April 2016 and adopted by the Council on 27 May 2016.

Some researchers have argued that it is preferable from a social standpoint for inventions to be patented because, in addition to protecting the returns from innovation, the disclosure required by patents encourages further innovation as others build upon the original idea, even if the technical value of patent disclosures has been questioned by some researchers[6].

In summary, the advantages of trade secrets include:

- Broad range of protectable subject matter, including inventions that may not qualify for patent protection;
- No formal registration required, avoiding the associated costs;
- Applies to innovation in the early stages of innovative process[7];
- Disclosure of invention not required;
- May be used in combination with other IP protection mechanisms to protect complex innovations[8];
- Unlimited term of protection.

Potential disadvantages of trade secret compared to registered IPRs, especially patents, include:

- Invention not protected against reproduction through reverse engineering, independent discovery or inadvertent disclosure;
- Requires substantial investments and ongoing expenses for internal controls to protect trade secrets from misappropriation;
- Requires explicit non-disclosure and not-compete clauses in employee contracts which may inhibit employee mobility or trigger payment of indemnification if enforceable;
- Application of trade secret laws uncertain and remedies may vary by jurisdiction.

In addition, from society's point of view, the non-disclosure of inventions inherent in trade secrets use may inhibit the dissemination of knowledge and technology.

When protecting innovations through patents, firms face a trade-off between disclosing information and obtaining a temporary monopoly for commercialising their inventions (Hall et al., 2014). Since disclosing information may help competitors to develop competing innovations based on a similar technological approach, firms may opt to keep their inventions secret. Theoretical studies show that the choice between patenting and secrecy depends on a variety of factors, including the strength of the protection instrument, the nature of the innovation and the ease of imitation, as well as market structure, firm capabilities and competitor strategies (see Anton and Yao, 2004; Kultti et al., 2006, 2007; Mosel, 2011; Panagopoulos and Park, 2015; Ottoz and Cugno, 2011). Empirical studies frequently find that firms favour secrecy over patenting (Levin et al., 1987; Brouwer and Kleinknecht, 1999; Cohen et al., 2000, 2002; Hall et al., 2013) and consider the former to be more effective than patenting (Arundel, 2001).

While many theoretical studies treat patenting and secrecy as substitutes, observed firm practices instead suggest that both protection methods are used simultaneously. At a firm level, provided that the two methods are employed for different innovations, this is straightforward. But firms may also

[6] See Lisa Larrimore Ouellette, "Do Patents Disclose Useful Information?" Harvard Journal of Law & Technology, 2012.
[7] Erkal (2004) stresses that trade secret law complements patent law in earlier stages of the innovation process by allowing innovators to work on their ideas until they become patentable.
[8] Ottoz, E., F. Cugno (2008), "Patent-secret mix in complex product firms"

choose to mix both strategies at the level of individual innovations by protecting some elements of a technology through patents and keeping others secret (Belleflamme and Bloch, 2014). For example, if innovations involve both codified and tacit knowledge, firms may patent the codified knowledge and keep the tacit knowledge secret (Arora, 1997). Firms may also combine patenting and secrecy in a way that enables them to keep the codified part of an invention secret, whilst maintaining the option of later patenting the invention (Graham, 2004).

In this study, the empirical analysis focuses on the choice of innovating firms to protect their innovations through patenting and/or secrecy, and whether this choice affects innovation success and firm performance. Starting from propositions of theoretical models on the interaction between patenting and secrecy, a number of factors that are thought to influence the use of the two protection mechanisms are investigated. Particular emphasis is placed on preferences for either patents or secrecy, and the factors affecting the choice for a combined protection strategy. The present study was conducted for Germany as a pilot for a comprehensive EU-wide study that is currently in progress. It was decided to conduct a pilot study to take advantage of a unique combination of expertise and German Community Innovation Survey (CIS) data available at the Centre for European Economic Research (ZEW) in Mannheim. The methodologies used in the present studies are subsequently being applied to the CIS data for other EU Member States.

In general, analysis at the individual innovation level is not possible with CIS data. However, in the case of Germany, information about the number of different innovations introduced by the firm during the period in question was available. This provided the opportunity to investigate the interaction of patenting and secrecy and the performance impacts of the chosen protection strategy not only on the level of the firm but also on the level of the individual innovation. This was done by carrying out supplementary analyses on a subset of the dataset, containing only firms with a single innovation and thereby ensuring that their answers to the relevant survey questions applied to that particular innovation.

In particular, drawing on Hall et al. (2013), two types of relationships are explored:

(i) the determinants of a firm’s decision to protect its innovations through patents, secrecy, or both; and
(ii) the impact of the chosen protection strategy on innovation performance.

The report is organised as follows: In the following section, hypotheses on determinants of the choice between patenting and secrecy from the theoretical and empirical literature are discussed. Section 3 describes the data and the models used and presents descriptive results. Section 4 presents and discusses results of model estimations. Finally, Section 5 provides a conclusion and discusses some perspectives for further research.

2. Literature and Hypotheses

In a recent literature survey, Hall et al. (2014) summarised the main results of theoretical and empirical work on firms' choices to protect their innovations through various formal and informal methods. Building upon these results, and considering some more recent literature, six hypotheses on the determinants of the use of patenting and secrecy as protection mechanisms for innovation are discussed and analysed in the academic literature. Therefore, these are the hypotheses that are tested in the present study. These propositions are introduced below in summary form, while extended detail is provided in Appendix A.

H1. Strength of IP law

An obvious, though often studied determinant of the use of patenting and secrecy as protection methods, is the effectiveness of patent and trade secrets law. The choice of patenting over secrecy is certainly affected by the probability that innovators can effectively protect their innovation from infringement by patent law. On the other hand, a strong trade secrets law may encourage firms to rely on this protection method.

H2. Degree of innovation competition

The assumption of a sole innovator in the model of Kultti et al. (2007) is rarely found in practice. Most technological markets are characterised by a larger number of firms with similar innovative capacities, which often enter into R&D races for the fastest technological solutions (Lemley, 2012). The degree of innovation competition is commonly seen as a driver for patenting. Where there is the possibility of simultaneous invention, the first inventor will opt for patenting (so as to be first filer and thus protected by EU law), thereby disadvantaging the others. In contrast, if an innovator has a large technological lead over its competitors, and expects to maintain this lead by soon generating new inventions, the lead innovator will prefer secrecy to patenting (Schneider, 2008; Zaby, 2010).

H3. Level of innovation

In their seminal paper, Anton and Yao (2004) model the role of the degree of innovation in terms of small vs. major innovations. They demonstrate that in a model with an innovator and a competitor with less innovative capacity, major innovations are not patented but kept secret to prevent imitation by competitors. Pajak (2010) uses data from the French innovation survey and finds, albeit for a very small sample of firms, that smaller innovations are patented while secrecy is used to protect large innovations.

H4. Type of innovation

Patenting is also preferred over secrecy if the threat of imitation, e.g. by reverse-engineering, is high. In this case, applying for a patent and hence disclosing details about the invention in the patent document would reveal no more information than one could obtain from looking at the innovation. In contrast, if rivals could substantially learn from the information provided in the patent document but could not reverse-engineer the innovation, firms would opt for secrecy (Hall and Harhoff, 2012). In general, reverse-engineering is easier to apply to product innovations. For process innovations that have been developed in-house, and that are not traded, reverse-engineering is largely impossible. For this reason, process innovation will be more likely subject to secrecy while product innovations will be more often protected by patenting.

H5. Open innovation practices

The way firms organise the innovation process is likely to have impacts on their protection strategy. In the literature, there are two views as to how external knowledge sourcing and the choice of protection methods are linked (Arora et al., 2015). The “spillover prevention” approach stresses that collaborating firms favour patenting in order to control spillovers to external partners (Cassiman and Veugelers, 2002), while adopting a secrecy strategy is more difficult when firms are engaged in collaboration (Giarratana and Mariani, 2014).

H6. Financial constrains

Applying for patents and monitoring potential infringements is costly. Consequently, firms with financial constraints may opt for protection methods which imply lower costs, such as secrecy[9]. Graham et al. (2009), as well as Cordes et al. (1999), have found that the most significant reason why start-ups and small high-tech firms refrain from patenting are the costs involved. The study by Hall et al. (2013) carried out using data from the UK innovation survey, found that firms reporting financial constraints on their innovative activity tend to prefer secrecy over patenting. In addition, patenting is often subject to economies of scale; larger businesses therefore tend to make greater use of patents (Lerner, 1995; Arundel and Kabla, 1998).

Combining patenting and secrecy

While much of the literature considers patenting and secrecy as substitutes for one another, or even as mutually exclusive protection strategies, they can also complement one another (Hall et al., 2014; Arora, 1997). Graham (2004) argues that firms may keep the codified part of an invention secret, while maintaining the option to later patent the invention. Hedge et al. (2009) stress the role of continuations in patenting which allow individual claims to be altered, thereby extending secrecy with regard to specific claims. In their empirical study, Graham and Hedge (2014) find that a small fraction of U.S. patent applications (7.5%) use a provision to keep their inventions secret before a patent is granted.

Patenting, secrecy and firm performance

Effective protection of innovations should give innovators a performance premium as they are then able to prevent others from imitating their innovation. It should hold for all types of protection methods, that effectively protected innovations enjoy higher levels of innovation success. There are rather few empirical studies investigating this relationship. Hussinger (2006) used German innovation data and found that sales from product innovations are higher for firms rating patents as important for protecting their innovations. A significant impact from secrecy on new product sales however, is not observed. Hall et al. (2013) use UK innovation data and identify a strong impact of patents (as well as trade marks) on sales from new-to-the-market innovations, but no impact on innovations that were only new to the firm. Informal protection methods, including secrecy, have a positive impact on both categories of product innovations, though the effect on new-to-firm innovations is lower and less significant. These findings suggest that patent protection is better suited to preventing competitors from imitating an innovation. It would also seem that firms overrate the effectiveness of secrecy as a

[9] Although it must be stated that trade secrets can be expensive to protect as well, requiring strict security measures and ongoing efforts for effective protection. The trade-off between patenting and secrecy also depends on the number of countries in which patent protection is desired.

protection method, perhaps because they lack a reference value for innovation success when using patent protection.

To date, there are no empirical analyses concerning patenting and secrecy on process innovations success. In addition, no empirical work has yet considered the interaction between patenting and secrecy when it comes to performance impacts of protection strategies. This study aims to begin filling this gap.

3. Model, Data and Descriptive Results

3.1. Data

This study is based on data from a German innovation survey panel, the Mannheim Innovation Panel which constitutes the German contribution to the European Commission's Community Innovation Surveys. Almost 6000 German companies responded to questions covering the effectiveness of various appropriation methods to protect their innovations in surveys carried out in 2010 and 2012.

This data is complemented by information on the firms' patent and trade mark applications. In contrast to previous empirical studies, the partial panel nature of the data was exploited in order to analyse innovation performance impacts for both product and process innovations.

Community Innovation Survey

The Community Innovation Survey (CIS) data form part of the suite of EU science and technology statistics. The survey is designed to provide information on the innovation activities of enterprises by sector, by type of enterprise, by type of innovation and on various aspects of the development of innovations. On occasion, questions about the use of IP rights and other methods for protecting innovation have been included in the survey. The CIS provides statistics broken down by countries, type of innovators, economic activities and size classes.

The CIS is carried out every two years by EU member states[10] and a number of ESS[11] countries. Compiling CIS data is voluntary, so that data for all 28 Member States is not always available for a particular survey year.

In the most recent CIS for which complete data are available (2012), a question about appropriability mechanisms was included in the harmonised survey. Such appropriability questions in CIS and similar surveys have been the basis for most empirical studies on trade secrets to date.

German data are collected by ZEW, which has been commissioned by the Federal Ministry of Education and Research to conduct the German CIS. ZEW included the appropriability questions not only in 2012 but also in the 2010 CIS. In both surveys a question about the number of innovations in the period was added. This additional information makes the German CIS data particularly valuable for studying the protection mechanisms used by innovating firms.

