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Connecting Standardization, Patenting and Strategic Publishing in the Framework of Firms' Innovation and Intellectual Property Management

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Connecting Standardization, Patenting and Strategic Publishing in the Framework of Firms' Innovation and Intellectual Property Management

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Abstract (Deutsch)

Einleitung

Immaterielle Vermögenswerte sind in den meisten Branchen heutzutage ein unerlässlicher Faktor für den Unternehmenserfolg. Dies gilt insbesondere für die Ideen und Erfindungen von Unternehmen, das sogenannte geistige Eigentum (engl. Intellectual Property, IP). Dieses geistige Eigentum, welches die Grundlage für Innovationen bildet, kann als Output des Forschungs- und Entwicklungsprozesses gesehen werden, einem der größten Kostenfaktoren in vielen innovativen Branchen. Deshalb ist die Aneignung der direkten Einnahmen von Innovationen, aber auch von indirekten wirtschaftlichen und strategischen Vorteilen, von höchster Bedeutung.

Zu diesem Zweck gibt es neben verschiedenen formellen Instrumenten, wie z.B. Patenten, Gebrauchsmustern, Marken oder Copyrights, auch informelle Methoden wie die Geheimhaltung grundlegender Bestandteile der Erfindung, die gezielte Publikation von Forschungsergebnissen (z.B. um Stand der Technik zu schaffen) oder die Einbringungen von Ideen und technischem Know-How in Standards (z.B. um Schnittstellentechnologien zu beeinflussen und Marktzugänge zu schaffen). Die Entscheidung für die Nutzung eines Instruments oder einer bestimmten Kombination von Instrumenten hängt dabei von den speziellen Zielen des Unternehmens in Bezug auf die Innovation ab. Allerdings gibt es noch sehr wenig wissenschaftliche Literatur zum strategischen Nutzen der meisten Instrumente, insbesondere in Bezug auf die Teilnahme an Normungsprozessen oder der strategischen Publikation von Forschungsergebnissen. Allein die strategischen Überlegungen zur Anmeldung von Patenten sind bisher häufig Gegenstand von Forschungsarbeiten gewesen. Allerdings stellen hier die meisten Arbeiten die Option der Patentanmeldung

alleine dar und schaffen keine Verknüpfung zu anderen Optionen im Rahmen des Managements von Innovationen und IP.

Diese Arbeit beschäftigt sich deshalb mit der Frage, wann und von welchen Unternehmen bestimmte Instrumente genutzt werden, welche Ziele dabei ausschlaggebend sind, und welche Kombinationen dieser Instrumente möglich sind und angewendet werden.

Überblick

Die Arbeit betrachtet in erster Linie die ökonomischen und strategischen Aspekte zwei spezieller Instrumente zum Umgang mit geistigem Eigentum: Die Anmeldung von Patenten sowie die Teilnahme am Normungsprozess (und somit das Einbringen von Ideen und Know-how in den Normungsprozess). Dabei stehen die Beweggründe der Unternehmen zur Nutzung der beiden Instrumente sowie der Einfluss bestimmter Firmencharakteristika auf diese Entscheidung im Mittelpunkt des Interesses. Zusätzlich wird am Ende der Arbeit noch eine weitere Dimension integriert, das sogenannte strategische Publizieren von Forschungsergebnissen.

Basierend auf diesem Ansatz ist der Aufbau der Arbeit folgendermaßen gegliedert: Zunächst wird im ersten Teil der Arbeit analysiert, welche spezifischen Charakteristika Firmen dazu bringen am Normungsprozess teilzunehmen. Es wird deutlich, dass die Innovativität eines Unternehmens dabei eine entscheidende Rolle spielt. Deshalb untersucht der zweite Teil der Arbeit das Zusammenspiel zwischen der Teilnahme am Normungsprozess und der Anwendung bzw. Implementierung von Normen für forschungsaktive Firmen. Da innovative Unternehmen sehr oft auch auf das Mittel der Patentanmeldung zurückgreifen, wird im dritten Papier untersucht, inwiefern die Gründe für Normungs- und Patentierungsaktivitäten zusammenhängen. Der vierte Teil der Arbeit beleuchtet dann die Patentierungsoption näher und analysiert, inwiefern sich die Bedeutung von Patenten, aber auch die Motive für die Anmeldung eines Patents, in den letzten Jahren verändert haben. Abschließend wird im letzten Teil der Arbeit dann die Option des strategischen Publizierens als Alternative sowie als ergänzende Maßnahme zur Anmeldung von Patenten vorgestellt.

Methodik und Daten

Für die empirischen Analysen dieser Arbeit werden hauptsächlich zwei verschiedene Datenquellen verwendet: Daten der Befragungswelle 2011 des Mannheimer Innovationspanel (MIP), welches jährlich vom Zentrum für Europäische Wirtschaftsforschung (ZEW) durchgeführt wird, sowie Daten aus einer Umfrage unter normenden und patentierenden Unternehmen im Rahmen des INS-Projekts „Die Interrelation zwischen Normen und Patenten", welches 2011 von der Technischen Universität Berlin im Auftrag des Bundesministerium für Wirtschaft und Technologie und DIN Deutsches Institut für Normung e. V. durchgeführt wurde. Während die Daten des INS-Projektes in den letzten vier Teilen der Arbeit genutzt werden, basieren die empirischen Ergebnisse des ersten Teils auf Daten des Mannheimer Innovationspanels. Verschiedene ökonometrische Verfahren (u.a. Propensity Score Matching, t-tests und verschiedene multivariate Regressionsmodelle) werden des Weiteren in vier der fünf Teile angewendet. Eine Ausnahme stellt dabei das fünfte Papier „The Interrelation Between Patenting, Secrecy and Strategic Publishing – Investigating the Role of Strategic Publications in Intellectual Property Management" dar, welches eher als konzeptioneller Ansatz zu verstehen ist.

Ergebnisse und Implikationen

Aufgrund der breit gefächerten Thematik dieser kumulierten Arbeit können vielfältige Ergebnisse gewonnen werden. Zunächst wird im ersten Teil der Arbeit deutlich, dass vor allem innovative Unternehmen in die Normung eintreten und dass auch die Unternehmensgröße bis zu einem gewissen Punkt einen positiven Einfluss auf diese Entscheidung hat. Folglich scheinen Unternehmen vor allem in die Normung zu gehen, wenn sie Innovationen an den Markt bringen und diese standardisieren wollen, oder wenn sie die für diese Innovationen relevanten Normen und Standards beeinflussen möchten. Außerdem bestehen für Kleinstunternehmen hohe Zugangsbarrieren bezüglich einer Teilnahme am Normungsprozess.

Im nächsten Teil der Arbeit kann gezeigt werden, dass forschungsaktive

Unternehmen in ihren Normungsaktivitäten die Gründe für die Teilnahme am Normungsprozess und der späteren Implementierung der Normen verbinden. Dies lässt auf eine integrierte Normungsstrategie innovativer Unternehmen schließen. Ob solch eine Normungsstrategie allerdings explizit in Unternehmen kommuniziert und verfolgt wird, muss in weiteren Forschungsarbeiten erläutert werden.

Im Anschluss daran wird der grundlegende Zusammenhang zwischen den Motiven und Barrieren für Normungs- und Patentierungsaktivitäten hergestellt, indem eine Korrelationsanalyse starke Gemeinsamkeiten zwischen den Beweggründen für die Nutzung beider Instrumente offenbart. Zur Realisierung von Effizienzgewinnen und Synergieeffekten sollten sich vor allem patentierende und normende Unternehmen dieses Zusammenhangs bewusst werden und ihre strategischen Aktivitäten für beide Tätigkeiten aufeinander abstimmen bzw. integrieren. Auch hier wird erneut deutlich, dass sich Klein- und Kleinstunternehmen bei beiden Instrumenten starken Hürden gegenübersehen.

Da sich die Patentlandschaft im letzten Jahrzehnt stark verändert hat, werden im vierten Papier Veränderungen bezüglich der Bedeutung von Patenten im Vergleich zu anderen Instrumenten zum Schutz geistigen Eigentums sowie Veränderungen bei den Motiven für Patentanmeldungen untersucht. Es wird deutlich, dass das Patent weiterhin von großer Bedeutung ist und das wichtigste formale Instrument zum Schutz geistigen Eigentums darstellt. Allerdings haben strategische Motive für die Anmeldung eines Patents an Bedeutung verloren, während der traditionelle Schutzaspekt weiterhin sehr wichtig bleibt.

Abschließend wird im letzten Papier das Zusammenspiel in der Nutzung von Patentierung, Geheimhaltung und strategischem Publizieren analysiert. Dabei wird deutlich, dass strategische Publikationen in manchen Situationen eine preisgünstige und schnelle Alternative zu Patenten darstellen können, allerdings von den Unternehmen nicht substitutiv zu Patentierung oder Geheimhaltung genutzt werden. Strategische Publikationen werden vor allem genutzt, wenn die Hauptziele der Schutz des Handlungsspielraums für weitere Forschungsvorhaben oder die Festlegung des Stands der Technik sind.

Abstract (English)

Introduction

Today, intangible assets are a crucial factor for business success in most industries. This is especially true for the ideas and inventions of firms, so called Intellectual Property (IP). IP forms the basis for innovation and can be regarded as output of the Research and Development (R&D) process, which happens to be one of the biggest cost factors for many innovative industries. That is why the acquisition of any immediate profits and indirect strategic or economic benefits generated by these ideas and inventions is paramount.

For this, next to several formal instruments, e.g. patents, utility models, brands or copyrights, there are also informal methods such as the non-disclosure of basic elements of the invention, the strategic publication of research results (e.g. to create state-of-the-art) or the integration of ideas and technical know-how into standards (e.g. to influence interface technologies and to create market access). The decision on which of these instruments to use depends on the goals pursued by the firm. However, there is still limited literature on the strategic benefits of these instruments, particularly with respect to standardization and strategic publishing. Only strategic considerations regarding patent applications have been in the focus of various economic research papers, but most of the literature does not connect this topic with other options in the framework of innovation and IP management. Consequently, this dissertation attempts to explore when and by which kind of firms the instruments patenting, standardizing and strategic publishing are used, which goals are most important and what combinations of instruments are used.

Overview

This work first and foremost examines the economic and strategic aspects of two instruments for handling intellectual property: The application of patents and the participation in the standardization process (and thereby the integration of know-how and technical knowledge into standards). The focus is laid for one on the reasons for which firms choose to make use of an instrument and for another on the influence of certain firm characteristics on these decisions. Moreover, another dimension is added – the so-called strategic publishing of research results.

On the basis of this approach, this dissertation is structured as follows: The first part of this dissertation analyzes which firm characteristics are typical for those firms that enter the standardization process. It becomes apparent that the innovativeness of a firm plays a decisive role. Therefore, the second part looks at the interplay between the reasons to participate in the standardization process and to implement standards for R&D-active firms. Another important instrument, particularly for R&D-innovative firms, is patenting. Thus, the connection between firms' motivations for participating in the standardization process and applying for patents is highlighted in the third part. The fourth part examines more deeply the patenting option and expands on how motives for the application of patents have changed over the last decade. Finally, the option of strategic publication as an alternative, but mainly as an additional instrument to patents is introduced.

Methodology and Data

For the empirical analyses in this paper, two main data sources are used: The Data of the 2011 survey wave of the "Mannheimer Innovationspanel" (MIP) which is annually carried out by the Centre for European Economic Research (ZEW) as well as the data of a survey conducted among standardizing and patenting companies within the frame of the INS-project "The Interrelation Between Formal Standards and Patents", which was conducted in 2011 by the Technical University of Berlin on behalf of the Federal Ministry of Economic Affairs and Technology and the DIN German Institute for Standardization e. V..