One of the limitations of this research is the lack of panel data analysis. As there were two survey waves containing information on protection strategies, it was possible to use one year lags for the impact of protection strategies on innovation output, although no real panel data analysis could be performed. While firms with a single innovation could be identified, allowing, to some extent, the assignment problem to be addressed, the sample of single innovators still could be a biased sample and may not be representative for the entire group of innovating firms.

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[10] Some countries carry out annual surveys.
[11] The ESS is a partnership between the EU statistical office (Eurostat), and the national statistical bodies in all EU Member States as well as the EEA and EFTA countries.

3.2. Descriptive Results

Table 1 provides detail on the size and structure of the survey sample, covering all innovating companies and the sub-samples of both single and multiple innovating companies.

Table 1: Descriptive statistics for innovating firms

	All innovators	Single innovators	Multiple innovators	Sig.[1)]
Age (years)	32.0	27.6	33.2	**
Size (# employees)	581.7	487.2	607.2	-
High technological uncertainty (%)	4.15	4.01	4.19	-
Large number of competitors (%)	22.3	22.8	22.2	-
Small number of competitors (%)	41.6	42.3	41.4	-
New-to-market innovation (%)	35.4	29.9	36.8	**
Innovation intensity (1,000 € per employee)	19.1	17.8	19.6	-
Process innovator (%)	61.3	52.1	63.8	**
Cooperation with businesses (%)	25.6	23.1	26.3	*
Cooperation with research (%)	31.3	31.0	31.4	-
Credit rating (index)	3.83	3.77	3.84	**
Sales share, new-to-market innovations (%)	5.61	5.49	5.64	-
Sales share, new-to-firm innovations (%)	15.4	12.5	16.2	**
Share of cost reduction from process inn. (%)	2.56	2.00	2.72	**
Profit margin (categorical 1 to 9)	5.68	5.61	5.70	-
Continuous R&D (%)	46.8	38.9	48.9	**
Capital intensity (1,000 € per employee)	155.7	118.4	166.2	-
No. of observations	5,857	1,246	4,611	

1) ** / *: difference between single and multiple innovators significant at the 1% / 5% level.

Statistical differences observed between Single and Multi innovators conform to prior expectations, as “older” multiple innovators have the capability to introduce greater numbers of new innovations to market, are able to engage in process innovation and cost reductions and have the financial capability (as indicated by their credit rating) to engage in continuous R&D.

Table 2 shows the use of patents and trade secrets and the perceived effectiveness of each of the two protection mechanisms. The share of innovating firms using patents to protect their IP and their innovations is significantly smaller than the share of firms using trade secrets. In the 2012 survey, 74.1% of all innovating firms, that is to say all firms having introduced product or process innovations, used trade secrets, while only 47.8% used patents.[12] For single innovators, these percentages are smaller with respect to the use of trade secrets (62.5%), and at a similar level for patents (45.0%).

[12] All descriptive results are based on weighted data. The German Innovation Survey is a sample survey based on a stratified random sample with 896 strata (56 NACE 2-digit sectors, 8 size classes, 2 regions). Weights are calculated using population figures from the official German Business Register. Weights have been adjusted for a potential non-response bias between innovating and non-innovating firms. See Aschhoff et al. (2013) for details on the weighting method.

There has been an increase of use of patents from 2010 to 2012 (36.8% to 47.8%) and an even greater increase in the use of trade secrets (57.3% to 74.1%).

Table 2: Use of patents and trade secrets in innovating firms in Germany 2010 and 2012

	Patents		Trade Secrets	
	2010[a)]	2012[b)]	2010[a)]	2012[b)]
a) all innovating firms	Percent			
Use	36.8	47.8	57.3	74.1
Therein: high importance / effectiveness	*11.9*	*18.8*	*34.5*	*24.8*
Therein: medium importance / effectiveness	*9.3*	*16.6*	*14.7*	*25.7*
Therein: low importance / effectiveness	*15.6*	*12.5*	*8.2*	*23.6*
b) innovating firms with a single innovation				
Use	38.4	45.0	60.6	62.5
Therein: high importance / effectiveness	*12.6*	*15.5*	*39.5*	*17.7*
Therein: medium importance / effectiveness	*10.5*	*16.4*	*15.3*	*23.4*
Therein: low importance / effectiveness	*15.4*	*13.2*	*5.7*	*21.3*

a) Used for protecting the intellectual property of a firm. - b) Used for maintaining or increasing the competitiveness of product and process innovations.
Source: German Innovation Survey (CIS 2010, CIS 2012), CIS core sectors only, weighted results.

These results confirm the findings of earlier empirical studies on the use of patents and secrecy which have frequently found that a higher proportion of innovating firms rely on secrecy than patenting (see Levin et al., 1987; Brouwer and Kleinknecht, 1999; Cohen et al., 2000, 2002; Arundel, 2001; Hanel, 2008).

Table 3 shows the use of patents and trade secrets by size of the company.

Table 3: Use of patents and trade secrets in innovating firms in Germany 2012, by size class (no. of employees)

	Patents			Trade Secrets		
	10-49	50-249	250+	10-49	50-249	250+
All innovating firms	40.9	58.6	72.8	71.2	79.1	82.4
Innovating firms with a single innovation	42.3	50.9	81.6	61.3	64.5	86.5

Source: German Innovation Survey (CIS 2012), CIS core sectors only, weighted results.

The larger the company, the greater is the use of both patents and trade secrets. All size groups make greater use of trade secrets than of patents, but the difference between the two protection mechanisms narrows as the firm size increases. Among innovating companies with 10 to 49 employees, 41% use patents while 71% use trade secrets, while for companies with more than 250 employees, these proportions are 73% and 82%, respectively, a much smaller difference.

Firms regularly combine patenting and secrecy to protect their innovations. The two protection methods are not mutually exclusive. Table 4 shows the use of patents and trade secrets in combination by innovating firms.

Table 4: Combination of patents and trade secrets in innovating firms in Germany 2012

		Trade Secrets	
		Used	Not used
a) all innovating firms			
Patents	Used	42.8	5.0
	Not used	31.3	20.9
b) innovating firms with a single innovation			
Patents	Used	38.6	6.4
	Not used	23.8	31.2

Source: German Innovation Survey (CIS 2012), CIS core sectors only, weighted results.

In 2012, 42.8% of all innovating firms in Germany used both patenting and secrecy, whilst 20.9% used neither. Among single innovators, the corresponding figures were 38.6% and 31.2%. Presumably, firms that use neither patents nor trade secrets use other protection methods such as lead time, trademarks, copyrights or industrial design rights. There is a further group of firms that do not protect their innovations at all, mostly because they are imitators ("new-to-firm only innovations").

3.3. Models

Following Hall et al. (2013), two types of empirical models are tested:

(i) the determinants of using patenting and secrecy as methods to protect a firm's innovations; and

(ii) the impact of patenting and secrecy effectiveness on a firm's product and process innovation output.

The analysis of Hall et al. (2013) is extended by considering a larger number of potential determinants, by looking at process innovation success, and by using firm profitability (rather than employment growth) as a performance measure. Importantly, this allows analysis for a sub-sample of innovators with only a single innovation to be completed. This approach enables the determinants and the impacts of combining patent and secrecy strategies to be defined. Further details on the mathematical construct of these models, data and the variables used to test the hypotheses laid out is provided in Appendix B.

The first model relates a firm's *i* decision to use patents or trade secrets as a protection methods (*pm*) to a set of variables that are intended to represent the six hypotheses discussed above (strength of IP law - *ip_str*, degree of innovation competition - *in_com*, level of innovation - *in_lev*, type of innovation - *in_typ*, open innovation practices - *in_op* and financial constraints - *fi_con*):

$$pm_i = \alpha + \beta_1\, ip\_str_i + \beta_2\, in\_com_i + \beta_3\, in\_lev_i + \beta_4\, in\_typ_i + \beta_5\, in\_op_i + \beta_6\, fi\_con_i + \chi X_i + \varepsilon_i \qquad [1]$$

where *pm* represents the use and effectiveness of patents and trade secrets. *pm* is operationalised in different ways. The main model variant employs the four combinations of using patents and trade secrets (none of them, both of them, only patenting, only secrecy). Other model variants employ binary measures (use of patents, use of trade secrets, high importance of patents, high importance of secrets, importance of patents dominate over trade secrets, importance of trade secrets dominate over patents) or the firms' assessment of the effectiveness of the two protection methods (measured at a 4-point Likert scale). In another model variant, the structure of Arundel (2001) and Hall et al. (2013) is followed by using a measure of the relative importance of trade secrets over patents. This measure gives the difference between the effectiveness rating of trade secrets and the effectiveness rating of patents and can hence range from +3 (trade secrets are highly effective, but patents are not effective at all) to -3. The vector *X* includes the size and age of a firm as well as the industry in which a firm operates.

The second model relates the level of innovation returns (*in_out*) a firm *i* obtained in period *z* to the chosen protection method in period *t*:

$$in\_out_{iz} = \alpha + \beta\, pm_{it} + \chi X_{it} + \varepsilon_{iz} \qquad [2]$$

where *in_out* covers measures of product innovation (sales with new products) and process innovation success (cost reduction). Control variables (vector *X*) include size, age and the level of innovation input.

In line with Hall et al. (2013), all models are restricted to innovating firms. These are firms which have introduced a product or a process innovation in the last three years. This restriction ensures that only firms that have had to decide whether and how to protect recently introduced innovations are included in the analysis.

4. Estimation Results

4.1. Protection Method Decision

A firm's choice to use secrecy or patenting to protect its innovation and IP, and the perceived effectiveness of the two instruments through different measures, were analysed. **Table 5** reports the results for the four combinations of using secrecy and patenting. In particular, this model variant allows the relevance of the six hypotheses on a firm's choice to use both protection methods simultaneously, or to rely only on one of the two, to be investigated. For comparison,

Table 9 (Appendix E) shows the model results when looking separately at a firm's decision to use trade secrets or patents (by allowing error terms to be correlated), and **Table 10** presents the respective estimation results for firms evaluating the effectiveness of trade secrets and patents as high.

The results of ordered probit regressions on the firm's Likert scale evaluation of the effectiveness of secrecy and patenting are shown in **Table 11** (Appendix E). Further model variants look at the relative importance of secrecy over patenting by taking the difference between the secrecy and patenting ratings, as done in Hall et al. (2013) (see **Table 12**, Appendix E), and by separating firms that rate the effectiveness of both secrecy and patenting as being medium or high from those that rate only one of the two methods as such (**Table 13**, Appendix E).

Models were estimated for all innovators and for single innovators. The estimation results of the various model variants reveal a number of common findings. Innovating firms are found to be more likely to combine patents with secrecy, as Intellectual Property law becomes stronger and as technology uncertainty increases. This outcome provides supporting evidence for H1 (see **Table 5** and in Appendix E, **Table 12** and **Table 13**). The results hold for both single innovators and for all innovators.

High technological uncertainty is a driver for combining secrecy and patenting both in firms with a single innovation, and in the entire group of innovators (see **Table 5**). This is in line with the findings illustrated in Ponce's (2007) model on preventing competitors from developing the same innovation.

Patents are more likely to be used (alone or in combination with secrecy), when innovations are new-to-market and in open innovation practices such as research cooperation, as discussed in H5. A positive and significant coefficient is found for the use of both patenting and secrecy, and the use of only patenting (see **Table 5** below and **Table 12** and **Table 13** in Appendix E).

The use of secrecy is identified as being more important for process innovations, lending some support to H4 above. The conclusion is supported mainly by the significant coefficient for the effectiveness of secrecy (see **Table 10** in Appendix E); it is also supported by the positive coefficient of preference in **Table 12,** and the negative coefficient for *patenting dominating* in **Table 13**. The results for single innovators are less conclusive.

Innovators with new-to-market innovations favour patenting over secrecy. A positive and significant coefficient is found for the use of both patenting and secrecy, and the use of only patenting. Single innovators that heavily invest in innovation prefer to combine both protection methods and are much less likely to refrain from using either of the two. This result supports H3 and is in line with the literature which stresses that patenting is more commonly used for large innovations (Moser, 2011).

A robust result for the impact of the degree of licensing on the choice of the protection method is not found.

H1 on the strength of IP law is confirmed, as firms operating in sectors with a high share of innovators with patents are more likely to prefer patenting and are less likely to rely on secrecy. The results hold for both single innovators and for all innovators.

A high degree of competition, measured in terms of the number of competitors in a firm's main market, reduces the use of both secrecy and patenting, as suggested by the model provided by Gill (2008), and the perceived effectiveness of both (see **Table 10** and **Table 11**, Appendix E). This, however, is somewhat contrary to H2 above, which posits a positive relationship between competition and the use of patenting.

Table 5: Determinants of using secrecy and/or patenting to protect a firm's innovations / IP: results of probit models (estimated coefficients, significance levels in brackets)

		All innovators				Firms with a single innovation			
		Neither secrecy nor patenting	Only patenting	Only secrecy	Both patenting and secrecy	Neither secrecy nor patenting	Only patenting	Only secrecy	Both patenting and secrecy
Strength of IP Law	Share of innovators with patents	-1.134***	0.505**	-0.643***	1.240***	-0.554*	0.506	-0.716***	1.005***
		(0.000)	(0.010)	(0.000)	(0.000)	(0.065)	(0.231)	(0.008)	(0.000)
	Share of out-licensed patents	-0.005	-0.046	0.009	0.017	-0.009	-0.047	0.012	0.008
		(0.756)	(0.148)	(0.564)	(0.244)	(0.747)	(0.341)	(0.644)	(0.772)
Degree of innovation competition	High technological uncertainty (D)[a)]	-0.133***	-0.086	-0.006	0.122***	-0.370***	-0.238	0.061	0.279***
		(0.003)	(0.179)	(0.879)	(0.002)	(0.000)	(0.102)	(0.482)	(0.001)
	Large no. of competitors (D)[a)]	0.009	-0.216**	0.026	0.017	0.219**	-0.142	-0.013	-0.156
		(0.867)	(0.017)	(0.604)	(0.740)	(0.049)	(0.481)	(0.904)	(0.151)
	Small number of competitors (D)[a)]	-0.004	-0.080	-0.087**	0.076*	0.115	0.094	-0.118	-0.050
		(0.935)	(0.222)	(0.049)	(0.077)	(0.255)	(0.516)	(0.211)	(0.591)
	Competition has increased (D)[a)]	-0.081*	-0.015	0.014	0.035	0.006	0.192	0.058	-0.096
		(0.095)	(0.840)	(0.743)	(0.426)	(0.951)	(0.234)	(0.544)	(0.323)
Level of innovation	Market novelty (D)[a)]	-0.527***	0.234***	-0.082*	0.369***	-0.542***	0.411***	-0.100	0.378***
		(0.000)	(0.000)	(0.059)	(0.000)	(0.000)	(0.004)	(0.293)	(0.000)
	Innovation intensity (log)[a)]	-0.095***	-0.060**	-0.030**	0.102***	-0.152***	0.017	0.001	0.105***
		(0.000)	(0.010)	(0.045)	(0.000)	(0.000)	(0.710)	(0.968)	(0.001)
	No innovation expenditure (D)	1.004***	0.142	-0.097	-0.862***	1.222***	-0.664	-0.160	-0.794***
		(0.000)	(0.428)	(0.370)	(0.000)	(0.000)	(0.127)	(0.491)	(0.001)
Type of innovation	Process innovator (D)	0.018	-0.143**	0.025	-0.005	0.101	-0.098	0.039	-0.113
		(0.672)	(0.021)	(0.522)	(0.904)	(0.238)	(0.458)	(0.625)	(0.160)
Open innovation practice	Cooperation with businesses (D)[a)]	-0.122*	-0.002	0.073	0.012	0.014	0.028	-0.086	0.114
		(0.064)	(0.979)	(0.176)	(0.809)	(0.915)	(0.873)	(0.441)	(0.283)
	Cooperation with research (D)[a)]	-0.336***	-0.066	-0.224***	0.388***	-0.265**	-0.092	-0.159	0.334***
		(0.000)	(0.408)	(0.000)	(0.000)	(0.025)	(0.561)	(0.128)	(0.001)

Table 5: Ctd.

		All innovators				Firms with a single innovation			
		Neither secrecy nor patenting	Only patenting	Only secrecy	Both patenting and secrecy	Neither secrecy nor patenting	Only patenting	Only secrecy	Both patenting and secrecy
Financial constraints	Credit rating (lagged)	0.040	-0.032	-0.007	-0.022	0.051	0.002	-0.023	-0.031
		(0.158)	(0.438)	(0.803)	(0.402)	(0.324)	(0.985)	(0.656)	(0.567)
	High profit margin (lagged)[a)]	-0.039	-0.100	-0.013	0.041	-0.006	-0.133	-0.036	0.058
		(0.459)	(0.201)	(0.791)	(0.382)	(0.951)	(0.432)	(0.710)	(0.557)
	Low profit margin (lagged)[a)]	-0.078	0.087	0.025	-0.005	-0.016	-0.014	-0.058	0.066
		(0.228)	(0.330)	(0.675)	(0.931)	(0.902)	(0.946)	(0.643)	(0.592)
Controls	Age (log # years)	0.076***	0.042	-0.023	-0.062***	0.153***	0.008	-0.006	-0.136***
		(0.000)	(0.175)	(0.228)	(0.001)	(0.001)	(0.915)	(0.894)	(0.002)
	Size (log # employees)	-0.113***	0.019	-0.095***	0.151***	-0.101***	0.023	-0.086**	0.150***
		(0.000)	(0.351)	(0.000)	(0.000)	(0.004)	(0.649)	(0.012)	(0.000)
Applies to		1,543	271	1,408	2,635	366	57	339	484
No. of observations		5,857	5,857	5,857	5,857	1,246	1,246	1,246	1,246

*, **, ***: significant at 10%, 5%, 1% level. D: dummy variable.
a) Missing values for these variables have been set to 0 and indicators were added to indicate this data change.
All models include 15 sector dummies and an indicator for the survey wave used.

The last hypothesis (H6) on the role of financial constraints is not supported by the data. A higher propensity to rely on secrecy rather than patenting for firms with lower financial resources is not found. Most indicators of a firm’s internal and external financial situation are insignificant in the majority of model variants. This could be the result of the uncertainty in respect of the cost trade-off between patenting and secrecy referred to in footnote 9 above. There is some indication that single innovators with a high level of profitability rate secrecy as being more effective than patenting, which is in contrast to the theoretical expectation.

With respect to the control variables for age and size it is found that younger firms as well as larger firms are more likely to rely on a combined strategy of secrecy and patenting. While the result for larger firms is to be expected, as a combined strategy is more demanding and tends to require more resources, the higher propensity of young firms may indicate that their innovations are more vulnerable to being copied or imitated by others as they lack complementary assets that can be used to protect their innovations such as reputation or brand value.

4.2. Innovation Returns

The results of the innovation return[13] models suggest that combining patenting and secrecy as protection methods yields higher returns with new-to-market innovations; the effect for patents is higher than for secrecy (see **Table 6** below). This result is supported by **Table 15** (Appendix E) which shows a weakly significant negative effect of the relative importance of secrecy over patenting for new product success.

A significant impact of the chosen protection method on innovation success with product imitation (new-to-firm-innovation) is not detected, suggesting that this type of innovation is difficult to protect effectively by using these two methods. For cost savings from process innovation, there is a slightly positive impact of innovators that rely more on secrecy than on patenting.

[13] "Innovation returns" refers to the new products and processes resulting from innovation activities. Its covers measures of product innovation (e.g., sales of new products) and process innovation (e.g., cost reduction).

Table 6: Effects of using secrecy and patenting on innovation success: results of OLS models (estimated coefficients, significance levels in brackets)

	All innovators						Firms with a single innovations					
	New-to-market innovations		Only new-to-firm innovations		Cost reductions owing to process innovations		New-to-market innovations		Only new-to-firm innovations		Cost reductions owing to process innovations	
	No lag	1 year lag	No lag	1 year lag	No lag	1 year lag	No lag	1 year lag	No lag	1 year lag	No lag	1 year lag
Secrecy only	0.605***	0.352*	0.411***	0.830***	0.224*	0.926***	0.380*	0.478	0.410	0.336	-0.012	0.282
(D)	(0.000)	(0.089)	(0.006)	(0.001)	(0.081)	(0.000)	(0.087)	(0.200)	(0.159)	(0.506)	(0.960)	(0.539)
Patenting only	1.591***	1.367***	0.388	0.530	-0.216	0.475	2.034***	1.196	-0.382	0.033	-0.536	0.169
(D)	(0.000)	(0.001)	(0.160)	(0.243)	(0.376)	(0.355)	(0.000)	(0.171)	(0.495)	(0.972)	(0.176)	(0.814)
Both secrecy and	1.398***	0.910***	0.418***	0.741***	0.248*	0.993***	1.131***	1.311***	0.252	0.116	-0.186	0.452
patenting (D)	(0.000)	(0.000)	(0.005)	(0.003)	(0.052)	(0.000)	(0.000)	(0.001)	(0.400)	(0.819)	(0.414)	(0.243)
Size (log #	0.470***	0.554***	0.750***	0.975***	0.695***	0.854***	0.115	0.143	0.357***	0.817***	0.452***	0.510***
employees)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.163)	(0.289)	(0.001)	(0.000)	(0.000)	(0.004)
Age (log #	0.005	-0.124	0.081	0.250***	-0.098*	-0.015	0.131	0.222	0.039	0.037	0.002	0.039
years)	(0.923)	(0.203)	(0.165)	(0.007)	(0.065)	(0.890)	(0.173)	(0.211)	(0.759)	(0.865)	(0.981)	(0.843)
Innovation	0.322***	0.293***	0.265***	0.307***	0.205***	0.376***	0.236***	0.264**	0.220**	0.307**	0.125*	0.307**
intensity (log)[a)]	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.016)	(0.014)	(0.046)	(0.069)	(0.032)
No innovation	-2.129***	-2.357***	-1.132***	-2.926***	-1.696***	-2.632***	-1.731***	-1.817**	-1.385**	-3.791***	-0.765	-2.707***
expenditure (D)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.019)	(0.046)	(0.000)	(0.134)	(0.002)
Continuous	1.163***	1.136***	0.469***	1.419***	0.275**	0.771***	1.003***	1.599***	-0.358	1.317***	0.530***	0.568
R&D (D)[a)]	(0.000)	(0.000)	(0.000)	(0.000)	(0.018)	(0.002)	(0.000)	(0.000)	(0.159)	(0.006)	(0.008)	(0.207)
No. of observations	4,662	1,676	4,662	1,648	4,662	1,229	1,033	363	1,033	360	1,033	257

*, **, ***: significant at 10%, 5%, 1% level. D: dummy variable.
a) Missing values for these variables have been set to 0 and indicators were added to indicate this data change.
All models include 15 sector dummies and an indicator for the survey wave used.

5. Conclusions and directions for further research

This study investigated the determinants and outcomes of German firms' decisions to protect their innovations though trade secrets and patents. In particular, the role played by a combined protection strategy, i.e. using secrecy and patenting simultaneously as a protection strategy was addressed. In order to overcome the assignment problem[14] common to firm-level innovation surveys, unique information on the number of completed innovation projects from the German innovation survey was used. By analysing the subset of firms with a single innovation as well as all innovators, it was possible to establish the drivers for using both secrecy and patenting to protect an innovation, and the performance effect of this strategy with respect to innovation returns, compared to using only one or none of the two methods. The empirical analysis is based on two survey waves of the German innovation survey (reference years 2010 and 2012), with a total of 5,857 observations on firms, 1,246 of which reported a single (product or process) innovation.

It is discovered that firms combine secrecy and patenting when the strength of patent protection in their sector is high, when technological uncertainty is high and when when innovations are new-to-market and require significant financial investment. In addition, innovators that co-operate with research bodies are more likely to use patents (alone or in combination with secrecy). . Younger firms, as well as larger firms have a higher propensity to follow a protection strategy that combines patenting and secrecy. Based on the data, financing constraints do not significantly affect the choice made between secrecy and patenting.