While the data of the INS-project is used in the last four parts of the dissertation, the empirical findings of the first part are based on the data of the MIP. Various econometric methods (e.g. propensity score matching, t-tests and multivariate regression models) are applied in four of the five parts. The fifth part, titled "The Interrelation Between Patenting, Secrecy and Strategic Publishing – Investigating the Role of Strategic Publications in Intellectual Property Management", forms an exception, as it is to be seen more as a conceptual approach.

Results and Implications

Due to the broad range of topics covered in this cumulated work, a great variety of conclusions can be drawn. The first paper of this dissertation suggests that primarily innovative firms enter the field of standardization and that firm size has a positive effect on this decision up to a certain point. Thus, firms seem to enter standardization mainly if they want to bring innovation to the market and aim to standardize them, or else if they wish to influence standards relevant to the innovation in question. For small firms there are considerable access barriers to the participation in the standardization process.

In the next part, it is shown that research-active and innovative companies combine the reasons for their participation in the standardization process and the implementation of standards within their standardization activities. This suggests that integrated standardization strategies are in place in innovative businesses. Whether or not such a standardization strategy is explicitly communicated and pursued within firms is an object of inquiry for further research.

Subsequently, the basic relations between motives for and barriers to standardization as well as patenting activities are revealed by conducting a correlation analysis. This highlights strong commonalities among the motives and particularly the barriers for the use of both instruments. In order to fully exploit efficiency gains and synergy effects, primarily firms active in patenting and standardization should be aware of this connection and coordinate or integrate their strategic activities in both fields. Again, it becomes clear that small sized firms find themselves facing severe

obstacles.

As the patenting landscape has shifted significantly over the last decade, changes concerning the significance of patents in comparison to other instruments for the protection of IP as well as motives for the registration of patents are examined in the fourth paper. It becomes apparent that patents are still highly important and the formal instrument of choice when it comes to IP protection. However, strategic considerations have a merely reduced influence on the application of patents, while the traditional protection aspect remains highly important.

Conclusively, the interplay of the use of patents, secrecy and strategic publishing is explored in the last paper. Apparently, strategic publications can be a cheaper and quicker alternative to patents. However, they aren't used by firms as a substitution for patents or secrecy, but rather as a complementary tool. Finally, strategic publishing is mainly applied if the main goals are to achieve freedom to operate for further research projects or to determine the technological state-of-the-art.

Publication and Submission Record

The essay "Why do Firms Join Standard-Setting Organizations? - Exploring the Influence of Firm Characteristics Using Survival Analyses" is entirely my own work. It is accepted and will be presented at the 19th EURAS Annual Standardization Conference in Belgrade, Serbia in September 2014 and was presented at the research colloquium of the Chair of Innovation Economics at the TU Berlin in May 2014.

The essay "Standardization Strategies of R&D-active German Firms - The Relation Between Implementing and Developing Standards" is coauthored by Knut Blind. It was presented at the 18th EURAS Annual Standardization Conference in Brussels, Belgium in June 2013.

The essay "The Interaction Between Patenting and Standardization Strategies: An Empirical Test of a Basic Model" is coauthored by Knut Blind. It was presented at the 17th EURAS Annual Standardization Conference in Košice, Slovakia in June 2012 and was presented at the research colloquium of the Chair of Innovation Economics at the TU Berlin in January 2012.

The essay "Is Strategic Patenting Still in Vogue? A Reassessment of Motives to Patent a Decade After the Patent Surge" is co-authored by Sören Simon Petersen and Knut Blind. This paper has been presented at the DRUID Academy Conference in Aalborg, Denmark in January 2013, the 8th Annual Conference of the European Policy for Intellectual Property (EPIP) in Paris, France in September 2013, and the OECD Conference "Patent Statistics for Decision Makers" in Rio de Janeiro, Brazil in November 2013. Also, it was presented at the research colloquium of the Chair of Innovation Economics at the TU Berlin in September 2012.

The essay "The Interrelation Between Patenting, Secrecy and Strategic Publishing – Investigating the Role of Strategic Publications in Intellectual Property Management" is co-authored by Jakob Marquard and Knut Blind. It was presented at the 8th Annual Conference of the European Policy for Intellectual Property (EPIP) in Paris, France in September 2013 and at the research colloquium of the Chair of Innovation Economics at the TU Berlin in June 2013.

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Julius Rauber

Content

Introduction

Context

This dissertation connects the fields of economic research on standardization, patenting as well as strategic publishing. Thereby, in the course of this dissertation, an integrated view on these topics from a firm's perspective shall be developed. In the following, the relevant concepts are shortly introduced in order to get a better understanding of the topics discussed in the dissertation.

Formal Standardization Process and Standards

Firms' participation in the standardization process is one of the key topics investigated in this dissertation. The economic research on standards and standardization at the firm level is still in the fledgling stages, although there are already some notable papers on firms' engagement in standardization (Blind, 2006; Blind & Mangelsdorf, 2013; Blind et al., 2011; Riillo, 2013;) as well as the impact of standards on firms' success (Wakke & Blind, 2012; Pradojo, 2011). Moreover, Swann (2000 and 2010) gives a comprehensive overview on the literature regarding the economic aspects of standards and the standardization process.

For this dissertation, it is important to distinguish between different types of standard and standardization processes in order to define the area of research accurately. Standards can be categorized according to economic impacts, such as variety reduction, compatibility, safety or measurement (David, 1987), the process of development, i.e. de facto versus formal standards (David and Greenstein, 1990), or the field of application, i.e. product, service or process (Swann, 2000). Especially the difference between de facto standards and formal standards is important for this work.

De facto standards are dominant voluntary standards developed by a single firm or a group of firms in a so called consortium (Swann, 2000 and 2010). Their dominance is market-driven and results from the demand behavior. Another important feature of de facto standards is the fact that others can be excluded from the development process as well as from the application of the standards.

In contrast, formal standard (also known as de jure standards) are issued by standard-setting organizations (SSOs). Here, the development process is open to all interested parties and no discrimination is possible, i.e. everyone can use the standard for the same price. Also, participating firms have to license intellectual property, which is essential for a standard according to fair, reasonable and non-discriminatory terms (FRAND). While formal standards and in particular firms' participation in the formal standardization process are the subjects of interest, all other forms of (informal) standards and standardization processes are excluded and not part of the analyses in this dissertation. Firms' strategic participation in the formal standardization process is studied in the first three parts of this dissertation. Moreover, the implementation of formal standards within the firm is subject of the second part. In the third part, a connection between standardizing and patentin is established.

Patents

The second focus of this dissertation is on firms' motivations to apply for patent protection. Patents are regarded as formal instrument to protect intellectual property amongst others (see e.g. Blind et al., 2006). The various reasons to apply for a patent were subject of many scientific papers around the turn of the millennium (see e.g. Arundel et al. 1995; Cohen et al., 2002; Duguet & Kabla 1998; Pitkethly, 2001). In contrast to knowledge that is integrated in formal standards, patents award exclusive property rights for a certain period of time to the patent owner (Blind & Thumm, 2004; Somaya, 2012). These exclusive rights are expected to increase firms' incentives to invest in research and development since they can appropriate the returns on investment exclusively (Lieberman & Montgomery, 1988). As can be seen in the fourth part of this dissertation, these motives can be grouped in traditional and strategic reasons. While the most important traditional motive is the protection against imitation,

there are several more strategic motives for a patent application, such as blocking of competitors' R&D efforts, motivation of R&D staff, measuring of R&D performance, attracting inventors and improving firms' image or reputation. However, there are also some barriers hindering specific groups of firms to apply for a patent. Especially small firms often abstain from patenting due to cost and time reasons (Cohen et al., 2000). The third part of this thesis connects and compares the motives and barriers to patent with the motives and barriers to participate in standardization, before changes over time in the reasons to patent are analyzed in the fourth part of the dissertation. In the last part, patents are compared to the instruments secrecy and strategic publishing.

Strategic Publications

Another option for firms to cope with their inventions is to publish them strategically. Strategic publications (also called defensive publications) document the existence and public accessibility of a technology. Thus, they set state-of-the-art and preserve firms' freedom to operate because third parties are unable to obtain exclusive rights with any subsequent patent applications ("lack of novelty" and "raise of inventive step", see e.g. German Patent Law §§ 1, 3, 4; European Patent Convention Art. 52, 54, 56; United States Code Title 35, §§ 100, 102, 103). Lower costs and faster publication are also advantages of strategic publishing since it entails very little effort and is thus often cheaper and faster than applying for patent protection at the Patent Office (Barrett, 2002). Also, published R&D results may bring competitors to change their R&D strategy if they do not want to compete on a certain field (Gill, 2008). The research on the economic and strategic impacts of strategic publishing is at its beginning and the last part of this dissertation aims to contribute to its further development.

Relationship between Patents, Standards and Strategic Publications

For the reader of this dissertation, the relationship between patenting, standardization activities and strategic publishing of firms might not be straightforward. Especially patents and standards have been regarded as opposed instruments in the literature. Patents secure the exclusivity for the patentee and thereby exclude the free

use by others. Formal standards, in contrast, can be regarded as some kind of public goods and are accessible to all interested parties (Blind & Thumm, 2004). However, all three instruments have one thing in common: They are alternatives for firms to cope with their new ideas or inventions (or at least they are assumed to be new) and the underlying knowledge is codified in patents, standards or publications. According to the different advantages and disadvantages mentioned above (and several more that will be introduced within the dissertation) of patents, standards and publications, an instrument is most suitable depending on the situation of a firm and the goals of the invention. Consequently, this dissertation aims to shed light on the interplay of these instruments to cope with intellectual property from a firm's perspective.

Overview

In this dissertation, an interdisciplinary approach is chosen by connecting the topics of patenting, standardizing and strategic publishing in the framework of innovation and IP management. Therefore, the literature on each of these topics is reviewed in the corresponding parts of the dissertation and the current state of research is summarized. Also, some concepts and theories from other disciplines (e.g. the resource-based view or the theory on open and closed business models) are integrated in order to create a solid theoretical basis for the empirical analyses. Consequently, each of the five parts of the dissertation (except for the last paper) starts with a literature overview or some conceptual considerations from which hypotheses (or at least propositions) are derived. These hypotheses or propositions are then tested by different empirical means.

The first paper identifies the driving factors which determine if firms enter the standardization process. According to a review of the literature, hypotheses are derived. In order to test these hypotheses, the method of survival analysis is applied. One main finding is that innovative firms are more likely to be active in SSOs.

Accordingly, the second paper investigates the interrelation between the reasons to participate in the standardization process and the motives to implement standards for R&D-active firms. Factor analyses reveal underlying structures in both sets of

motives. These factors serve as explaining and dependent variables for multivariate ordinary-least-square-regressions which reveal strong interdependencies between implementation and participation motives.

In a next step, the relationship between participation motives and reasons to patent is analyzed in order to reveal underlying connections between both activities on firm level. Patenting and participating in SSOs are connected by reviewing the literature on open and closed business models in order to conduct analyses on firm level. Correlations between the motives and barriers of each instrument are tested for significance. These correlations construct a universe of four matrices. The share of significant correlations of a matrix is used as measure of commonality. Consequently, the shares of the matrices are compared by two-group proportion tests.

Since the patent landscape has changed over the last decade, variations in the motivations to apply for patents are topic of the fourth paper. Therefore, patenting and the corresponding motives are regarded in the framework of the resource-based view in order to derive hypotheses about changes over time. Moreover, propensity score matching, t-test and factor analysis are applied in the empirical part.