When comparing the determinants for the choice of either secrecy or patenting as a protection strategy, few differences are discovered. Both secrecy and patenting tend to play a more important role as the level of innovation increases, patent protection is stronger and if technological uncertainty is high. The main difference relates to process innovators which are more likely to rely on secrecy rather than on patenting. While both protection methods trigger innovation returns (compared to innovators using neither of the two instruments), secrecy is more effective with respect to obtaining higher cost reductions from process innovation, whilst patenting is more effective for new-to-market innovations.

In carrying out future studies of this type, panel data and information on innovation-specific protection strategies of multiple innovators would be extremely helpful to widen the understanding of the role of secrecy and patenting for increasing the returns to innovation. It is therefore very important that questions on appropriability mechanisms used by firms continue to be a core part of the Community Innovation Survey in the coming years[15].

Restoring these questions will allow further analysis of the development and uses of trade secrets, patents, and other forms of IP rights following the implementation of the Trade Secret Directive[16]. The CIS would become even more useful as evidence base for policy formulation if the question on the number of innovations initiated in a particular period were included, as has been the case in the German version of the survey.

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[14] That is, the inability to associate a particular protection strategy with a particular innovation in a firm that has several innovations.

[15] Similar support for the continuation of the appropriability questions in the CIS can be found in a study on Trade Secrets and Confidential Business Information in the Internal Market, by Baker & McKenzie, carried out for the European Commission in 2013, which recommended that such questions should be reinstated in the CIS.

[16] It should also be noted that with the Defend Trade Secrets Act of 2016, the USA, like the EU, has new legislation on trade secret protection. It is therefore of interest to carry out further studies on the use and impact of trade secrets on both sides of the Atlantic in the coming years.

6. References

Alexy, O., P. Criscuolo, A. Salter (2009), Does IP strategy have to cripple open innovation? *MIT Sloan Management Review* 51, 71–77.

Alexy, O., G. George, A.I. Salter (2013), Cui bono? The selective revealing of knowledge and its implication for innovative activity, *Academy of Management Review* 38, 270–291.

Anton, J.J., D.A. Yao (2004), Little patents and big secrets: managing intellectual property, *RAND Journal of Economics* 35(1), 1–22.

Arora, A. (1997), Patents, licensing and market structure in the chemical industry, *Research Policy* 26(4–5), 391–403.

Arora, A., W. Cohen, J. Walsh (2016), The Acquisition and Commercialization of Invention in American Manufacturing: Incidence and Impact, *Research Policy* 45, 1113–1128.

Arora, A., S. Athreye, C. Huang (2015), *The Paradox of Openness Revisited: Collaborative Innovation and Patenting by UK innovators*, UNU-MERIT Working Paper Series 2015-031, Maastricht.

Arundel, A. (2001), The relative effectiveness of patents and secrecy for appropriation, *Research Policy* 30(4), 611–624.

Arundel, A., I. Kabla (1998), What percentage of innovations are patented? Empirical estimates for European firms, *Research Policy* 27(2), 127–141.

Aschhoff, B., E. Baier, D. Crass, M. Hud, P. Hünermund, C. Köhler, B. Peters, C. Rammer, E. Schricke, T. Schubert, F. Schwiebacher (2013), *Innovation in Germany - Results of the German CIS 2006 to 2010*, ZEW Documentation 13-01, Mannheim.

Belleflamme, P., F. Bloch (2014), *Dynamic Protection of Innovations through Patents and Trade Secrets*, mimeo, Université Catholique de Louvain.

Bhattacharya, S., S. Guriev (2006), Patents vs. trade secrets: knowledge licensing and spillover, *Journal of the European Economic Association* 4(6), 1112–1147.

Biswas, T., J. MacHardy (2012), *Secrecy versus Patents: Process Innovations and the Role of Uncertainty*, Department of Economics Working Paper 1749-8368, University of Sheffield.

Bos, B., T.L.J. Broekhuizen, P. de Faria (2015), A dynamic view on secrecy management, *Journal of Business Research* (doi: 10.1016/j.jbusres.2015.04.009).

Brouwer, E., A. Kleinknecht (1999), Innovative output, and a firm's propensity to patent: an exploration of CIS micro data, *Research Policy* 28(6), 615–624.

Buss, P., C. Peukert (2015), R&D outsourcing and intellectual property infringement, *Research Policy* 44, 977–989.

Cassiman, B., R. Veugelers (2002), R&D cooperation and spillovers: some empirical evidence from Belgium, *American Economic Review* 92, 1169–1184.

Cohen, W.M., A. Goto, A. Nagata, R.R. Nelson, J.P. Walsh (2002), R&D spillovers, patents and the incentives to innovate in Japan and the United States, *Research Policy* 31(8–9), 1349–1367.

Cohen, W.M., R.R. Nelson, J.P. Walsh (2000), *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)*, National Bureau of Economic Research Working Paper 7552, Cambridge, Ma.

Cordes, J.J., F.R. Hertzfeld, N.S. Vonortas (1999), *A Survey of High Technology Firms*, Report to the Office of Chief Counsel for Advocacy at the United States Small Business Administration, Washington: The George Washington University.

Cosh, A., J.J. Zhang, A. Bullock, I. Milner (2011), *Open Innovation Choices - What Is British Enterprise Doing?* London: UK-Innovation Research Centre.

Crass, D. (2014), *The Impact of Brand Use on Innovation Performance – Empirical Results for Germany,* ZEW Discussion Paper No. 14-119, Mannheim.

Cugno, F., E. Ottoz (2006), Trade secret vs. broad patent: the role of licensing, *Review of Law and Economics* 2(2), 209–221.

Dass, N., V. Nanda, S.C. Xiao (2015), *Intellectual Property Protection and Financial Markets: Patenting vs. Secrecy*, mimeo, Georgia Institute of Technology.

Denicolò, V., L. Franzoni (2004), Patents, secrets, and the first-inventor defense, *Journal of Economics and Management Strategy* 13, 517–538.

Denicolò, V., L. Franzoni (2010), On the winner-take-all principle in innovation races, *Journal of the European Economic Association* 8(5), 1133–1158.

Erkal, N. (2004), On the interaction between patent and trade secret policy, *Australian Economic Review* 37, 427–435.

Geroski, P., S. Machin, J. van Reenen (1993), The profitability of innovating firms, *RAND Journal of Economics* 24, 198–211.

Gill, D. (2008), Strategic Disclosure of Intermediate Research Results, Journal of Economics and Management Strategy 17, 733-758.

Giarratana, M.S., M. Mariani (2014), The relationship between knowledge sourcing and fear of imitation, *Strategic Management Journal* 35(8), 1144–1163.

Graham, S.J.H. (2004), *Hiding in the Patent's Shadow: Firms' Uses of Secrecy to Capture Value from New Discoveries*, GaTech TI:GER Working Paper Series, Georgia Institute of Technology.

Graham, S.J.H., D. Hegde (2014), *Do Inventors Value Secrecy in Patenting? Evidence from the American Inventor's Protection Act of 1999*, mimeo, New York University.

Graham, S.J.H., R.P. Merges, P. Samuelson, T. Sichelman (2009), High technology entrepreneurs and the patent system: results of the 2008 Berkeley Patent Survey, *Berkeley Technology Law Journal* 24(4), 1255–1327.

Hagedoorn, J., A.-K. Ridder (2012), *Open Innovation, Contracts, and Intellectual Property Rights: An Exploratory Empirical Study*, UNU-MERIT Working Paper Series 2012-025, Maastricht.

Hall, B.H., D. Harhoff (2012), Recent Research on the Economics of Patents, *Annual Review of Economics* 4(1), 541–565.

Hall, B.H., C. Helmers, M. Rogers, V. Sena (2013), The importance (or not) of patents to UK firms, *Oxford Economic Papers* 65(3), 603–629.

Hall, B.H., C. Helmers, M. Rogers, V. Sena (2014), The choice between formal and informal intellectual property: a review, *Journal of Economic Literature* 52(2), 1–50.

Hanel, P. (2008), The use of intellectual property rights and innovation by manufacturing firms in Canada, *Economics of Innovation and New Technology* 17(4), 285–309.

Harabi, N. (1995), Appropriability of technical innovations: an empirical analysis, *Research Policy* 24(6), 981–992.

Hedge, D., D.C. Mowery, S.J.H. Graham (2009), Pioneering inventors or thicket builders: which U.S. firms use continuations in patenting? *Management Science* 55(7), 1214–1226.

Henkel, J., S. Schöberl, O. Alexy (2014), The emergence of openness: how and why firms adopt selective revealing in open innovation, *Research Policy* 43, 879–890.

Horstman, I., G. MacDonald, A. Slivinski (1985), Patents as information transfer mechanism: to patent or (maybe) not to patent, *Journal of Political Economy* 93, 837–856.

Hussinger, K. (2006), Is silence golden? Patents versus secrecy at the firm level, *Economics of Innovation and New Technology* 15(8), 735–752.

Jensen, P.H., E. Webster (2009), Knowledge management: does capture impede creation? *Industrial and Corporate Change* 18, 701–727.

Klingebiel, R., C. Rammer (2014), Resource allocation strategy for innovation portfolio management, *Strategic Management Journal* 35(2), 246–268.

Kultti, K., T. Takalo, J. Toikka (2006), Simultaneous model of innovation, secrecy, and patent policy, *American Economic Review* 96(2), 82–86.

Kultti, K., T. Takalo, J. Toikka (2007), Secrecy versus patenting, *RAND Journal of Economics* 38(1), 22–42.

Kwon, I. (2012a), Patent thicket, secrecy, and licensing, *The Korean Economic Review* 28, 27–49.

Kwon, I. (2012b), Patent races with secrecy, *The Journal of Industrial Economics* 60(3), 499–516.

Laursen, K. A.J. Salter (2006), Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms, *Strategic Management Journal* 27(2), 131–150.

Laursen, K., A.J. Salter (2014), The paradox of openness: appropriability, external search and collaboration, *Research Policy* 43(5), 867–878.

Leiponen, A., C. Helfat (2010), Innovation objectives, knowledge sources, and the benefits of breadth, *Strategic Management Journal* 31(2), 224–236.

Lemley, M.A. (2012), The myth of the sole inventor, *Michigan Law Review* 110(5), 709–760.

Lerner, J. (1995), Patenting in the shadow of competitors, *Journal of Law and Economics* 38, 463–495.

Mairesse, J., P. Mohnen (2010), Using innovation surveys for econometric analysis, in: B.H. Hall, N. Rosenberg (eds.), *Handbook of the Economics of Innovation*, Amsterdam and New York: Elsevier, 1129–1155.

Mosel, M. (2011), *Big Patents, Small Secrets: How Firms Protect Inventions When R&D Outcome Is Heterogeneous*, Bavarian Graduate Program in Economics Discussion Paper 105, Munich.

Moser, P. (2012), Innovation without patents: evidence from world's fairs, *Journal of Law and Economics* 55(1), 43–74.

Ottoz, E., F. Cugno (2008), Patent-secret mix in complex product firms, *American Law and Economics Review* 10, 142–158.

Ottoz, E., F. Cugno, (2011), Choosing the scope of trade secret law when secrets complement patents, *International Review of Law and Economics* 31, 219–227.

Ouellette. Lisa L, "Do Patents Disclose Useful Information?" Harvard Journal of Law & Technology, 2012, 531-593.

Pajak, S. (2010), *Do Innovative Firms Rely on Big Secrets? An Analysis of IP Protection Strategies with the CIS 4 Survey*, mimeo, Department of Economics and Social Sciences, Telecom ParisTech.

Panagopoulos, A., I.-U. Park (2015), *Patenting vs. secrecy for startups and the trade of patents as negotiating assets*, mimeo, University of Crete.

Perng Pan, S., S. Mion (2010), *Hybrid Use of Trade Secret and Patent Protection in Green Technology*, Bloomberg Law Reports 3(4), New York.

Peters, B., C. Rammer (2013), Innovation panel surveys in Germany, in: F. Gault (ed.), *Handbook of Innovation Indicators and Measurement*, Cheltenham and Northampton/Ma.: Edward Elgar, 135–177.

Piening, E.P., T.O. Salge (2015), Understanding the antecedents, contingencies, and performance implications of process innovation: a dynamic capabilities perspective, *Journal of Product Innovation Management* 32(1), 80–97.