Finally, the last paper concerns another option to cope with firms inventions, namely strategic publishing, which depicts an alternative to the established instruments of patenting and secrecy. The main aim of the paper is to investigate the importance of strategic publishing in the framework of IP management in a rather explorative way. Therefore, no hypotheses are developed, but quantitative data is connected with case studies and conceptual considerations in order to get a comprehensive first view on the topic.

Contribution of This Dissertation

This dissertation especially addresses audiences in the fields of IP and standardization management. While the first and second part are very beneficial for readers that are interested in standardization management, the fourth and fifth part of the dissertation are of special interest for scholars and managers active in IP management and research. The third part of the dissertation connects both fields by

drawing a bow between patenting and standardizing.

Standardization is of particular interest to innovative firms.

The identification of the main factors that drive firms' decision to participate in standardization processes is the major contribution of the first part. Previous work was not able to solve the endogeneity problems between innovation and standardization. Owning to the approach of survival analysis, I am able to cope with that problem at least to a certain degree. It is revealed that the successful development of product or service innovations of a firm enhances the likelihood to enter formal standardization processes in the following. Consequently, standardization is very attractive to innovative firms, probably to shape the standard and market access for their new products.

Standardizing efforts and the implementation of standards are strongly connected in R&D-active firms.

In this context, the relationship between developing and implementing standards from an R&D-active firm's perspective is of special interest. Since there is no existing empirical work on this topic, the second part constitutes a first approach to connect the development process of standards with the implementation. The findings show that there are a lot of significant underlying correlations between motives to implement standards and motives to develop standards in the framework of SSOs. Thus, especially R&D-active and innovative firms should integrate the decision processes regarding the management of implementing standards and standardization participation more strategically.

There are strong commonalities between the reasons to patent as well as to standardize on firm level.

Economic researches on patenting and standardization have been seen as different streams of literature and thus investigations on the similarities of both instruments are missing. One main insight of this dissertation is that patenting and standardization

should not be regarded separately, but rather as different options in the process of managing knowledge and inventions. This is especially true for the connection between patenting and standardizing motives and barriers on firm level, which is highlighted in the third part of the dissertation. Thus, firms should also question if their management regarding patents and standardization needs to be more integrated.

Patents are still important, but the marginal effect of their strategic benefit has decreased.

Of special interest for expert from the field of IP management and research is the fourth part of the dissertation. Here, the results of various papers on firms' motives to apply for patents are checked. Moreover, data from 2002 is compared to data from 2011. It is revealed that there have been significant changes regarding the utilization of patents over time. Patenting is still important, especially for the so-called traditional reason, i.e. to protect an invention from imitation. However, the strategic use of patents observed in the early 2000's seems to be less relevant nowadays.

Defensive publishing can be an alternative to patents or secrecy in some cases.

The last part of this dissertation integrates an additional instrument to cope with intellectual property, the so-called strategic publishing. It can be seen as complementary instrument for patenting firms and may be advantageous compared to patents when the main aims of the invention is to secure freedom to operate or to create state-of-the-art.

Summing up, this dissertation can be regarded as first attempt to forge a link between standardizing, patenting and strategic publishing. Therefore, different theories and concepts are connected and empirical analyses are applied in order to shed light on the interplay between these instruments within a firm's intellectual property strategy.

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Why Do Firms Join Standard-Setting Organization? - Exploring the Influence of Firm Characteristics Using Survival Analyses

Abstract

This paper aims to expose the drivers for firms' decisions to join open standard-setting organizations (SSOs). In particular, the influence of several firm characteristics such as firm size, R&D intensity, patenting activity, innovation activity and sector affiliation on the propensity to start participating at the German Institute for Standardization (German: Deutsches Institut für Normung, DIN e.V.) is explored. For this purpose, data of the "Mannheimer Innovationspanel" (MIP) 2011 is merged with the information of firms' participation at the German Institute for Standardization (DIN) between 2010 and 2013. Therefore, for the first time it is possible to identify the moment when firms enter a formal SSO and hence eliminate the problem of simultaneity. For the multivariate estimations, a survival analysis approach is chosen, where the entrance of firms in standardization can be regarded as events taking place within the observed time period. Results show that the likelihood to enter the SSO rises with firm size. Also, firms that introduce new products or services into the market are significantly more likely to join formal standardization in the following years while R&D intensity on its own does not have a significant positive influence. Finally, the protection of innovations by patents enhances the likelihood to enter SSOs as well. These results indicate that standards enable the diffusion of innovative products or services, that very small firms refrain from entering SSOs and that patenting seems to be important as protection instrument against potential knowledge spillovers.

Content

1. Introduction

The strategic engagement of firms in a formal standard-setting organization (SSO) has been a topic of rising interest to the community of researchers on standardization as well as innovation over the last years. In particular, some quantitative papers have been published (Blind, 2006; Blind & Mangelsdorf, 2013; Blind et al., 2011; Riillo, 2013) exploring the characteristics of firms that participate in SSOs. One main reason for this development in research is that standardization serves as a platform for coalition formation which is accessible for all interested parties (e.g. Axelrod et al., 1995) and therefore is no longer seen as a necessary evil but rather as a strategic instrument which can help to gain competitive advantages.

Considering this development, this paper aims to reveal the drivers for a firm's decision to join committees at the main formal standard-setting organization for Germany, the German Institute for Standardization (German: Deutsches Institut für Normung, DIN e.V.).[1]

Thereby, two limitations of previous studies are addressed: first, the limited empirical work mentioned above is either only representative for a specific sector (e.g. Blind et al. (2011) for the service sector or Blind & Mangelsdorf (2013) for the electrical engineering and machinery industry) or cannot rely on a representative sample for the analyzed population (Blind, 2006; Blind & Thumm, 2004).

Second, and even more important, all existing papers explore correlations between firm characteristics and standardization engagement using cross-sectional data and may therefore be subject to serious endogeneity problems due to simultaneity. For example, the relationship between innovative and standards is in theory assumed to be reciprocal (Allen & Sriram, 2000). Also, innovative firms are supposed to be more likely to participate in standardization committees since "the standardization process is a continuation of the development phase of internal R&D" (Blind, 2006; p. 159). Conversely, engagement in standardization is supposed to help converting firms' R&D results into successful innovations. Thus, it is not clear if innovative firms are more often active in SSOs or if the participation in SSOs helps firms to innovate successfully. Since both directions of action are reasonable, it is not possible to identify the isolated

1 This paper focuses exclusively on the participation in open SSOs and does not cover participation in closed consortia since there are probably other factors influencing the likelihood to enter consortia.

effects by solely observing one point in time. However, all existing papers only can rely on cross-sectional data and are not capable of identifying the driving factors for firms' decision to enter standardization.

Consequently, this paper aims to contribute to the research on the drivers for entering standardization, solving the problem of simultaneity by deploying different points in time. Using survival analysis (also known as time-to-event analysis), the effect of firm size, R&D intensity, innovation activity, patent activity, and sector affiliation on the propensity to enter formal SSOs in the following years is identified. Therefore, I can rely on data of the "Mannheimer Innovationspanel" (Community Innovation Survey for Germany) 2011 which contains information about firm characteristics for the years 2008-2010. This data is enriched with information about the participation of firms at the DIN in 2010 as well as the entry of firms between 2011 and 2013. Using different points in time for observing firm characteristics (2008-2010) and the time of entry at the DIN (2011-2013) respectively, it is possible to rule out endogeneity due to simultaneity between the explaining variables and the dependent variable.

The remainder of the paper is structured as follows: first, the literature on the most important drivers for standardization engagement is outlined and some hypotheses are derived. Second, the sample is introduced and the empirical methodology is explained. Afterwards, results of the survival analysis are presented. Finally, the results are discussed and some implications are presented.

2. Literature Review and Hypotheses

As outlined in the introduction of this paper, standardization has become an increasingly strategic tool for firms over the last decades. Regarding the strategic involvement of firms in standardization processes, a trailblazing work is the paper "Choosing How to Compete: Strategies and Tactics in Standardization", written by Besen and Farrell in 1994. The authors emphasize the growing importance of the subject by stating that "standard-setting has been transformed from an internal matter for individual firms to a subject of cooperation and competition among individual placers" (Besen & Farell, 1994; p. 117). Moreover, they highlight that "a firm that controls a technology that becomes establishes as a standard can have an extremely profitable market position" (p. 119). This is especially true for so-called "standard-wars"[2] which can lead to a single dominating de facto standard.

However, as an alternative to competing between standards, firms can agree on a common standard which might be developed in formal SSOs. The standardization process in formal SSOs is (in contrast to a consortium) open to all interested parties, thus no one can be excluded. There are several reasons for firms to join formal standardization in SSOs and thereby help to develop standards. In particular, firms contribute to the standardization process even if formal standards are seen as public goods in the literature (see e.g. Kindleberger, 1983; Swann, 2000 or Swann, 2010). Thus, it is not possible to appropriate the outcome of the standardization process to the firm exclusively. However, the involvement in the development process facilitates the implementation of the standard (Blind & Rauber, 2013) and creates a competitive advantage compared to firms not active in the standardization process (Blind, 2006). Likewise, firms can influence the upcoming standards in the standardization process and hence raise costs for their rivals (Salop & Scheffman, 1983), fight for the best position to diffuse their technologies (Blind & Gauch, 2009; Iversen et al., 2004), and thereby raise their own market shares (Leiponen, 2008; Wakke et al., 2012). Moreover, regarding the relationship of standardization and standards, Blind and Rauber (2013) disclosed for a sample of R&D-active and innovative firms that there is an underlying relationship between the reasons to participate in the standardization process and the

2 Examples for standard wars are VHS vs. BETAMAX, Nintendo vs. Sony and Microsoft vs. Apple.

motives to implement standards within the firm. This is another indication that the participation in SSOs is not arbitrary but strategic and that it depends on several firm characteristics. The main characteristics according to the literature and their possible influence on the decision to enter standardization are discussed in the following section. Furthermore, hypotheses are derived which build the basis for the empirical part of this paper.

Firm Size and Standardization

Blind and Thumm (2004) are the first to conclude that "the most decisive factor for participation in the standardization process is company size" (p. 1593). This positive relationship is confirmed by Blind (2006), Blind et al. (2011) as well as Blind and Mangelsdorf (2013). There are several possible explanations for the positive correlation between firm size and participation in formal standardization. Since the engagement in standardization is costly and time consuming, larger firms might be more willing to join SSOs than smaller ones due to greater resources they can spend on different business-related tasks, standardization being one among them (Blind, 2006). On the other hand, firms that participate in standardization committees might grow due to the positive effects of the standardization process, such as knowledge spillovers or the possibility to influence a standard, which might lead to a facilitated market access. This endogeneity problem might bias the results of the papers using cross-section analysis. It is avoided in this paper since the influence of firm size on the likelihood to enter standardization can be investigated separately by deploying different points in time. Thus, the explanation that larger firms have more resources and are therefore more likely to enter a SSO is central in the line of argument here. However, the largest firms are supposed to be already active at the DIN before 2011 since the engagement in formal standardization is a long term strategy. Moreover, all large firms that are not already active in standardization might be in such a strong market position that they do not need the support of standards (see e.g. Blind & Thumm, 2004). Consequently, an inverted U-shape relationship between firm size and the propensity to enter formal SSOs is expected, which leads to the first hypothesis:

H1: The likelihood to enter formal standardization processes increases with firm size up to a certain point.