Ponce, C.J. (2007), *More Secrecy ... More Knowledge Disclosure? On Disclosure Outside of Patents*, Departamento de Economia Working Paper 07-72, Universidad Carlos III de Madrid.

Rexhäuser, S., C. Rammer (2014), Environmental innovations and firm profitability: unmasking the Porter hypothesis, *Environmental and Resource Economics* 57(1), 145–167.

Schneider, C. (2008), Fences and competition in patent races, *International Journal of Industrial Organization* 26(6), 1348–1364.

Zaby, A.K. (2010), Losing the lead: the patenting decision in the light of the disclosure requirement, *Economics of Innovation and New Technology* 19(2), 147–164.

Zhang, T. (2012), Patenting in the shadow of independent discoveries by rivals, International *Journal of Industrial Organization* 30, 41–49.

Zobel, A.-K., B. Balsmeier, H. Chesbrough (2013), *Does Patenting Enable or Inhibit Open Innovation? Evidence from New Technology Organizations in the Solar Industry*, mimeo, Haas School of Business, Institute for Business Innovation, University of California Berkeley.

Appendix A – Literature and Hypotheses

H1 – Strength of IP law (cont)

In a theoretical model, Kultti et al. (2007) demonstrate that an effective patent system stimulates patenting particularly where firms expect that other firms will develop similar inventions. Secrecy is preferred only if innovators can be quite sure that they are the sole innovators. Denicolò and Franzoni (2004) consider the length of patent protection and prior-user rights. Longer patent life implies a higher propensity to patent for first inventors, while prior-user rights would foster innovation in highly competitive markets.

Dass et al. (2015) empirically analyse the role of the relative protection provided by patent and trade secrets law in the US. They find that the strengthening of trade secret law by U.S. states led to fewer patent applications, increased opaqueness, greater stock illiquidity, and worse announcement reaction to seasoned equity offerings (SEOs). In contrast, the implementation of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) was followed by an increase in patenting, enhanced transparency, greater stock liquidity, and a less negative stock-market reaction to SEOs. Png (2012) studied the impact of changes in U.S. trade secrets law on firms' R&D investment and found a negative effect in low technology industries; and a positive effect in high technology industries. In a study relying on historical data of innovations presented at four global fairs in the second half of the nineteenth and in the early twentieth century, Moser (2012) showed a substantial variation in the use of patenting across sectors which could be linked to differences in effectiveness of patenting and secrecy in these sectors at that time.

The role of patent law as an incentive to use patenting becomes more complex in the case of innovations that are subject to patent thickets and if licensing is a strategic option. Theoretical models suggest that patenting is relatively more attractive than secrecy in such situations. Panagopoulos and Park (2015) look at this strategic capacity of patents and show that patents are preferred over secrecy as they can foster technology transfer by both creating and resolving an IP conflict. Kwon (2012a) considers the situation of patent thickets, i.e. when firms compete for multiple complementary patents (i.e. operating in a patent thicket). In such a case, patent protection will result in a decrease in the R&D investment of firms. In contrast, if firms compete over a single innovation, patent protection will result in an increase in R&D investment. In the case of licensing, and when the propensity of patenting is small, strengthening patent protection can decrease the incentive for firms to innovate (Kwon, 2012b). Licensing is also considered by Bhattacharya and Guriev (2006), who analyse the choice between an open sale after knowledge has been patented, and a closed sale which precludes further disclosure. Contracting parties will choose the closed sale whenever the interim knowledge is more valuable and leakage is sufficiently high.

H2. Degree of innovation competition (cont)

Kultti et al. (2006) present a theoretical model in which patenting is preferred over secrecy, particularly when firms can expect that other firms will develop similar inventions. Other models stress the choice of neither patenting nor secrecy in patent races, but rather voluntary disclosure as a strategy. Gill's (2008) model demonstrates that an innovator with a lead over its competitor opts for strategic disclosure in order to persuade the competitor to exit the patent race. Ponce (2007) shows that the innovator may opt for secrecy, but will disclose some knowledge to prevent a potential second innovator from developing the same innovation and patenting it. Zhang (2012) investigates the impact of innovation arrival rates and the number of firms competing for innovations. Firms that innovate early are more inclined to choose secrecy. A higher innovation arrival rate will increase the incentives to patent, while an increase in the number of firms may cause patenting to occur earlier if the strength of patent protection is high.

H3. Level of innovation (cont)

In a similar paper, which assumes competitors have the same innovative capacity as the innovator, Mosel (2011) demonstrates that it is rather major innovations that are patented, while patenting small innovations does not pay-off due to high filing costs. These results would imply that the impact of the level of innovation on patenting and secrecy will depend on the competitors' innovative capacity. There are few empirical studies on this issue. Hall et al. (2013) find that firms involved in R&D are more likely to rely on patenting than innovators that do not perform R&D (and will hence have a lower level of technological novelty contained in their innovations). The historical study by Moser (2012) found that patented innovations were more often awarded a prize, indicating that more valuable innovations were more frequently patented.

H4. Type of innovation (cont)

In a theoretical model, Biswas and McHardy (2012) analyse the circumstances under which process innovators will opt for patenting instead of secrecy, even if secrecy is costless. They find that low-cost firms are more likely to opt for patenting. High-cost firms will use patenting only if they can profitably bluff and pass themselves off as a low-costs firm in the market. The incentive to patent rather than maintain secrecy, increases as the probability that the rival firm is a low-cost firm falls, and as the proportion of cost reduction obtained by the rival firm through innovation declines after the underline patent has expired.

H5. Open innovation practices (cont)

Buss and Pukert (2015) found that firms which outsource R&D are more likely to suffer from IP infringement. Patenting may also be used by firms following an open innovation strategy in order to signal the firm's innovative capabilities to potential cooperation partners (Alexy et al., 2009; Hagedoorn and Ridder, 2012). The "organisation openness" approach argues that collaborating firms will rather refrain from patenting in order to reduce collaboration with external actors (Laursen and Salter, 2014) as keeping knowledge in-house may impede collaborative knowledge-creating processes. There is some evidence that firms deliberately disclose certain knowledge to the general public ("selective revealing") in order to spur complementary innovations (Alexy et al., 2013; Henkel et al., 2014). In addition, the strategic use of secrecy has been supported by the emergence of thorough secrecy management in firms (Bos et al., 2015).

There are empirical results to support both views. Cassiman and Veugelers (2002), Cosh et al. (2011), Zobel et al. (2013) and Huang et al. (2014) find a positive relation between openness and patenting. Arora et al. (2015) show that patenting due to openness is higher amongst technologically leading firms, while firms focussing on incremental innovations are less willing to patent. Arundel (2001) finds only weak evidence that participation in cooperative R&D increases the returns of a patent-based protection strategy for product innovations as compared to a secrecy strategy. Laursen and Salter (2014) investigate the "paradox of openness". While the creation of innovations often requires openness, their commercialization necessitates their protection. Their empirical analysis shows a concave relation between openness and appropriability. Openness first increases with the strength of the appropriability strategy, before displaying the opposite trend. Jensen and Webster (2007) find that firms conducting internal R&D and relying upon secrecy and patenting to protect their innovations are less likely to engage in external knowledge exchange. Another study by Arora et al. (2015) shows that firms relying on customers and suppliers for their inventions are less likely to patent the focal invention whereas knowledge sourcing from universities and R&D suppliers increases patenting.

Combining patenting and secrecy (cont)

In a theoretical model, Belleflamme and Bloch (2014) analyse the conditions under which innovators may choose to combine patenting and secrecy as protection strategy in case of complex innovations and an imitation risk. Such a situation will occur if the imitator is required to learn about a large proportion of the innovation in order to be able to usefully exploit it. Otherwise, the innovator will choose to either patent the entire innovation, or keep it secret in its entirety. Mixing patents and trade secrets was also analysed by Ottoz and Cugno (2008, 2011) and Cugno and Ottoz (2006). They demonstrate that in a situation that allows a single innovation to be protected both by patents and trade secrets, strengthening patent breadth may induce a lower level of patenting as innovators will rely on secrecy. Where the part of the technology kept secret is highly relevant for the economic performance of an innovation, and the costs involved in duplicating the innovation are sufficiently high, protection via a strong trade secret is preferable as it saves duplication costs. In addition, secrecy is superior over patents due to the lack of an independent invention defence in patent law.

The hybrid use of patents and trade secrets has also been studied from a legal perspective. Perng Pan and Mion (2010) illustrate that an appropriate combination of these two protection methods is particularly important where aspects of green technology can be partitioned into different segments, some of which are easy to re-design or replicate, and some which are not. Erkal (2004) stresses that trade secret law complements patent law in earlier stages of the innovation process by allowing innovators to work on their ideas until they become patentable. Afterwards, the two protection methods become substitutes for one another.

Appendix B – Model specifications, data and variables

Data

The empirical analysis is based on data from the German innovation survey. This survey is part of the Community Innovation Surveys (CIS) of the European Commission. In contrast to most national contributions to the CIS, the German survey is based on a panel sample and conducted annually. The survey is conducted by the Centre for European Economic Research located in Mannheim, and is hence also called the “Mannheim Innovation Panel” (MIP) (see Peters and Rammer, 2013, for more information on the panel nature of the survey). The MIP data have been matched with patent application data (from the European Patent Office and the German Patent and Trade Mark Office) and with trade mark application data (at the European Union Intellectual Property Office and at the German Patent and Trade Mark Office). This allows to complement the survey data with firm-specific patent indicators and to control for the use of trade marks as an alternative protection method.

For this paper, two recent survey waves that contained information on the use and importance of different methods to protect a firm’s innovations (see Appendix for the exact wording and layout of the questions) are used. Both the 2010 and 2012 surveys asked firms to rate the importance of eight methods used to protect a firm’s IP and innovations (see Appendix C for the exact wording of the questions). The eight methods include patents, utility patents, industrial designs, trade marks, copyrights, lead time advantages, complexity of goods or services, and secrecy. For each method firms were required to state whether they had used this method within the previous three-year period (2008 to 2010, and 2010 to 2012, respectively), and how important a role it played in their protecting efforts. In 2010, importance was rated in terms of the role methods played in protecting the firm’s IP, while in 2012, the question was phrased differently, asking firms to rate the effectiveness of each method in terms of maintaining or increasing the competitiveness of product and process innovations. In both surveys, importance was measured on a three-point Likert scale (high, medium, low). This information is used to build five types of dependent variables for model [1]: (i) categorical variables measuring the importance of patenting and secrecy, respectively, as a method for protecting a firm’s innovations on a 4-point Likert scale (no, low, medium, high importance); (ii) dummy variables indicating the use of patenting and secrecy, respectively; (iii) dummy variables for patenting and secrecy, respectively, having a high importance for protecting innovations; (iv) dummy variables for using neither patenting nor secrecy, for using both, and for using only one of the two methods; (v) dummy variables for firms that either rate both patenting and secrecy of medium or high importance or only one of the two; (vi) an indicator measuring the difference in importance between patenting and secrecy, following Arundel (2001) and Hall et al. (2013).

A main drawback of existing firm-level analysis of patenting and secrecy is that many firms advance several innovations at the same time. If it is only known whether a firm has used patenting or secrecy for any innovation in a certain period of time, as is the case with CIS-type data, it is impossible to determine which innovation was protected by which method. One solution is to collect information on protection methods for only a single innovation, e.g. the firm’s most important innovation (see Arora et al., 2016). A drawback of this approach is that there might be spillovers from other innovations in the same firm on the choice of protection methods and their effectiveness for the single innovation being analysed. Another option is to focus on firms with only one innovation. This is the approach followed in this paper. Fortunately, the MIP data collects information on the number of different innovation projects a firm has conducted within the three-year reference period, distinguishing between successfully completed, ongoing and discontinued projects.[17] This allows single innovation firms to be identified, i.e. firms that have completed only one innovation project during the three-year period, and which have neither ongoing, nor discontinued projects. It would seem that 24% of all innovating firms in the sample are single innovation firms. 39% of these single innovation firms combine patenting and secrecy.