R&D Intensity and Standardization

The study by Blind (2006) reveals an inverse U-shaped relationship between R&D intensity and the propensity to be active in SSOs, i.e. the relationship is positive only up to a certain turning point. In the literature (e.g. Blind, 2006), standardization is seen as part of internal R&D. Moreover, R&D-intensive firms have a higher absorptive capacity (Cohen & Levinthal, 1990), indicating that the ability to profit from knowledge spillovers is more distinct for these firms (Blind & Mangelsdorf, 2013). Since knowledge sourcing is one of the main reasons for joining SSOs (see Blind & Rauber, 2012), R&D-intensive firms might be more likely to enter SSOs. However, knowledge spillovers can detain very R&D-intensive firms from entering standardization since possible spillovers are more a threat than an opportunity to these firms (see Blind & Mangelsdorf, 2013; Blind, 2006). Therefore, the second hypothesis is:

H2: The likelihood to enter formal standardization processes increases with R&D intensity up to a certain point.

Innovation Activities and Standardization

The hypothesis concerning successful innovations is strongly connected to the hypothesis about R&D intensity. Expenditures for R&D can be regarded as inputs to the innovation process, while product or services new to the market ("successful innovations") represent the output (Greenhalgh & Rogers, 2010). Regarding the relationship between successful innovations and standardization, Tassey (2000) states that "standards affect the R&D, production, and market penetration stages of economic activity and therefore have a significant collective effect on innovation, productivity, and market structure" (p. 587). Conversely, this means that firms have to think about

strategic activities in SSOs in order to shape standards, especially if they are very innovative and want to penetrate the market with new products. However, it can be assumed that firms might prefer to set on proprietary standards basing on IP protected innovations. Concerning this matter, Hussinger and Schwiebacher (2013) find that "disclosure of standard-relevant IP ownership [in committees of SSOs, author's note] is positively related with company valuation if associated patent rights are referred to explicitly" (p. 3). Therefore, they suggest, "that product market advantages from standardized technology outweigh the loss of exclusivity from contributed IPR" (p. 3). Following this thought, firms that conduct successful product or service innovation might have higher incentives to join formal SSOs and to shape the relevant standards in order to gain product market advantages rather than enforcing their IP exclusively. The next hypothesis is hence formulated as follows:

H3: The likelihood of entering formal standardization processes is higher for firms that successfully introduce product or service innovations to the market.

Patent Activities and Standardization

As stated above, firms may abstain from enforcing exclusive rights such as patents in order to create standards which facilitate access to the market. Also, in theory, patents and standards have been seen as contradicting instruments for a long time. While patents are an instrument to appropriate the revenues of R&D expenditures, formal standards (and hence the added knowhow of firms participating in SSOs) are open to all interested parties. Empirically, Blind and Thumm (2004) explore the relationship between patenting strategies and standardization activity by measuring the influence of firms' patent portfolios and other firm characteristics on the likelihood to participate in formal standardization on national, European or international level. They discover that a higher patent intensity lowers the likelihood of participating in standardization. This indicates that very patent-intensive firms are reluctant to join standardization. However, they do not find a significant effect when they differentiate between patenting firms and such without patents. Moreover, seeing standardization

as a kind of firm collaboration, Olander, Vanhala and Hurmelinna-Laukkanen (2014) state that "firms with IPR protection may feel more inclined to collaborate because of the smaller perceived risk" (p. 208). Consequently, a low degree of patent protection might be necessary in order to protect against potential knowledge spillover. Another important reason for patenting firms to join standardization is to introduce standard essential patents in the standard so as to gain licensing revenues according to FRAND[3] terms from all standards user (Lemley, 2002) which may outweigh the loss of exclusivity (Hussinger & Schwiebacher, 2013). This is especially true for the ICT sectors (Bekkers et al., 2002; Rysman & Simcoe, 2008). Consequently, firms with patents are expected to be more likely to join formal standardization than firms without any patent protection and the last hypothesis is:

H4: The likelihood of entering formal standardization processes is higher for patenting firms.

3 FRAND is short for "fair, reasonable and non-discriminatory" licensing terms.

3. Data and Methodology

Sample Description

In order to obtain a dataset which allows for testing of the hypotheses, data from the "Mannheimer Innovationspanel" (MIP) 2011 is matched with information about the standardization activities of German firms between 2010 and 2013 at the DIN. The MIP is conducted yearly by the Centre for European Economic Research in Mannheim (ZEW) since 1995, representing the Community Innovation Survey (CIS) for Germany. Although the MIP only includes firms with five or more employees, it is considered as representative for the corporate landscape in Germany.[4]

As several firm characteristics are expected to influence the decision to join formal standardization in the future (which is the core question of this analysis), the data about firm characteristics has to be observed prior to the information about the standardization engagement in order to utilize survival analysis. Therefore, the survey from 2011 of the MIP is used since its information refers to the period from 2008 to 2010. It contains information about the successful introduction of new products or services into the market, patenting activities as well as expenditures on research and development. Furthermore, some additional information about firms' background characteristics such as turnover and sector affiliation[5] is available. Finally, a dataset of 4,071 observations is obtained, from which 2% (78 observations) started standardization activities at the DIN between 2011 and 2013 ("entering firms") and about 6% (238 observations) have already been active in 2010 ("established standardizers"). Since entries before 2011 and after 2013, respectively, cannot be observed, the sample is left- and right-censored. The descriptive statistics for all relevant variables are available in TABLE 1.

4 For further information about the MIP, see http://www.zew.de/en/projekte/374.

5 Since the number of observations for the dependent variable is quite small, it is not possible to control for differences between single sectors. Thus, it is controlled for differences between the higher and lower technology sector within the groups of service and manufacturing firms based on the OECD Manual. The according sectors are higher- technology manufacturing industries (HTMI; consisting of high and medium-high-technology industries), lower- technology manufacturing industries (LTMI; consisting of low and medium-low-technology industries)as well as knowledge-intensive services (KIS) and less knowledge-intensive services (LKIS) For further information see http://www.oecd.org/science/inno/48350231.pdf and http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/Annexes/htec_esms_an3.pdf.

TABLE 1: Descriptive statistics: means and shares of the sample (standard deviation)

Variables	Total (N=4,071)	Non-standardizers (N=3,755)	Entering firms (N=78)	Established standardizers (N=238)
Average turnover (in millions €)	50.94 (490.80)	38.23 (448.32)	228.35 (1057.93)	193.41 (745.79)
Average R&D intensity (R&D expenditures/turnover)	0.03 (0.08)	0.02 (0.08)	0.06 (0.13)	0.05 (0.13)
Share of patenting firms (Patent application 2008-10)	0.31 (0.46)	0.28 (0.45)	0.68 (0.46)	0.75 (0.43)
Share of innovative firms (Market introduction 2008-10)	0.47 (0.50)	0.44 (0.49)	0.77 (0.42)	0.79 (0.41)
Share of firms from lower-technology manufacturing industries (LTMI)	0.34 (0.47)	0.34 (0.47)	0.21 (0.41)	0.34 (0.47)
Share of firms from higher-technology manufacturing industries (HTMI)	0.19 (0.39)	0.17 (0.37)	0.40 (0.49)	0.45 (0.50)
Share of firms from knowledge-intensive services (KIS)	0.36 (0.48)	0.38 (0.48)	0.35 (0.48)	0.18 (0.38)
Share of firms from less knowledge-intensive services (LKIS)	0.11 (0.31)	0.12 (0.32)	0.05 (0.22)	0.04 (0.20)

It becomes obvious that established standardizers and entering firms are quite similar, while both groups differ very much from firms that do not enter the DIN in the observed time period ("non-standardizers"). This is true for the variables firm size, R&D intensity as well as innovation and patenting activities. However, having a look at the sectors distribution, it falls into place that there are also some differences between entering firms and established standardizers (see TABLE 1). Whereas about 35% of the firms that entered the DIN between 2011 and 2013 stem from knowledge-intensive services (KIS), this is only the case for about 18% of the firms that have been active at the DIN at the beginning of the observation period. Though, while 34% of the established standardizers belong to the lower-technology manufacturing industries (LTMI), this is only true for 21% of the entering firms. Regarding the higher-technology manufacturing industries (HTMI) and the less Knowledge-intensive services (LKIS) respectively, there are only small differences between established standardizers and entering firms. Altogether, it can be stated that firms that enter SSOs as well as established standardizers are larger, more R&D-intensive, more likely to be

patent-active and innovative than firms that did not start standardization activities in the observed period at all. Moreover, it seems like standardization is getting more important in knowledge intensive service industries since they represent a high share of the entering firms. The opposite seems to be true for firms of LTMI. Multivariate estimations are conducted in the following in order to carve out which of these firm characteristics have significant influences on the likelihood of firms to enter SSOs.

Estimation Method and Important Concepts

The main aim of this paper is to identify the relevant firm characteristics that influence a firm decision to enter a SSO. Since it is possible to observe the firm characteristics in 2010 and the entries of firms in the years 2011, 2012 and 2013, survival analysis (also called time-to-event analysis) is an adequate estimation method. In survival analysis, the dependent variable is determined by the duration of an observation in the sample until the event happens (failure) or it is not observed anymore. Thus, it is a combination of the length of the observed time without event or censoring and the event variable which is 1 if the event happens and 0 otherwise. In the context of this paper, observations are tracked until they enter standardization or are not observable anymore.

The two main concepts of this approach are the survival rate and the hazard rate. The survival rate $S(t)$ is defined as the probability that the duration of an observation in the sample is at least t and thus is equal to 1- $F(t)$, which represents the converse probability that the duration will be less than t:

$$F(t) = Prob(T \leq t) = \int_0^t f(s)ds$$

$$S(t) = 1 - F(t) = Prob(T \geq t)$$

Thus, it indicates how long it takes until an event happens (i.e. how long does it take until a firm enters standardization). The hazard rate captures the likelihood for an observation to fail (i.e. to enter standardization), i.e. it is defined as the probability that

the event will happen given that the individual is still at risk[6]:

$$h(t) = \frac{f(t)}{S(t)}$$

The cumulative hazard function is the accumulation of all hazard rates over time, i.e. the probability that the event has occurred at a certain point in time. The survivor function is usually pictured as Kaplan-Meier-survival curve (Kaplan & Meier, 1958) and depicts the share of observations that have not experienced the event (i.e. entered standardization) over time. Since there are only four points in time and a constant hazard ratio in the Cox proportional model (which is applied in this paper) is assumed, graphical presentations of these non-parametric estimations are not very meaningful and thus not presented here. Rather, the distribution of the events over time and the survival function are shown in TABLE 2.

TABLE 2: Distribution of the survivor function

Year (t)	Observations at beginning of the period	Events in year t	Net Loss	Survivor Function	Standard Error	[95% Confidence Intervall]	
2010 (0)	4,071	238	238	-	-	-	-
2011 (1)	3,833	22	0	0.9943	0.0012	0.9913	0.9962
2012 (2)	3,811	37	0	0.9846	0.0020	0.9802	0.9881
2013 (3)	3,774	19	3755	0.9797	0.0023	0.9747	0.9837

The 238 observations which are failures from the beginning represent firms that are already active in SSOs in period 0. Consequently, it is not possible to include them into further analysis. Furthermore, it becomes obvious that most firms enter standardization two years after their characteristics are observed. Since it is not possible to observe them after 2013, all observations leave the sample after three periods and the net loss is 3755.

As stated above, the group of the 238 established standardizers cannot be included

6 Obviously, the hazard rate can change over time, i.e. it can rise and fall. In the case of the "risk" to enter standardization, the hazard rate might change according to firm age. However, since the age of a firm is not known and therefore the point in time the characteristics are observed is arbitrary, the Cox proportional model is applied and a constant hazard rate is assumed in order to facilitate the analysis and the interpretation of the results.

in the survival estimation since their entry is left censored. However, the characteristics of already standardizing firms within a sector might influence the likelihood of other firms to join the DIN. For example, firms might join standardization committees because there are already some very large firms active in standardization in this field (see Axelrod et al., 1995). Additionally, firms that exhibit lower R&D intensities compared to the average standardizing firm in their sector might be more likely to enter standardization due to potential knowledge spillovers of the R&D-intensive, established standardizers.

Since it is not possible to include the group of established standardizers in the upcoming estimations due to the features of survival analysis, two additional estimations are conducted as robustness checks. First, the firm's R&D intensity divided by the average R&D intensity of the established standardizing firms in the sector (variable called "proportion R&D") as well as the firm's own size divided by the average firm size of the established standardizing firms in the sector (variable called "proportion size") are included in the estimations. Significant negative influences of the first variable would direct to the conclusion that firms with lower R&D intensities compared to the average standardizing firm in their sector are more likely to enter standardization and, accordingly, that the group of established standardizers has an significant impact on the decision to join the DIN. The same line of thought applies for firm size, respectively. As a second robustness check, it is simulated that all left-censored observations (i.e. the established standardizers) enter in the first observation period and the following entries are moved back by one period. Thereby, the influence of the characteristics of the established standardizers on the outcome variable is included in the estimation. Changing significances would indicate that there are substantial differences between new entering firms and established standardizers.

For the multivariate part, the Cox proportional model (Cox, 1972) is applied where the hazard ratios or coefficients can be reported. The hazard ratios are connected to the hazard rate and can be interpreted in the following way: a hazard ratio of e.g. 1.5 means that a one-unit increase of the explaining variable equals a rise of the hazard rate by 50%. On the contrary, a hazard ratio of 0.7 means that a one-unit increase of the explaining variable leads to a decline in the hazard rate of 30%. Thus, a hazard ratio of greater than one means that the event is more likely to happen and therefore a lower

duration in the sample is expected while a ratio less than one indicates that the event is less likely to happen and the duration is higher. Since the influence of the variables on the likelihood to enter standardization is the main interest here, the hazard ratios will be reported in the result table due to their meaningful interpretation.

4. Results and Discussion

In the following Cox proportional estimations, all variables of TABLE 1 as well as quadratic terms for firm size and R&D intensity are included in order to identify the driving forces for the decision of a firm to start participating at the DIN; results are depicted in estimation (1). Additionally, estimations (2) and (3) present the results of the robustness checks mentioned in chapter 3. All estimation results are displayed in TABLE 3.

First, it has to be mentioned that all estimations fit the model quite well according to the Likelihood-Ratio-Test and that there appears to be no multicollinearity issues since the variance inflation factors (VIF) of all variables are low.[7]

Estimation (1) shows the results of the main regression. At first glance, the results show that there is a non-linear relationship between firm size and the likelihood to join standardization committees since the influence of the linear firm-size term is significantly positive (i.e. hazard ratio greater than one) while its square term is significantly negative (i.e. Hazard Ratio less than one)[8]. Thus, very small and very large firms seem to refrain from joining the DIN and hypothesis 1 is verified. In this context, the significant positive coefficient of the patenting variable is very interesting. It seems like patent protection is a necessary requirement for many firms that join standardization, probably connected to the argument of knowledge spillovers. Conversely, R&D intensity does not enhance the likelihood to enter standardization per se, although the introduction of successful innovations to the market does.[9] Apparently, especially firms with successful R&D activities which lead to market-ready innovations are starting standardization activities at the DIN. Regarding the differences between sectors, it becomes obvious that firms from higher-technology manufacturing industries are more likely to enter standardization compared to firms from lower-technology manufacturing industries, which is the basis in the estimations.

7 According to Myers (1990), multicollinearity is expected if the VIF of an explaining variable is greater than 10. The VIFs for the explanatory variables of all estimations are presented in TABLE A1 in the appendix of the paper.

8 An estimation without the square term for firm-size was conducted. However, the coefficient was insignificant. Thus, the squared term was included.

9 Also, an estimation without the square term for R&D intensity was conducted. Like in the estimation including the squared term, the coefficient was insignificant. Thus, a significant influence of R&D intensity can be ruled out.

TABLE 3: Results of the Cox proportional estimations

Variables	(1) hazard ratio	(2) hazard ratio	(3) hazard ratio
Turnover (in millions €)	1.001**	-	1.001***
	(0.0004)		(0.0002)
Turnover square (in millions €)	0.999*	-	0.999***
	(5.39e-08)		(2.65e-08)
R&D intensity	2.204	3.693	1.977
	(5.052)	(11.75)	(2.308)
R&D intensity (square)	0.852	0.764	1.445
	(2.742)	(2.569)	(2.200)
Patenting (dummy)	3.493***	3.486***	3.798***
	(0.929)	(0.922)	(0.529)
Innovation (dummy)	2.157***	2.274***	2.025***
	(0.634)	(0.665)	(0.303)
Proportion size	-	1.021	-
		(0.0155)	
Proportion R&D	-	0.950	-
		(0.124)	
HTMI	2.276***	2.308***	1.492***
	(0.723)	(0.739)	(0.208)
KIS	1.337	1.368	0.596***
	(0.437)	(0.471)	(0.0982)
LKIS	0.918	0.946	0.560**
	(0.517)	(0.531)	(0.161)
Likelihood-Ratio	77.33	84.00	362.47
Prob → chi2	0.00	0.00	0.00
Observations	3,833	3,833	4,071

Hazard ratios with standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Moreover, changing the base sector reveals that firms from higher-technology manufacturing industries are also more likely to enter SSOs compared to knowledge-intensive service industries (KIS) as well as less knowledge-intensive service industries (LKIS). Finally, there are no significant differences between firms from lower-technology manufacturing industries, knowledge-intensive service industries

(KIS) or knowledge-intensive service industries (LKIS).[10]

The variables controlling for possible influences of the group of established standardizing firms in estimation (2) have no significant effect on the likelihood to start participation at the DIN for the other firms[11] and the influences of the explaining variables remain significant. Including the established standardizers in estimation (3) does also not change the results, except for the sector dummies. Firms from the service sector are significantly less likely to be active in standardization compared to firms from the LTMI, since there are many firms from low-technology manufacturing industries among the established standardizers. Altogether, the results of estimation (1) can be regarded as robust.

10 Results with changed base categories are not shown in the tables due to shortage of space. Results are available upon request.

11 Firm size was excluded in this estimation due to multicollinearity issues with the variable "proportion size".

5. Summary and Conclusions

The main aim of this paper is to identify the most important firm characteristics that influence the decision to join standardization. In contrast to previous research approaches which rely on cross-sectional analyses, different points in time for the explaining and the dependent variables are used. Therefore, possible endogeneity problems – particularly those between innovation and standardization or firm size and standardization – can be avoided. This is one of the main contributions of this paper. An appropriate tool to analyze this kind of data is the Cox Proportional Model, a semi-parametric survival analysis estimation method. The results of this analysis reveal that a higher R&D intensity per se does not lead to an enhanced probability to enter standardization. In fact, firms that have successfully developed innovations are more likely to join SSOs. Moreover, patent protection seems to be an important issue when it comes to the decision to enter a SSO since knowledge spillovers are seen as main issues of standardization (Blind & Mangelsdorf, 2013). Finally, it can be stated that a certain firm size is necessary in order to be able to acquire the benefits of standardization processes.

From a managerial perspective, it seems to be beneficial for firms with successful innovations to enter standardization. Thus, firms should consider the option of standardizing a new product or service when they think about the opportunities for their innovations. However, firms need to be prepared against possible knowledge spill-overs by protecting their intangible assets, as there is a lot of knowledge exchange with parties external to the firm in the standardization process.

In addition, there are policy implications regarding small firms entering standardization. Despite certain efforts of the German government to foster the development of small firms, firms of this type still appear to be abstaining from entering standardization. This is probably the case due to a lack of resources and capacities of these firms which are needed in order to participate in standardization (see Blind & Rauber, 2012). Also, small firms might not be aware of all opportunities that the participation in standardization might offer them. Thus, decision makers in politics have to think about new ways to help these firms to overcome possible obstacles so that their knowhow can be integrated in the standardization process and hence in new

standards.

For all that interesting results, some limitations of this paper have to be mentioned. First, the results are only representing the German corporate landscape. Furthermore, some important variables, such as competition intensity, are not included in the analysis and a more differentiated sector classification would be appreciated. Therefore, a larger number of entering firms would be required to verify the results. Likewise, a real panel analysis would be preferable in order to account for any changes to firm characteristics during the observation period. In this context, it has to be alluded that it is not possible to rule out the influence of possible unobserved shocks after 2010 on the observed entries at the DIN between 2011 and 2013. Also, including established standardizers in the estimations is not possible using survival analysis. Even though these observations were included in some robustness checks, further research should address this issue in more detail. A closer look at the relationship between patenting, market introduction of innovations and standardization engagement is also a potential task for further research, as the analysis revealed the significant importance of these variables for firms that enter into standardization.

Despite these limitations, this paper constitutes a first approach regarding the topic of drivers for entering standardization, and contributes in particular to research by differentiating between firms that enter standardization and established standardizers.

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7. Appendix

TABLE A1: Variation inflation factors for all estimations

Estimation	**(1)**	**(2)**	**(3)**
Variables	**VIF**	**VIF**	**VIF**
Turnover (in millions €)	4.23	-	3.91
Turnover (square)	4.22	-	3.89
R&D intensity	5.78	8.47	5.95
R&D intensity (square)	5.47	5.78	5.64
Patenting (dummy)	1.16	1.16	1.19
Innovation (dummy)	1.21	1.21	1.23
Proportion size	-	1.00	-
Proportion R&D	-	2.40	-

Standardization Strategies of R&D-active German Firms - The Relation Between Implementing and Developing Standards

Abstract

This article constitutes a first attempt to investigate the relationship between the reasons to implement formal standards and the motives to participate in formal standard-setting organizations (SSOs) by empirical means. For this, we rely on a sample of R&D-active German firms which participated in a survey in 2011. After a brief overview on the limited literature regarding this topic and the development of a conceptual model, we evaluate the relevance of the motives to implement standards as well as the motives to participate in formal SSOs. Furthermore, we conduct two factor analyses. We find that there are three underlying factors representing the motives to implement formal standards as well as five underlying factors representing the motives to participate in SSOs. Consequently, we develop some propositions regarding the connection between the implementation factors and participation factors. Finally, we run some multivariate regressions in order to determine the impact of several implementation factors on the assessment of different participation factors while controlling for various background variables. We find that most implementation factors have the predicted significant positive coefficients which lead us to the conclusion that R&D-active firms follow an integrated strategy regarding implementation of standards and the standardization process, at least intuitively.

Content

1. Introduction

Research on standardization has gained in importance over the last 20 years especially due to its meaning for the growing ICT-sector and the impact of intellectual property rights (IPR) on the standardization process (Bekkers & West, 2009; Bekkers et al., 2002; Iversen, 1999; Lemley, 2002). As a result of this increased interest, researchers as well as practitioners have also directed their attention towards the relationship between standards and innovation. One main insight of the research on standards and innovation was that both activities do not work in opposite directions, but that standards may be a helpful tool for innovative firms (Choi et al., 2011; Swann, 2010). Moreover, Allen and Sriram (2000) find a reciprocal relationship between standards and innovation: On the one hand, "standards are often derived from innovative technology", while, on the other hand, "innovation is often spurred – directly and indirectly – from standards as well" (p. 171). Concluding, they find the positive effects in the relation between standards and innovation to outnumber the negative ones. Moreover, there is some empirical work on the connection between standardization activities and innovation. Blind and Mangelsdorf (2013) find that the likelihood to be involved in formal standardization rises with R&D intensity up to a certain point (inverted U-shape) and thereby confirm early findings of Blind (2006). Moreover, Rauber (2014) finds that firms which conduct successful product or service innovations are more likely to join a formal standard-setting organization in the following years.