By focussing analysis on single innovators it is known that the protection methods used refer to one and the same innovation. This choice of course limits the conclusions that can be drawn from this study as findings apply only to this specific group of innovators. This limitation does not seem to be particularly severe, however, as single innovators do not differ substantially from the average innovator.

Descriptive statistics (see **Table 1**) show that on average, single innovators are younger, but a significant difference in size is not identified, as there many large firms also included in this group. The market environment in which single innovators operate seems to be rather similar to that of multiple innovators. There are also no significant differences with respect to capital and innovation intensity and financial performance (profit margin). A main difference is that single innovators report a lower level of innovation performance both in terms of continuous in-house R&D activity and innovation success (introduction of new-to-market innovations, sales share of new-to-firm innovations, cost reduction from process innovation). In addition, they are less frequently process innovators and are less often engaged in cooperation with other businesses.

In order to compare the results obtained for single innovators with the entire group of innovating firms, models were run for the entire sample of innovators and the results for both samples reported.

<u>Variables</u>

In order to test the six hypotheses discussed in section 2, the following variables in the protection method decision model [1] were used:

- *Strength of IP law (H1)*: In general, patent and trade secrets law is uniform for all firms in Germany. The effectiveness of patent law protection may vary by field of technology and sector, however, depending on the legal possibility of patenting new knowledge, and on court practice in dealing with patent litigation. Following Hussinger (2006), the proportion of innovating firms using patents was used as an indicator for the strength of patent law.[18] This proportion is calculated by dividing the number of firms with valid patents (granted patents that are still active) by the number of innovating firms, using the 3-digit sector level. The number of firms in Germany with valid patents is taken from the Patstat database which has been linked with company data (provided by Creditreform, the German source of the Bureau van Dijk databases) to establish the sector code of patent applicants. The number of innovating firms is calculated on the basis of the innovation survey data using weighted results. In addition, the share of valid patents in a sector that has been licensed out to third parties is calculated, using information on the number of out-licensed patents collected in the 2010 wave of the MIP. As there is no evidence to suggest that trade secret law, part of common law in Germany, varies systematically by sectors or technology, an indicator for the strength of trade secret law is not used.

[17] This question as well as a series of other questions we use in this paper go beyond the harmonised CIS questionnaire and are not included in the questionnaires of other countries that participate in the CIS data collection effort.
[18] We do not follow Hussinger (2006) exactly as she calculated the share of firms using patents and secrecy from the sample she used for model estimations. We believe that this procedure suffers from technical endogeneity since the dependent variable is used to construct an independent model variable.

- *Degree of innovation competition (H2)*: A variable that captures the degree of technological uncertainty, assuming that a market with high technological uncertainty is characterised by a large number of firms competing for innovation is employed. If a firm is the dominating innovator in its market, technological uncertainty shall be low for this firm. The degree of technological uncertainty has been measured directly in both waves of the MIP. In order to control for the general intensity of competition, the number of competitors in the firm's main product market and separate firms with a high number of competitors (16 or more) from those with few competitors (5 or less) is used. In addition, a dummy variable indicating whether the number of competitors has recently increased is added.

- *Level of innovation (H3)*: Following Hall et al. (2013), new-to-the-market innovations from innovations only new to the firm are distingushed. In addition, information on the extent of a firm's innovation activities (innovation expenditure per employee) to control for the amount of new knowledge generating by the firm's innovative activities is used.

- *Type of innovation (H4)*: As suggested by the theoretical literature, product and process innovation are distinguished between. Since service innovations are virtually excluded from patent protection under German and European patent law, differentiation is made between product innovation for manufactured goods and product innovation for services.

- *Open innovation practice (H5)*: A dummy variable, that indicates whether a firm engages in innovation cooperation with external partners, distinguishing between cooperation with business partners on the one hand (clients, suppliers, competitors), and partners from universities and private or public research organisations on the other is introduced.

- *Financial constraints (H6)*: Both internal and external financial constraints are measured. For likely internal financial constraints a firm's lagged profitability is used. External financial constraints are measured by the credit rating a firm was given by Germany's largest credit rating agency (Creditreform).

For the *innovation performance model* [2] three dependent variables are used: sales from new-to-the-market innovations, sales from innovations that were only new to the firm ('imitations'), and the degree of cost reduction resulting from process innovations. While the first two variables are well established in innovation research (see Mairesse and Mohnen, 2010) and were also used by Hussinger (2006) and Hall et al. (2013), the third indicator of process innovation performance has as yet rarely been used (Piening and Salge, 2015, being one of the few examples), despite the fact that the MIP has included this variable since 1994. The independent variables of the innovation performance model include, in addition to patenting and secrecy, innovation input, size and age. Innovation input is measured by innovation intensity (innovation expenditure per employee) and continuous R&D activity as a measure of the degree of novelty of the generated knowledge (see Laursen and Salter, 2006; Leiponen and Helfat, 2010; Klingebiel and Rammer, 2014). Since performance impacts of protection strategies may be lagged, the model was tested with different lags between the reference period of the protection strategy and the year for which innovation success is measured.

All models include size, firm age and sector as well as a dummy variable for the year of observation as further controls.

Appendix C – Questions on protection methods in the 2010 and 2012 German Innovation Surveys

a) 2010

14.1 Which of the following measures did your enterprise use to protect its intellectual property during 2008 to 2010, and how important have they been?

	Yes	No	Importance: high	medium	low
Formal measures					
Applying for patents	☐1	☐2	☐1	☐2	☐3
Applying for utility patents	☐1	☐2	☐1	☐2	☐3
Registering of industrial designs	☐1	☐2	☐1	☐2	☐3
Registering of trademarks	☐1	☐2	☐1	☐2	☐3
Copyright	☐1	☐2	☐1	☐2	☐3
Strategic measures					
Secrecy	☐1	☐2	☐1	☐2	☐3
Complex design of goods or services	☐1	☐2	☐1	☐2	☐3
Lead time advantage over competitors	☐1	☐2	☐1	☐2	☐3

b) 2012

11.1 How effective were the following protection methods for maintaining or increasing the competitiveness of product and process innovations introduced during 2010 to 2012?

Please mark one X for each line!	Degree of **Effectiveness**: High	Medium	Low	Not used
Patents	☐1	☐2	☐3	☐4
Utility Patents	☐1	☐2	☐3	☐4
Design registration	☐1	☐2	☐3	☐4
Trade marks	☐1	☐2	☐3	☐4
Copyright	☐1	☐2	☐3	☐4
Lead time advantage over competitors	☐1	☐2	☐3	☐4
Complex design of goods / services	☐1	☐2	☐3	☐4
Secrecy (incl. include non-disclosure agreements)	☐1	☐2	☐3	☐4

Appendix D – Descriptive Statistics

Table 7: Descriptive statistics for the protection method decision models

	All innovators				Firms with a single innovation			
	Mean	St.dev.	Min	Max	Mean	St.dev.	Min	Max
Dependent variables								
Neither secrecy nor patenting (D)	0.26	0.44	0	1	0.29	0.46	0	1
Only patenting (D)	0.05	0.21	0	1	0.05	0.21	0	1
Only secrecy (D)	0.24	0.43	0	1	0.27	0.45	0	1
Both patenting and secrecy (D)	0.45	0.50	0	1	0.39	0.49	0	1
Effectiveness of secrecy (Likert)	1.56	1.23	0	3	1.44	1.22	0	3
Effectiveness of patenting	1.07	1.22	0	3	0.92	1.18	0	3
Use of secrecy (D)	0.69	0.46	0	1	0.66	0.47	0	1
Use of patenting (D)	0.50	0.50	0	1	0.43	0.50	0	1
Secrecy highly important (D)	0.32	0.47	0	1	0.28	0.45	0	1
Patenting highly important (D)	0.21	0.41	0	1	0.18	0.38	0	1
Relative importance of secrecy (index)	0.49	1.32	-3	3	0.53	1.31	-3	3
Both secrecy and patenting important (D)	0.28	0.45	0	1	0.22	0.42	0	1
Secrecy dominating (D)	0.32	0.46	0	1	0.35	0.48	0	1
Patenting dominating (D)	0.09	0.29	0	1	0.09	0.29	0	1
Independent variables								
Share of innovators with patents	0.37	0.20	0	1	0.35	0.18	0.0	1
Share of out-licensed patents	0.52	1.39	0.00	12.56	0.64	1.66	0.00	12.56
High technological uncertainty (D)	0.32	0.47	0	1	0.31	0.46	0	1
Large number of competitors (D)	0.22	0.42	0	1	0.23	0.42	0	1
Small number of competitors (D)	0.42	0.49	0	1	0.42	0.49	0	1
Competition has increased (D)	0.25	0.43	0	1	0.24	0.43	0	1
Market novelty (D)	0.35	0.48	0	1	0.30	0.46	0	1
Innovation intensity (log)	-3.62	2.47	-10.9	0.12	-4.22	2.39	-10.8	0.00
No innovation expenditure (D)	0.08	0.27	0	1	0.07	0.25	0	1
Process innovator (D)	0.61	0.49	0	1	0.52	0.50	0	1
Cooperation with businesses (D)	0.26	0.44	0	1	0.23	0.42	0	1
Cooperation with research (D)	0.31	0.46	0	1	0.31	0.46	0	1
Credit rating (lagged)	3.83	0.70	0	6	3.77	0.77	0	6
High profit margin (lagged)	0.26	0.44	0	1	0.27	0.45	0	1
Low profit margin (lagged)	0.13	0.33	0	1	0.14	0.35	0	1
Age (log # years)	2.98	1.01	-0.69	6.23	2.87	0.96	-0.69	6.15
Size (log # employees)	3.91	1.71	0.00	12.86	3.33	1.37	0.92	12.86
No. of observations	5,857				1,246			

D: dummy variable

Table 8: Descriptive statistics for the innovation output models [2]

	All innovators				Firms with a single innovation			
	Mean	St.dev.	Min	Max	Mean	St.dev.	Min	Max
Dependent variables								
New-to-market innovations (log)	-4.27	3.69	-6.91	9.38	-4.99	3.02	-6.91	5.14
Only new-to-firm innovations (log)	-1.70	3.85	-6.91	10.48	-2.94	3.46	-6.91	8.37
Cost reduction from process inn. (log)	-4.79	3.47	-6.91	9.47	-5.59	2.71	-6.91	6.06
Independent variables, secrecy/patenting								
Only patenting (D)	0.45	0.50	0	1	0.40	0.49	0	1
Only secrecy (D)	0.25	0.43	0	1	0.27	0.44	0	1
Both patenting and secrecy (D)	0.45	0.50	0	1	0.40	0.49	0	1
Secrecy, low effectiveness (D)	0.15	0.35	0	1	0.16	0.37	0	1
Secrecy, medium effectiveness (D)	0.23	0.42	0	1	0.23	0.42	0	1
Secrecy, high effectiveness (D)	0.31	0.46	0	1	0.27	0.45	0	1
Patenting, low effectiveness (D)	0.13	0.34	0	1	0.13	0.33	0	1
Patenting, medium effectiveness (D)	0.15	0.36	0	1	0.13	0.34	0	1
Patenting, high effectiveness (D)	0.21	0.40	0	1	0.18	0.39	0	1
Relative importance of secrecy (index)	0.49	1.32	-3	3	0.51	1.29	-3	3
Independent variables, others	3.81	1.62	0.92	11.61	3.29	1.33	0.92	9.07
Size (log # employees)	2.97	1.00	-0.69	6.23	2.86	0.97	-0.69	6.15
Age (log # years)	-3.77	2.39	-10.93	0.00	-4.26	2.31	-10.81	0.00
Innovation intensity (log)	0.08	0.27	0	1	0.06	0.23	0	1
No innovation expenditure (D)	0.46	0.50	0	1	0.40	0.49	0	1
Continuous R&D (D)	-4.27	3.69	-6.91	9.38	-4.99	3.02	-6.91	5.14
No. of observations	4,662				1,033			

D: dummy variable

Appendix E – Estimation Results

Table 9: Determinants of using secrecy and patenting for protecting a firm's innovations / IP: results of bivariate probit models (estimated coefficients, significance levels in brackets)