Thus, standards as well as standard-setting seem to be of particular significance especially to innovative firms which spend money on research and development. Consequently, firms may have special incentives not only to implement standards but also to influence the development process of standards in order to shape them according to their needs and strategic considerations. Strategy-oriented firms will probably have an integrated strategy which links their motives to participate in SSOs (see Blind & Mangelsdorf, 2010) with their reasons to implement a standard (see Prajogo, 2011; Wakke & Blind, 2012). As there is no scientific evidence for this link, this paper aims to point out the influence of several motives to implement standards on the motivations to participate in formal SSOs for R&D-active firms.

The remainder of the paper is structured as follows. First, we give a summary

on the literature regarding the motivation for the implementation of standards as well as the motivation for participating in SSOs. Unfortunately, there is not much specific literature on the regarded topics, thus we try to develop a conceptual model that displays the connection between the decisions about the implementation of standards and the participation in formal SSOs. The empirical part then starts with the introduction of the data. Third, we analyze the relevance of motives to implement formal standards and conduct a factor analysis. Fourth, we rank firms' reasons to participate in formal SSOs and, again, conduct a factor analysis in order to reduce the amount of different variables. Afterwards, we develop propositions for the multivariate part of the paper. The extracted factors are used to construct the explaining variables (factors of motives to implement formal standards) as well as the dependent variables (factors of motives to participate in formal SSOs) for the multivariate regression analysis. Other control variables are included in order to control for other influences. Finally, we discuss the results as well as limitations and future research.

2. Literature Review and Basic Model

The main goal of this part of our paper is to build a conceptual model which depicts the process of firms' standardization activities and, in particular, the connection between the implementation of formal standards into a product or service and the participation of firms in formal SSOs. Therefore, we scan existing literature for relevant articles on both topics which constitute the basis for theoretical considerations between firms' reasons to implement standards and to participate in SSOs.

Unfortunately, as mentioned in the introducing part of this article, only little research on reasons to implement standards has been conducted. Furthermore, the focus of this research work is almost exclusively on quality management standards such as ISO 9000 standards, which can be seen as service standards, whereas there is no literature on the implementation of product standards (see Wakke & Blind, 2012, p. 365), on which this paper focuses. According to existing literature on quality management standards, there are internal as well as external motives to implement such standards (see e.g. Bhuiyan & Alam, 2005; Boiral & Roy, 2007; Gotzamani & Tsiotras, 2002). Wakke and Blind (2012) state that "internal motives emphasize the willingness of the firm to implement the standard voluntarily, while external motives reflect different kinds of pressure to implement the standard from outside the company" (p. 364). Thus, Wakke and Blind (2012) as well as Pradojo (2011) find internal motives to influence the benefits of the implementation of standards positively while external reasons have a negative impact. In particular, this result points to the conclusion that it is very important for firms to shape standards which they are going to implement since only standards implemented due to internal reasons have a positive impact on the performance of a firm. However, these findings are limited to quality management standards and cannot be transferred one-to-one to the implementation of standards per se. Also, both articles solely examine the different impacts of internal and external motivations on the benefits of the standard implementation and on the organizational performance, but do not establish a link to the participation in SSOs.

Regarding the literature on the motives to participate in formal SSOs, the situation is quite poor, too. There is one article that addresses the topic of motives to participate in SSOs by investigating the determinants of the importance of different reasons to

participate in formal SSOs, written by Mangelsdorf and Blind (2010). For this, they combine the topics of strategic alliances and formal standardization in order to build a bridge between strategic firm behavior and reasons to participate in formal SSOs. Moreover, they find five underlying factors which display firms' motives to participate in formal SSOs: "regulation", "company interests", "knowledge seeking", "market access" and "technical solution". Finally, they identify the drivers for the importance of these factors. They find that innovative firms participate in SSOs in order to influence regulations[1] and moreover that especially SMEs find "knowledge seeking" to be a very important rationale to participate in standardization processes in contrast to large firms. However, no research work mentioned in the two paragraphs above addresses the connection between the reasons to implement a formal standard and the motives to participate in formal SSOs.

In order to connect the two topics, we develop a basic model depicting the connection between the implementation of standards and participation in SSOs in the framework of a firm's standardization strategy. Hence, we regard our work as a first attempt to get a better understanding of the relationship between the motivations for both actions. FIGURE 1 shows the supposed sequence of a firm's activities regarding the implementation of standards into a product or service and the development of formal standards in SSOs.

We assume that there are two simple steps: First, a standard is developed within a formal SSO during the standardization process. Afterwards, the standard is implemented by firms. As stated in the literature overview, only quality management standards that are implemented due to internal reasons have positive impacts on the firm performance, whereas the reverse is true for standards implemented due to external reasons (see Prajogo, 2011; Wakke & Blind, 2012). The same can be assumed for the implementation of standards into products which is why it is vital for firms to implement standards that are shaped according to their needs. This is especially true if the implementation is imposed on them for external reasons in order to diminish the negative effects. Consequently, the motives for the participation in formal standard-setting where firms can contribute to the development of a standard

1 This result is especially true for Germany and the European Union. Due to the use of European standards to specify European regulations ("New Approach"), it is possible to influence indirectly regulations by shaping standards.

are expected to be highly influenced by the reasons to implement a standard.

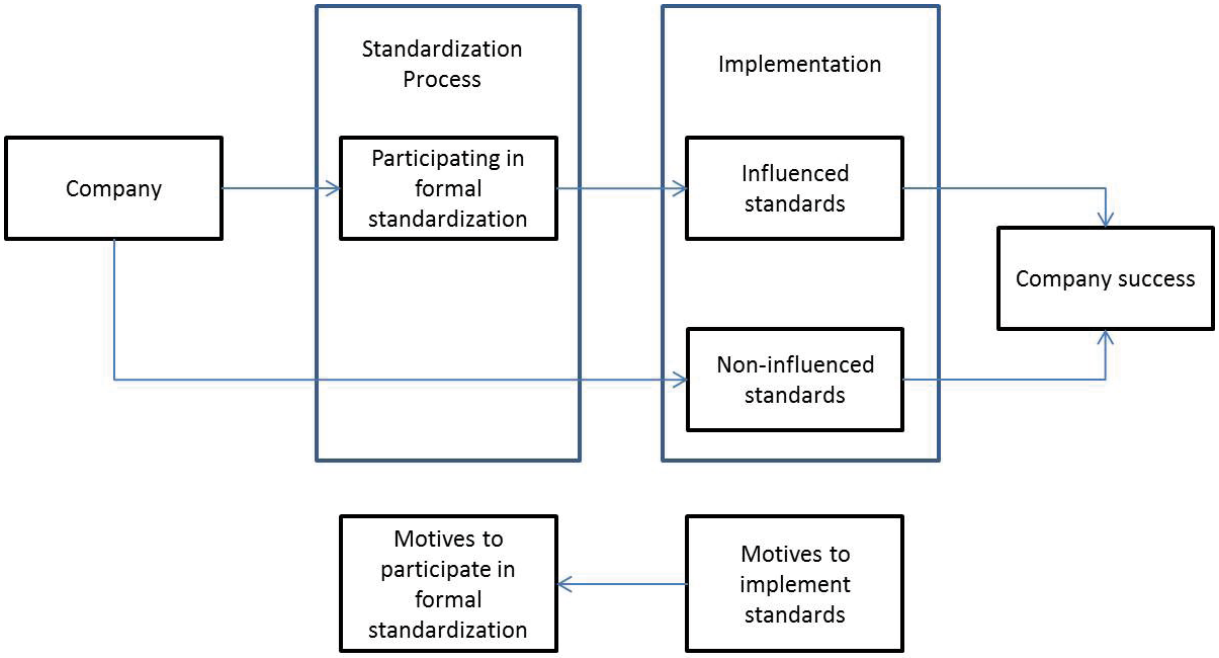

FIGURE 1: Relationship between standardization process and the implementation of formal standards in the framework of a firm's standardization strategy

Moreover, there are similar underlying reasons for the implementation and for the participation, e.g. motives related to cost reduction. Therefore, we assume that there is an interaction between a firm's implementation strategy (which is mirrored by the motives to implement standards) and the participation strategy (which is mirrored by the motives to participate in formal SSOs). According to these considerations, we formulate a set of propositions regarding the connections between the reasons to implement standards and the reasons to participate in SSOs in the third chapter of this paper which will then be tested by empirical means.

3. Sample Description and Descriptive Results

In this section, we give an overview on the distribution of sizes and sectors in the sample, introduce and rank the motives for both actions according to their importance. Also, we conduct two factor analyses in order to reduce the array of items. In the fourth part of the paper, we derive some propositions regarding the interplay of the factors. Finally, we run multivariate regressions in order to test these propositions.

In order to test the relevance of the theoretically developed connection between the implementation strategy and the participation strategy, we rely on survey data gathered from German firms in 2011. In the course of the INS basic investigation "The Interrelation between Formal Standards and Patents", all German firms active in the DIN, the German Institute for Standardization, were asked to answer the questionnaire[2]. 721 of the questionnaires were analyzable. For our analyses, we exclude all firms without R&D expenditures in order to get a sample of innovative firms. Moreover, all firms with missing variables regarding the motives to implement standards, the motives to participate in standardization, size and sector were excluded. Finally, the subsample consists of 364 R&D-active firms. Regarding the innovativeness of the sample, it can be stated that next to the fact that all firms have invested in R&D, also 92% have applied for at least one patent between 2008 and 2010. Since R&D expenditures are one of the most common input indicators for firms' innovativeness while patents are the most used output indicator, we regard our sample as accumulation of innovative firms.

TABLE 1 displays the sector and size distribution in order to obtain a deeper understanding of the structure of our sample. It becomes obvious that most of the firms are active either in the mechanical engineering sector or in the electrical engineering sector whereas there are only few firms in the construction sector. Moreover, there is a high mean in the number of employees in the sector "Motor Vehicles" whereas the opposite is true for the sector "Rubbers & Plastics". Finally, it can be stated that about one-tenth of our sample consists of non-manufacturing firms from the service sector.

2 Moreover, all German firms that applied for at least one patent at the DPMA, EPO or via PCT procedure between 2003 and 2009 were addressed. Altogether, about 13,000 firms were contacted.

TABLE 1: Sector and size distribution of the sample

Sector	Observations	Percent	Average number of Employees
Mechanical Engineering	87	23.9	1139
Chemistry (incl. Biotechnology & Pharma)	29	7.97	5670
Consumer Goods	40	10.99	624
Metal Production	40	10.99	955
Electrical Engineering	79	21.7	1157
Motor Vehicles	15	4.12	34974
Rubber and Plastics	18	4.95	494
Construction	15	4.12	2986
Service	41	11.26	673
Total	364	100	2813

Having evaluated the distribution and structure of our sample, we now turn to the empirical evaluation of the motives to implement formal standards. First, we rank the items by their average importance and then search for underlying factors in order to reduce the number of variables and to get a clearly arranged picture of the reasons. TABLE 2 displays the ranking of 11 items which were assessed by the participants of the survey. Safety, quality and legal certainty seem to be the most relevant reasons for firms to implement standards. In contrast, motives connected to cost issues do not seem to play an important role regarding a firm's decision whether to implement standards or not. Furthermore, size and network effects are even more dispensable. Regarding the relative importance of the different variables, it can be concluded that the most significant item is rated more than two units higher than the most dispensable one.

The following factor analysis sheds light on the connections among the motives to implement standards and exhibits the underlying factors. In detail, the principal-component factor method is used to analyze the correlation matrix since underlying components can be expected. Moreover, orthogonal varimax rotation is applied. In doing so the rotated factors remain uncorrelated with each other which is a necessary requirement for the following multivariate analyses.

TABLE 2: Ranking of motives to implement standards (N=364)

Motive	Rank	Mean	S.E.
Product safety	1	4.34	0.05
Quality assurance	2	4.20	0.05
Increasing legal certainty through the implementation of standards	3	4.05	0.06
Reduction of health and environmental risks	4	3.65	0.07
Promoting interoperability of components within a system and between products	5	2.98	0.07
Reduction of adjustment costs	6	2.89	0.07
Signaling	7	2.72	0.07
Reduction of information costs	8	2.59	0.06
Reduction of transaction and negotiation costs	9	2.51	0.06
Gains in efficiency from network effects	10	2.35	0.06
Generating economies of scale	11	2.05	0.05

Note: The mean is derived from a five point Likert-scale:
1 (= very unimportant) until 5 (= very important)
S.E. = Standards Errors

The results in TABLE 3 show that there are three different underlying reasons to implement standards. The explained variance of 64% as well as the Kaiser-Meyer-Olkin-measure of 0.82 are very satisfying. Factor 1 can be condensed to "Cost Reduction". Only the item "Promoting interoperability of components within a system and between products" seems not to fit in perfectly but it is also a kind of cost-reducing measure in the broader sense, i.e. avoiding costs for missing interoperability (Brunnermeier & Martin, 2002; Ray, 2009).

Second, there is a factor compositing all reasons related to quality and safety issues which we thus call "Safety & Quality". Finally, the third factor consists of the items "Gains in efficiency from network effects", "Generating economies of scale" and "Signaling". As displayed in TABLE 2, these items are only of minor importance to firms. This factor seems to contain all items that are related to dynamic productivity or cost effects in contrast to Factor 1 which contains static cost arguments. On the supply side, the implementation of economies of scale may drive down the production costs over time.

TABLE 3: Explanatory factor analysis of the motives to implement standards (N=364)

Motive	Factor 1	Factor 2	Factor 3
Reduction of information costs	0.81	0.08	0.16
Reduction of transaction and negotiation costs	0.85	0.09	0.13
Promoting interoperability of components within a system and between products	0.64	0.08	0.30
Reduction of adjustment costs	0.71	0.11	0.36
Quality assurance	0.13	0.80	-0.02
Reduction of health and environmental risks	0.02	0.70	0.23
Product safety	0.00	0.83	0.10
Increasing legal certainty through the implementation of standards	0.25	0.70	0.12
Gains in efficiency from network effects	0.28	0.13	0.75
Generating economies of scale	0.25	0.03	0.82
Signaling	0.12	0.17	0.73

Notes:
Factor analysis method: principal-component factors with orthogonal Varimax rotation
Amount of variance explained: 0.64
Kaiser-Meyer-Olkin measure of sampling adequacy: 0.82

Analogous to the procedure on the motives to implement standards, we rank the motives to participate in formal standardization by importance and subsequently conduct a factor analysis. The results of the ranking of the 19 items are presented in TABLE 4.

The most important reason to participate in SSOs for our sample of R&D-active firms is the "Prevention of standards that contradict own interests" followed by the quality and character of standards. Surprisingly, promoting of interoperability with suppliers of complementary products is least important to innovative firms. This may be due to the fact that innovative firms are at the leading edge of the innovation-to-market-process and therefore do not need to care much about the interfaces to other firms' products. Another explanation for this result might be that our sample does not contain many firms of the ICT sector[3]. In this industry, complementarity and also "Integration of own intellectual property rights in standards" or "Preventing the integration of intellectual property rights of other firms in standards" are expected to

3 There are five firms, which can be assigned to the ICT sector (according to the NACE classification) in our sample, but due to this small number and their service orientation they are contained in the sectors "service".

be significantly more important than in other sectors.

TABLE 4: Ranking of motives to participate in formal SSOs (N=364)

Motive	Rank	Mean	S.E.
Prevention of standards that contradict own interests	1	3.61	0.06
Creation of a well-engineered standard	2	3.57	0.06
Gaining competitive advantage by being more knowledgeable	3	3.54	0.06
Addressing technical problems in the standardization committees and controlling the technology development	4	3.42	0.06
Legal certainty on new science and technology fields (e.g. reducing the risk of liability)	5	3.40	0.06
Industry-appropriate design of regulations	6	3.39	0.06
Certainty of technological development scope	7	3.31	0.06
Generation of new knowledge in standardization committees	8	3.22	0.06
Favoring the diffusion of own technologies through standards (Opening of markets)	9	3.22	0.07
Increasing the firm's reputation by participating	10	3.15	0.07
Observing technical knowledge of other firms	11	3.14	0.06
Prevention of regulations	12	3.11	0.07
Prevention of market power of proprietary de facto standards	13	3.10	0.07
Reduction of R & D costs through knowledge gain in the standardization process	14	3.07	0.06
Reduction of trade barriers	15	2.98	0.07
Preventing the integration of intellectual property rights of other companies in standards	16	2.94	0.06
Making contacts with potential partners for future economic projects	17	2.88	0.06
Integration of own intellectual property rights in standards	18	2.57	0.06
Promoting of interoperability with suppliers of complementary products	19	2.55	0.06

Note: The mean is derived from a five point Likert-scale:
1 (= very unimportant) until 5 (= very important)
S.E. = Standards Errors

Finally, it can be ascertained that, contrary to the ranking of the motives to implement standards, the difference in the means between the most important and the least important item is only about one unit. Thus, compared to the drivers for the implementation of standards, the picture regarding the driving forces for the participation in SSOs is more balanced as there are no exclusively outstanding reasons to participate.

Regarding the motives to participate in formal standardization, a factor analysis is even more strongly required due to the high number of variables.

TABLE 5 shows the outcomes of the factor analysis. Again, the KMO-measure as well as the variance explained by the factors are very satisfying. Moreover, the five factors contain between two and five items.

TABLE 5: Explanatory factor analysis of the motives to participate in formal SSOs (N=364)

Motive	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Observing technical knowledge of other firms	0.76	0.00	0.05	0.07	0.32
Gaining competitive advantage by being more knowledgeable	0.79	0.08	0.04	0.16	0.26
Reduction of R & D costs through knowledge gain in the standardization process	0.70	0.33	0.18	0.04	0.05
Generation of new knowledge in standardization committees	0.70	0.16	0.24	0.36	-0.07
Increasing the firm's reputation by participating	0.59	0.19	0.34	0.14	0.01
Legal certainty on new science and technology fields (e.g. reducing the risk of liability)	0.14	0.65	0.21	0.24	0.07
Reduction of trade barriers	0.12	0.73	0.17	0.11	0.03
Industry-appropriate design of regulations	0.14	0.76	-0.04	0.26	0.24
Prevention of regulations	0.15	0.62	0.10	0.10	0.54
Certainty of technological development scope	0.34	0.46	0.20	0.35	0.15
Favoring the diffusion of own technologies through standards (Opening of markets)	0.10	0.04	0.62	0.38	0.29
Promoting of interoperability with suppliers of complementary products	0.01	0.32	0.54	0.28	0.05
Making contacts with potential partners for future economic projects	0.42	0.33	0.57	0.00	-0.06
Integration of own intellectual property rights in standards	0.20	0.03	0.77	0.03	0.30
Addressing technical problems in the standardization committees and controlling the technology development	0.28	0.20	0.14	0.76	0.07
Creation of a well-engineered standard	0.09	0.21	0.06	0.81	0.20
Prevention of standards that contradict own interests	0.18	0.17	0.15	0.25	0.74
Preventing the integration of intellectual property rights of other companies in standards	0.18	0.16	0.28	0.08	0.70

Factor analysis method: principal-component factors with orthogonal varimax rotation
Amount of variance explained: 0.65
Kaiser-Meyer-Olkin measure of sampling adequacy: 0.89

We find similar factors as Blind and Mangelsdorf (2010) and can thereby confirm their findings for the electrical engineering sector and machinery industry on a more

comprehensive level. Factor 1 can be described as very knowledge-related but also enhancing a firm's reputation seems to play an important role. Therefore, the factor is called "Knowledge Seeking & Reputation". The second factor includes variables with reference to regulation and law issues. Thus, we name it "Regulation & Law". Variables regarding cooperation and thereby getting access to markets are assembled in the third factor called "Cooperation and Market Access".

Another underlying reason for the participation in SSOs is to shape and influence standards which is reflected in factor four named "Technical Solution". This topic is closely related to the matter of free and non-conflicting standards which is summarized in the factor "Freedom to Operate". Complementary to the three received factors for the motives to implement standards which are the explanatory variables for our multivariate analysis, the five factors of motives to participate in SSOs build our dependent variables in the multivariate part of this paper.

4. Development of Propositions

Before the multivariate analysis, we develop some propositions regarding the connection between the implementation and participation factors. We abstain from calling these expected connections "hypotheses" since there is obviously a lack of theoretical literature on this topic, which could serve as basis for sound hypotheses.

According to the developed conceptual model, the reasons to implement standards are correlated with the motives to join formal SSOs. Thus, the same is expected for the factors. Consequently, we build propositions about the relationship between the three factors covering the motives to implement standards and the five factors that consist of the motives to participate in SSOs.

To begin with, we expect all coefficients to be positive because the reasons to implement standards should not be opposed to the motives to participate in formal standardization. Therefore, no negative propositions are built. We group our propositions according to the three explaining factors containing the reasons to implement standards. The conceptual model implies that the implementation and the participation motives are similar and interrelated at least to a certain degree. For example, implementing standards as well as participating in SSOs can take place in order to reduce several kinds of costs. Accordingly, the first four propositions concerning cost aspects are formulated as follows:

P1: Coefficients of the implementation factor "Cost Reduction"

a) We expect a significant positive coefficient of the implementation-factor "Cost Reduction" with respect to the participation-factor "Knowledge Seeking & Reputation" as knowledge-spillovers within standardization committees can replace own R&D efforts (Blind, 2006). Therefore, firms that implement standards to reduce costs might participate in SSOs in order to acquire knowledge.

b) Furthermore, we assume that there is a significant positive coefficient of "Cost Reduction" in regard to "Regulation & Law" since influencing regulations by

participating in committees of SSOs might lower the probability of process cost for a firm.

c) Also, the factor "Cooperation and Market Access" is expected to be significantly positive correlated with "Cost Reduction" since finding partners for cooperation in the standardization process may replace other options to find cooperation partners e.g. for innovation projects. Searching cost maybe additional costs and very high compared to standardization fees. Therefore, standardization may be a low priced alternative.

d) Our last proposition regarding the factor "Cost Reduction" concerns the participation-factor "Freedom to operate". We expect a significant positive coefficient since standards that contradict a firm's own interests or standards that are affected by IPR can cause severe costs to a firm (Blind et al. 2011).

According to the ranking, implementation motives related to safety and quality are of major importance for the surveyed firms. Here, the connection between the participation in a committee and the implementation of the standard as "outcome" of this process is very obvious. Shaping and influencing standards is of particular importance when a firm plans to implement standards in order to enhance product safety or quality. Therefore, the next propositions are formulated as follows:

P2: Coefficients of the implementation factor "Safety & Quality"

a) "Safety & Quality" is expected to be significantly positive correlated with the participation-factor "Regulation & Law" because firms that implement standards in order to increase legal certainty might participate in formal standardization in order to get legal certainty about new science and technology fields.

b) Moreover, we expect a significant positive coefficient of "Safety & Quality" with respect to "Technical solution" as firms that implement standards due to quality reasons need well-engineered standards. Thus, they will join formal

standardization in order to shape the standards they are going to implement.

The third, and according to the ranking least important, implementation factor is called "Network Externalities". Two more propositions are built in the following. While the first addresses the signaling aspect of the factor, the second concerns the network-related variables of the factor.