		All innovators		Firms with a single innovation	
		Use of secrecy[1)]	Use of patenting[1)]	Use of secrecy[1)]	Use of patenting[1)]
Strength of IP Law	Share of innovators with patents	0.764*** (0.000)	1.405*** (0.000)	0.375 (0.180)	1.069*** (0.000)
	Share of out-licensed patents	0.023 (0.141)	0.005 (0.734)	0.019 (0.511)	0.000 (0.998)
Degree of innovation competition	High technological uncertainty (D)[a)]	0.138*** (0.001)	0.098** (0.013)	0.388*** (0.000)	0.218** (0.011)
	Large no. of competitors (D)[a)]	0.053 (0.297)	-0.042 (0.409)	-0.167 (0.118)	-0.189* (0.083)
	Small number of competitors (D)[a)]	0.024 (0.586)	0.051 (0.232)	-0.137 (0.148)	-0.011 (0.903)
	Competition has increased (D)[a)]	0.069 (0.126)	0.038 (0.387)	-0.062 (0.527)	-0.036 (0.708)
Level of innovation	Market novelty (D)[a)]	0.337*** (0.000)	0.450*** (0.000)	0.312*** (0.001)	0.498*** (0.000)
	Innovation intensity (log)[a)]	0.098*** (0.000)	0.087*** (0.000)	0.120*** (0.000)	0.113*** (0.000)
	No innovation expenditure (D)	-0.963*** (0.000)	-0.816*** (0.000)	-0.934*** (0.000)	-0.988*** (0.000)
Type of innovation	Process innovator (D)	0.027 (0.500)	-0.042 (0.274)	-0.058 (0.481)	-0.141* (0.079)
Open innovation practice	Cooperation with businesses (D)[a)]	0.091 (0.112)	0.011 (0.830)	0.034 (0.771)	0.112 (0.295)
	Cooperation with research (D)[a)]	0.294*** (0.000)	0.387*** (0.000)	0.250** (0.019)	0.309*** (0.002)
Financial constraints	Credit rating (index, lagged)	-0.019 (0.480)	-0.028 (0.296)	-0.039 (0.473)	-0.033 (0.524)
	High profit margin (lagged)[a)]	0.060 (0.213)	0.020 (0.664)	0.055 (0.586)	0.027 (0.779)
	Low profit margin (lagged)[a)]	0.023 (0.704)	0.025 (0.670)	0.032 (0.789)	0.062 (0.617)
Controls	Age (log # years)	-0.090*** (0.000)	-0.047** (0.014)	-0.143*** (0.001)	-0.125*** (0.005)
	Size (log # employees)	0.089*** (0.000)	0.166*** (0.000)	0.075** (0.021)	0.156*** (0.000)
Applies to (no. of observations)		4,043	2,906	823	541
No. of observations (total)		5,857	5,857	1,246	1,246

1) Secrecy or patenting of low, medium or high effectiveness.

*, **, ***: significant at 10%, 5%, 1% level. D: dummy variable.

a) Missing values for these variables have been set to 0 and indicators were added to indicate this data change.

All models include 15 sector dummies and an indicator for the survey wave used.

Table 10: Determinants of secrecy and patenting being highly important for protecting a firm's innovations / IP: results of bivariate probit models (estimated coefficients, significance levels in brackets)

		All innovators		Firms with a single innovation	
		Secrecy highly important	Patenting highly important	Secrecy highly important	Patenting highly important
Strength of IP Law	Share of innovators with patents	0.545*** (0.000)	0.926*** (0.000)	0.465* (0.097)	0.972*** (0.000)
	Share of out-licensed patents	0.038** (0.011)	0.043** (0.017)	0.034 (0.204)	0.026 (0.380)
Degree of innovation competition	High technological uncertainty (D)[a)]	0.048 (0.223)	0.057 (0.196)	0.130 (0.148)	0.168* (0.080)
	Large no. of competitors (D)[a)]	-0.036 (0.475)	-0.181*** (0.003)	-0.368*** (0.002)	-0.266** (0.043)
	Small number of competitors (D)[a)]	0.004 (0.923)	0.078* (0.092)	-0.048 (0.609)	-0.062 (0.547)
	Competition has increased (D)[a)]	0.084* (0.055)	0.038 (0.446)	-0.028 (0.779)	-0.043 (0.705)
Level of innovation	Market novelty (D)[a)]	0.244*** (0.000)	0.308*** (0.000)	0.193** (0.036)	0.330*** (0.001)
	Innovation intensity (log)[a)]	0.073*** (0.000)	0.096*** (0.000)	0.047 (0.150)	0.093*** (0.007)
	No innovation expenditure (D)	-0.618*** (0.000)	-0.669*** (0.000)	-0.593** (0.022)	-0.535** (0.048)
Type of innovation	Process innovator (D)	0.099*** (0.010)	-0.068 (0.118)	0.082 (0.325)	-0.171* (0.066)
Open innovation practice	Cooperation with businesses (D)[a)]	0.027 (0.584)	-0.010 (0.855)	0.129 (0.229)	0.258** (0.020)
	Cooperation with research (D)[a)]	0.293*** (0.000)	0.305*** (0.000)	0.319*** (0.002)	0.063 (0.564)
Financial constraints	Credit rating (index, lagged)	-0.055** (0.042)	-0.020 (0.511)	-0.075 (0.177)	-0.016 (0.793)
	High profit margin (lagged)[a)]	0.101** (0.030)	0.102* (0.051)	0.453*** (0.000)	0.100 (0.373)
	Low profit margin (lagged)[a)]	0.019 (0.741)	0.132** (0.041)	0.043 (0.736)	0.155 (0.264)
Controls	Age (log # years)	-0.107*** (0.000)	-0.044** (0.041)	-0.104** (0.025)	-0.038 (0.451)
	Size (log # employees)	0.062*** (0.000)	0.171*** (0.000)	0.032 (0.362)	0.135*** (0.000)
Applies to (no. of observations)		1,880	1,232	347	220
No. of observations (total)		5,857	5,857	1,246	1,246

*, **, ***: significant at 10%, 5%, 1% level. D: dummy variable.

a) Missing values for these variables have been set to 0 and indicators were added to indicate this data change.

All models include 15 sector dummies and an indicator for the survey wave used.

Table 11: Determinants of the effectiveness of secrecy and patenting for protecting a firm's innovations / IP: results of ordered probit models (estimated coefficients, significance levels in brackets)

		All innovators		Firms with a single innovation	
		Effectiveness of secrecy[1]	Effectiveness of patenting [1]	Effectiveness of secrecy[1]	Effectiveness of patenting[1]
Strength of IP Law	Share of innovators with patents	0.597*** (0.000)	1.190*** (0.000)	0.396* (0.086)	0.986*** (0.000)
	Share of out-licensed patents	0.035*** (0.008)	0.021 (0.145)	0.031 (0.188)	0.011 (0.679)
Degree of innovation competition	High technological uncertainty (D)[a)]	0.093*** (0.004)	0.076** (0.026)	0.252*** (0.000)	0.178** (0.020)
	Large no. of competitors (D)[a)]	0.018 (0.653)	-0.073 (0.102)	-0.226*** (0.008)	-0.199** (0.043)
	Small number of competitors (D)[a)]	0.009 (0.800)	0.072* (0.051)	-0.095 (0.227)	-0.024 (0.770)
	Competition has increased (D)[a)]	0.062* (0.084)	0.028 (0.457)	-0.054 (0.501)	-0.038 (0.668)
Level of innovation	Market novelty (D)[a)]	0.280*** (0.000)	0.373*** (0.000)	0.243*** (0.001)	0.409*** (0.000)
	Innovation intensity (log)[a)]	0.079*** (0.000)	0.094*** (0.000)	0.083*** (0.001)	0.108*** (0.000)
	No innovation expenditure (D)	-0.797*** (0.000)	-0.801*** (0.000)	-0.764*** (0.000)	-0.836*** (0.000)
Type of innovation	Process innovator (D)	0.063** (0.046)	-0.070** (0.038)	0.019 (0.780)	-0.157** (0.031)
Open innovation practice	Cooperation with businesses (D)[a)]	0.061 (0.142)	0.010 (0.809)	0.106 (0.251)	0.168* (0.063)
	Cooperation with research (D)[a)]	0.275*** (0.000)	0.344*** (0.000)	0.239*** (0.005)	0.216** (0.011)
Financial constraints	Credit rating (index, lagged)	-0.044** (0.045)	-0.023 (0.334)	-0.061 (0.146)	-0.018 (0.685)
	High profit margin (lagged)[a)]	0.072* (0.057)	0.056 (0.164)	0.218*** (0.009)	0.053 (0.547)
	Low profit margin (lagged)[a)]	0.024 (0.619)	0.075 (0.136)	0.040 (0.677)	0.082 (0.457)
Controls	Age (log # years)	-0.099*** (0.000)	-0.053*** (0.002)	-0.122*** (0.001)	-0.101** (0.011)
	Size (log # employees)	0.074*** (0.000)	0.174*** (0.000)	0.057** (0.040)	0.161*** (0.000)
No. of observations		5,857	5,857	1,246	1,246

1) measured on a 4-point Likert scale: not used, low, medium, high effectiveness.

*, **, ***: significant at 10%, 5%, 1% level. D: dummy variable.

a) Missing values for these variables have been set to 0 and indicators were added to indicate this data change.

All models include 15 sector dummies and an indicator for the survey wave used.

Table 12: Determinants of the relative importance of secrecy over patenting for protecting a firm's innovations / IP: results of ordered probit models (estimated coefficients, significance levels in brackets; positive coefficients indicate preference of secrecy over patents).

		All innovators		Firms with a single innovation	
		Including firms neither using secrecy nor patenting	Excluding firms neither using secrecy nor patenting	Including firms neither using secrecy nor patenting	Excluding firms neither using secrecy nor patenting
Strength of IP Law	Share of innovators with patents	-0.385*** (0.000)	-0.699*** (0.000)	-0.444** (0.043)	-0.646*** (0.009)
	Share of out-licensed patents	0.018 (0.117)	0.014 (0.313)	0.023 (0.230)	0.019 (0.435)
Degree of innovation competition	High technological uncertainty (D)[a)]	0.019 (0.528)	-0.006 (0.849)	0.069 (0.301)	-0.014 (0.853)
	Large no. of competitors (D)[a)]	0.077** (0.043)	0.086* (0.057)	-0.056 (0.489)	-0.042 (0.659)
	Small number of competitors (D)[a)]	-0.048 (0.162)	-0.043 (0.255)	-0.092 (0.222)	-0.063 (0.465)
	Competition has increased (D)[a)]	0.022 (0.514)	0.024 (0.527)	-0.000 (0.997)	-0.012 (0.896)
Level of innovation	Market novelty (D)[a)]	-0.061* (0.068)	-0.152*** (0.000)	-0.125* (0.099)	-0.247*** (0.002)
	Innovation intensity (log)[a)]	-0.004 (0.705)	-0.018 (0.161)	-0.011 (0.643)	-0.043 (0.119)
	No innovation expenditure (D)	-0.129* (0.097)	0.093 (0.368)	-0.093 (0.592)	0.185 (0.423)
Type of innovation	Process innovator (D)	0.096*** (0.001)	0.121*** (0.000)	0.122* (0.051)	0.162** (0.029)
Open innovation practice	Cooperation with businesses (D)[a)]	0.051 (0.225)	0.031 (0.475)	-0.043 (0.639)	-0.067 (0.501)
	Cooperation with research (D)[a)]	-0.065 (0.109)	-0.115*** (0.007)	0.023 (0.788)	-0.039 (0.678)
Financial constraints	Credit rating (index, lagged)	-0.019 (0.340)	-0.013 (0.587)	-0.044 (0.264)	-0.017 (0.664)
	High profit margin (lagged)[a)]	0.004 (0.910)	0.023 (0.559)	0.114 (0.129)	0.179** (0.038)
	Low profit margin (lagged)[a)]	-0.047 (0.313)	-0.062 (0.241)	-0.022 (0.817)	-0.010 (0.928)
Controls	Age (log # years)	-0.043*** (0.003)	-0.020 (0.240)	-0.039 (0.221)	0.019 (0.640)
	Size (log # employees)	-0.073*** (0.000)	-0.097*** (0.000)	-0.073*** (0.005)	-0.105*** (0.000)
No. of observations (total)		5,857	4,314	1,246	880

*, **, ***: significant at 10%, 5%, 1% level. D: dummy variable.

a) Missing values for these variables have been set to 0 and indicators were added to indicate this data change.

All models include 15 sector dummies and an indicator for the survey wave used.

Table 13: Determinants of the combined importance of secrecy and patenting to protect a firm's innovations / IP: results of probit models (estimated coefficients, significance levels in brackets)

		All innovators			Firms with a single innovation		
		Both secrecy and patenting[1)]	Secrecy dominating[2)]	Patenting dominating[3)]	Both secrecy and patenting[1)]	Secrecy dominating[2)]	Patenting dominating[3)]
Strength of IP Law	Share of innovators with patents	0.830*** (0.000)	-0.317*** (0.005)	0.681*** (0.000)	0.919*** (0.001)	-0.508* (0.051)	0.508 (0.168)
	Share of out-licensed patents	0.037** (0.022)	0.007 (0.648)	-0.023 (0.308)	0.035 (0.228)	0.008 (0.749)	-0.105* (0.083)
Degree of innovation competitior	High technological uncertainty (D)[a)]	0.078* (0.063)	0.034 (0.373)	-0.019 (0.707)	0.202** (0.033)	0.140* (0.093)	-0.046 (0.697)
	Large no. of competitors (D)[a)]	0.036 (0.525)	0.029 (0.543)	-0.241*** (0.001)	-0.123 (0.326)	-0.095 (0.361)	-0.067 (0.670)
	Small number of competitors (D)[a)]	0.160*** (0.000)	-0.120*** (0.004)	-0.116** (0.032)	0.045 (0.653)	-0.184** (0.042)	0.033 (0.790)
	Competition has increased (D)[a)]	0.036 (0.446)	-0.009 (0.839)	-0.027 (0.644)	-0.159 (0.145)	0.010 (0.918)	0.121 (0.368)
Level of innovation	Market novelty (D)[a)]	0.281*** (0.000)	0.017 (0.668)	0.241*** (0.000)	0.216** (0.024)	0.029 (0.745)	0.449*** (0.000)
	Innovation intensity (log)[a)]	0.130*** (0.000)	-0.030** (0.039)	-0.029 (0.125)	0.143*** (0.000)	-0.001 (0.973)	0.010 (0.785)
	No innovation expenditure (D)	-0.919*** (0.000)	-0.197* (0.057)	0.027 (0.853)	-1.154*** (0.000)	-0.266 (0.247)	0.039 (0.895)
Type of innovation	Process innovator (D)	-0.065 (0.116)	0.073* (0.051)	-0.146*** (0.004)	-0.095 (0.296)	0.078 (0.319)	-0.169 (0.126)
Open innovation practice	Cooperation with businesses (D)[a)]	0.079 (0.121)	0.046 (0.362)	-0.096 (0.159)	0.194* (0.071)	-0.092 (0.386)	-0.024 (0.873)
	Cooperation with research (D)[a)]	0.363*** (0.000)	-0.154*** (0.002)	0.045 (0.489)	0.196* (0.063)	-0.067 (0.495)	0.079 (0.569)
Financial constraints	Credit rating (index, lagged)	-0.038 (0.189)	-0.017 (0.505)	0.027 (0.438)	0.013 (0.828)	-0.076 (0.136)	-0.015 (0.846)
	High profit margin (lagged)[a)]	0.114** (0.021)	-0.057 (0.204)	-0.036 (0.562)	0.204* (0.056)	-0.054 (0.576)	-0.148 (0.292)
	Low profit margin (lagged)[a)]	0.024 (0.703)	-0.036 (0.530)	0.176** (0.017)	0.099 (0.465)	-0.062 (0.603)	-0.001 (0.993)
Controls	Age (log # years)	-0.086*** (0.000)	-0.026 (0.160)	0.026 (0.298)	-0.162*** (0.001)	-0.031 (0.468)	0.081 (0.194)
	Size (log # employees)	0.198*** (0.000)	-0.108*** (0.000)	0.029* (0.065)	0.186*** (0.000)	-0.078** (0.018)	0.028 (0.519)
Applies to (no. of observations)		1,649	1,846	548	280	436	113
No. of observations (total)		5,857	5,857	5,857	1,246	1,246	1,246

1) Both patenting and secrecy are of medium or high importance. 2) Secrecy is of higher importance than patenting, and patenting is neither of high nor medium importance. 3) Patenting is of higher importance than secrecy, and secrecy is neither of high nor medium importance.

*, **, ***: significant at 10%, 5%, 1% level. D: dummy variable.

a) Missing values for these variables have been set to 0 and indicators were added to indicate this data change.

All models include 15 sector dummies and an indicator for the survey wave used.

Table 14: The impact of secrecy and patenting effectiveness on innovation success: results of OLS models (estimated coefficients, significance levels in brackets)

	All innovators						Firms with a single innovation					
	New-to-market innovations		Only new-to-firm innovations		Cost reductions owing to process innovations		New-to-market innovations		Only new-to-firm innovations		Cost reductions owing to process innovations	
	No lag	1 year lag	No lag	1 year lag	No lag	1 year lag	No lag	1 year lag	No lag	1 year lag	No lag	1 year lag
Secrecy, low effectiveness (D)	0.268*	0.392	0.229	0.864***	0.156	1.018***	0.183	1.266**	0.506	0.329	-0.004	0.562
	(0.086)	(0.146)	(0.205)	(0.003)	(0.319)	(0.002)	(0.507)	(0.013)	(0.143)	(0.564)	(0.986)	(0.301)
Secrecy, medium effectiveness (D)	0.276*	-0.005	0.336**	0.555**	0.148	0.698**	-0.096	-0.157	0.517*	0.390	-0.124	0.122
	(0.054)	(0.985)	(0.034)	(0.033)	(0.295)	(0.016)	(0.704)	(0.706)	(0.095)	(0.451)	(0.613)	(0.808)
Secrecy, high effectiveness (D)	0.605***	0.141	0.352**	0.697***	0.432***	0.937***	0.257	0.400	0.451	0.422	0.329	0.577
	(0.000)	(0.546)	(0.020)	(0.006)	(0.002)	(0.001)	(0.362)	(0.319)	(0.153)	(0.418)	(0.193)	(0.265)
Patenting, low effectiveness (D)	0.557***	0.346	0.065	-0.230	0.074	-0.142	0.734**	0.565	-0.582*	-0.983*	-0.043	-0.731
	(0.000)	(0.163)	(0.694)	(0.386)	(0.624)	(0.644)	(0.013)	(0.238)	(0.092)	(0.079)	(0.867)	(0.153)
Patenting, medium effectiveness (D)	0.899***	0.608**	0.207	0.217	-0.253*	0.183	1.145***	0.734	0.275	0.423	-0.152	1.702***
	(0.000)	(0.019)	(0.195)	(0.397)	(0.091)	(0.579)	(0.001)	(0.143)	(0.415)	(0.439)	(0.576)	(0.005)
Patenting, high effectiveness (D)	1.343***	1.119***	-0.010	0.076	0.084	0.379	0.996***	1.153**	-0.203	0.010	-0.576**	-0.144
	(0.000)	(0.000)	(0.953)	(0.758)	(0.579)	(0.244)	(0.001)	(0.024)	(0.545)	(0.985)	(0.020)	(0.801)
Size (log # employees)	0.441***	0.526***	0.750***	0.965***	0.693***	0.835***	0.119	0.151	0.348***	0.776***	0.471***	0.533***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.152)	(0.248)	(0.002)	(0.000)	(0.000)	(0.003)
Age (log # years)	0.018	-0.118	0.084	0.254***	-0.094*	-0.008	0.128	0.235	0.041	0.045	0.008	0.054
	(0.735)	(0.227)	(0.154)	(0.006)	(0.074)	(0.939)	(0.184)	(0.180)	(0.750)	(0.835)	(0.937)	(0.778)
Innovation intensity (log)[a)]	0.297***	0.272***	0.262***	0.295***	0.202***	0.358***	0.242***	0.271**	0.207**	0.286*	0.129*	0.285**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.016)	(0.022)	(0.061)	(0.061)	(0.046)
No innovation expenditure (D)	-2.042***	-2.285***	-1.127***	-2.884***	-1.672***	-2.551***	-1.830***	-1.985**	-1.319*	-3.685***	-0.727	-2.681***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.015)	(0.058)	(0.000)	(0.157)	(0.002)
Continuous R&D (D)[a)]	1.093***	1.118***	0.466***	1.416***	0.252**	0.739***	0.948***	1.562***	-0.389	1.244***	0.528***	0.244
	(0.000)	(0.000)	(0.000)	(0.000)	(0.031)	(0.004)	(0.000)	(0.000)	(0.132)	(0.010)	(0.009)	(0.597)
No. of observations	4,662	1,676	4,662	1,648	4,662	1,229	1,033	363	1,033	360	1,033	257

*, **, ***: significant at 10%, 5%, 1% level. D: dummy variable. a) Missing values for these variables have been set to 0 and indicators were added to indicate this data change.

All models include 15 sector dummies and an indicator for the survey wave used.

Table 15: The impact of the relative difference of secrecy over patenting effectiveness on innovation success: results of OLS models (estimated coefficients, significance levels in brackets)

	All innovators						Firms with a single innovation					
	New-to-market innovations		Only new-to-firm innovations		Cost reductions owing to process innovations		New-to-market innovations		Only new-to-firm innovations		Cost reductions owing to process innovations	
	No lag	1 year lag	No lag	1 year lag	No lag	1 year lag	No lag	1 year lag	No lag	1 year lag	No lag	1 year lag
Relative importance of secrecy over patenting (index)	-0.103*** (0.009)	-0.168*** (0.010)	0.056 (0.164)	0.067 (0.286)	0.073** (0.049)	0.091 (0.242)	-0.148* (0.056)	-0.196 (0.113)	0.080 (0.326)	0.007 (0.960)	0.125* (0.051)	-0.009 (0.954)
Size (log # employees)	0.517*** (0.000)	0.575*** (0.000)	0.766*** (0.000)	0.998*** (0.000)	0.708*** (0.000)	0.895*** (0.000)	0.151* (0.070)	0.178 (0.188)	0.362*** (0.001)	0.811*** (0.000)	0.454*** (0.000)	0.525*** (0.002)
Age (log # years)	-0.026 (0.621)	-0.141 (0.150)	0.074 (0.206)	0.238** (0.010)	-0.102* (0.054)	-0.037 (0.723)	0.082 (0.399)	0.212 (0.241)	0.033 (0.796)	0.042 (0.847)	0.013 (0.887)	0.017 (0.928)
Innovation intensity (log)[a)]	0.367*** (0.000)	0.316*** (0.000)	0.277*** (0gri.000)	0.325*** (0.000)	0.216*** (0.000)	0.417*** (0.000)	0.298*** (0.000)	0.308*** (0.005)	0.229*** (0.009)	0.308** (0.044)	0.115* (0.081)	0.326** (0.022)
No innovation expenditure (D)	-2.600*** (0.000)	-2.655*** (0.000)	-1.262*** (0.000)	-3.158*** (0.000)	-1.776*** (0.000)	-3.007*** (0.000)	-2.279*** (0.000)	-2.328*** (0.003)	-1.443** (0.034)	-3.827*** (0.000)	-0.645 (0.199)	-2.840*** (0.001)
Continuous R&D (D)[a)]	1.380*** (0.000)	1.281*** (0.000)	0.528*** (0.000)	1.510*** (0.000)	0.311*** (0.007)	0.908*** (0.000)	1.138*** (0.000)	1.834*** (0.000)	-0.318 (0.206)	1.352*** (0.004)	0.505** (0.012)	0.632 (0.168)
No. of observations	4,662	1,676	4,662	1,648	4,662	1,229	1,033	363	1,033	360	1,033	257

*, **, ***: significant at 10%, 5%, 1% level. D: dummy variable.

a) Missing values for these variables have been set to 0 and indicators were added to indicate this data change.

All models include 15 sector dummies and an indicator for the survey wave use.

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