P3: Coefficients of the implementation factor "Network Externalities"

a) The explaining factor "Network Externalities" includes the variable "Signaling". As the participation factor "Knowledge Seeking &Reputation" includes the variable "Increase the firm's reputation by participating in formal SSOs", we believe that there is a significant positive correlation between both factors as signaling of quality and enhancing reputation are very similar goals. Thus, firms that implement standards in order to signal competences to others are expected to participate in formal standardization in order to increase their reputation.

b) The last proposition concerns the relationship between "Network Externalities" and "Cooperation & Market access". Here, we expect a significant positive coefficient since firms that implement standards in order to be able to exploit network effects more efficiently might join formal standardization in order to strengthen and enlarge their network.

For all remaining connections between factors regarding implementation and factors regarding the participation in SSOs, we do not expect any significant coefficients as there are no convincing considerations from our point of view. In order to give a well-arranged overview on the expected relationships, TABLE 6 shows a matrix which depicts the predicted coefficients between all factors.

TABLE 6: Expected significant coefficients between the explaining and dependent factors

Factors of motives to participate in formal SSOs → / Factors of motives to implement standards ↓	Knowledge Seeking & Reputation	Regulation & Law	Cooperation & Market access	Technical Solution	Freedom to operate
Cost Reduction	+	+	+		+
Safety & Quality		+		+	
Network Externalities	+		+		

5. Results of the Multivariate Analyses and Discussion

Having developed our propositions, we now turn to the results of five multivariate regression analyses in order to test these propositions. Values for each of the eight factors that are used in the estimations are predicted by the saved factor scores[4]. Thus, continuous variables are created and we can apply the method of ordinary least square regression. In order to control for other influences, we additionally include a number of control variables amongst others firm size, R&D intensity and sector dummies.

The results of the regression analyses are illustrated in TABLE 7. The adjusted-R^2 of the models ranges from 0.07 to 0.23. These are satisfying values which indicate that we have included very relevant variables for explaining the importance of the participation factors.

First, the influences of the control variables are regarded. Firm size is significantly negative correlated with the factor "Knowledge Seeking & Reputation". This means that small firms find it more important to achieve knowledge in the standardization process and to improve their public image by participating than larger firms. Maybe, smaller firms do not have the capacity for a lot of own R&D efforts and therefore join standardization in order to seek for knowledge spillovers. This result confirms the findings of Blind and Mangelsdorf (2010). Moreover, the importance of the factor "Regulation & Law" decreases with R&D intensity. Thus, R&D-intense firms are less interested in these aspects when they think about joining SSOs since other reasons may be more important to them. Furthermore, being active in SSOs on the national, European or international level has a significant positive influence on two factors: "Technical Solution" and Freedom to Operate". This means that these factors are more relevant for firms that are actually active in standardization than for firms that are not.

Finally, there only seem to be slight differences in the importance of the factors between the sectors[5].

While finding technical solutions and thereby creating good standards seems to be of special importance for firms in the metal producing sector, knowledge seeking

4 As a robustness check, the factor scores are calculated as means of the corresponding variables. However, the results do not change significantly.

5 Mechanical engineering is excluded as this sector serves as reference category. Thus, all conclusions for the sectors are drawn in comparison to this sector.

TABLE 7: Results of the multivariate analyses

VARIABLES	(1) Knowledge Seeking & Reputation	(2) Regulation & Law	(3) Cooperation & Market Access	(4) Technical Solution	(5) Freedom to Operate
Control Variables:					
Logarithm of employees	-0.072**	0.030	-0.015	0.031	0.018
	(0.029)	(0.027)	(0.029)	(0.027)	(0.027)
R&D Intensity	-0.283	-0.491***	0.087	-0.156	0.256
	(0.184)	(0.171)	(0.182)	(0.172)	(0.188)
Participation in SSO	0.125	0.086	-0.135	0.573***	0.193*
	(0.111)	(0.104)	(0.110)	(0.104)	(0.114)
Sector Dummies:					
Chemistry (incl. Biotech. & Pharma)	-0.022	0.183	0.0044	-0.276	-0.244
	(0.209)	(0.195)	(0.207)	(0.196)	(0.214)
Consumer Goods	0.241	-0.002	-0.103	0.062	0.146
	(0.186)	(0.173)	(0.184)	(0.174)	(0.190)
Metal Production	-0.117	-0.097	0.109	0.386**	-0.010
	(0.185)	(0.172)	(0.184)	(0.174)	(0.189)
Electrical Engineering	0.241	-0.119	0.175	-0.134	0.167
	(0.150)	(0.139)	(0.148)	(0.140)	(0.153)
Motor Vehicles	0.457*	-0.334	-0.115	0.195	0.396
	(0.275)	(0.256)	(0.273)	(0.258)	(0.281)
Rubber and Plastics	0.676***	-0.056	0.003	0.286	-0.157
	(0.252)	(0.234)	(0.249)	(0.236)	(0.257)
Construction	0.206	-0.070	0.134	-0.220	0.306
	(0.273)	(0.254)	(0.270)	(0.255)	(0.278)
Services	-0.0319	-0.332*	0.376**	0.487***	-0.206
	(0.189)	(0.176)	(0.187)	(0.177)	(0.193)
Implementation Factors:					
Cost Reduction	0.135**	0.222***	0.105**	0.054	0.0108
	(0.053)	(0.049)	(0.052)	(0.050)	(0.054)
Safety & Quality	0.102*	0.226***	-0.001	0.247***	0.118**
	(0.053)	(0.050)	(0.053)	(0.050)	(0.054)
Network Externalities	0.197***	0.270***	0.302***	-0.008	-0.005
	(0.052)	(0.048)	(0.051)	(0.047)	(0.053)
Constant	0.193	-0.083	0.075	-0.572***	-0.267
	(0.185)	(0.173)	(0.184)	(0.174)	(0.189)
Observations	364	364	364	364	364
R-squared	0.111	0.230	0.128	0.219	0.072

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

and reputation enhancement is crucial for car manufacturers and firms from the rubbers and plastics industry. For service firms, regulations are quite unimportant compared to market access, cooperation and the creation of good standards.

Moving on to the relation between our explaining and dependent variables, we have to recall the developed propositions. Regarding the propositions about the interrelation between "Cost Reduction" and the participation factors (P1), we can state that three (P1a, P1b and P1c) out of four propositions are verified. While the coefficient of "Cost Reduction" is significant and positive with respect to "Knowledge Seeking &Reputation", "Regulation & Law" and "Cooperation & Market Access", there is no significant coefficient with respect to the "Freedom to Operate"-factor. Thus, firms that implement standards in order to reduce cost seem also to participate in standardization committees in order to shape regulations. Also, these results show that the cost-related reasons to implement standards are linked to knowledge-seeking reasons for the participation in SSOs and moreover that they are connected to "Cooperation & Market Access". This indicates that firms which implement standards in order to safe cost might join formal standardization in order to get access to markets and enter cooperation which might lead to savings indirectly.

Our second set of propositions concerns the connection between "Safety & Quality" and the underlying factors for the motives to participate in formal SSOs. The predicted coefficients with the factors "Regulation & Law" as well as "Technical Solution" are significant and we can therefore verify our propositions P2a and P2b. However, the coefficients with "Knowledge Seeking &Reputation" and "Freedom to Operate" are also significant unlike we predicted[6]. These results imply that quality- and safety-related reasons for the implementation of formal standards are strongly connected with these motives for the participation in formal standardization since firms anticipate that the outcome of the standardization process is important for a smooth implementation of standards.

Finally, propositions P3a and P3b regarding the positive relationship between "Network Externalities" and the dependent variables "Knowledge Seeking & Reputation" and "Cooperation & Market Access" can also be verified. Accordingly,

6 It has to be mentioned that the coefficient of "Safety & Quality" in estimation 1 is only significant at the 10% significance level.

the assumed relation between implementing standards due to signaling reasons and joining standardization in order get a better reputation (P3a) as well as to enter and enlarge cooperation (P3b) seems to exist in firms' standardization strategies. Besides, there is a non-predicted significant positive coefficient of "Network Externalities" with respect to "Regulation & Law". This might be due to the fact that firms which implement standards in order to enlarge their network or generate economies of scale also join formal standardization in order to shape or prevent regulations which might hamper these attempts. Concluding, it can be stated that seven out of eight propositions are verified by our analyses and that three additional significant coefficients of the implementation factors are found which were not foreseen in the propositions.

6. Summary and Conclusion

This article is a first attempt to identify the interaction between the reasons to implement standards and the motives to participate in formal SSOs by applying empirical methods. Our literature review reveals that there has been no previous work on this integrated topic but solely on the implementation of standards and the standardization process separately. However, there are only a limited number of articles even on these more narrowly defined subjects. Hence, we develop a basic model depicting firms' standardization activities as a successive process which serves as foundation for the development of some propositions regarding the interaction between the reasons for the implementation of formal standards and the participation in formal SSOs. These propositions refer to eight factors that are underlying to the single items.

The multivariate regression analyses reveal that there are many significant correlations between the underlying factors of the motives to implement standards and the underlying factors of the motives to participate in formal standardization. Seven out of eight propositions could be verified while one proposition had to be rejected. However, there were three more significant coefficients of the implementation factors with respect to the participation factors that we did not address in our set of propositions. Finally, it can be stated that innovative firms seem to pursue an integrated standardization strategy regarding the implementation and the participation in SSOs due to the high number of significant coefficients.

Closing, the limitations of our work have to be mentioned. First, we only address R&D-active German firms and thus our results are only applicable for this group of firms. Moreover, a larger number of firms might be required in order to be able to interpret the statistical results as representative for Germany. To finish, some qualitative work on the relationship between motives to implement and motives to participate in formal SSOs has to be conducted in order to get a better understanding of the firm-intern standardization process. This is crucial for the development of our basic model depicting firms' standardization activities as a successive process since it is not clear if all firms really follow an elaborated strategy regarding their standardization activities. In the end, this fact might depend on firm size and sector affiliation.

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3

The Interaction Between Patenting and Standardization Strategies - An Empirical Test of a Basic Model

Abstract

This paper examines the general relationship between the options of patenting as well as introducing ideas and knowledge in the standardization process of formal standard-setting organizations (SSOs) within firms' innovation strategy. It aims to provide both conceptual considerations as well as empirical evidence on the general interrelation between the motives and the barriers to use these two strategies regarding the exploitation of innovations. Based on the conceptual considerations, we develop a decision tree on invention level which leads us to three hypotheses regarding the basic interactions between patenting and standardization strategies on firm level. Therefore, we connect patenting and standardization with different kind of business models. Subsequently, we test the hypotheses by ranking the motives and barriers according to their importance and analyzing four appropriate correlation matrices. Furthermore, we control for differences between SMEs and large firms. Finally, the findings are used to derive recommendations for firms' IP and standardization management.

Content

1. Introduction

In the last years, empirical research connecting patents and standards has been focusing on patents referenced in standards especially since this phenomenon is concentrated on mobile telecommunications, an area of great interest not only for industry, but also for consumers. Starting with Rysman and Simcoe (2008), who find a higher value of patents referred to in standards, Simcoe et al. (2009) analyze the likelihood of litigation for these patents. Recently, Bekkers et al. (2011) identified the determinants of patents becoming essential for standards. These insights are complemented by Berger et al. (2012), who show that firms put much more effort in the filings of essential patents compared to similar patents.

Besides the specific interaction of patents with standards via immediate referencing, there is little work on the general relationship between patenting and standardization activities or even strategies. In addition, although there is quite a large body of literature focusing on strategic patenting motives (see e.g. Blind et al., 2006; Cohen et al., 2000), little work has been done on strategic motives to participate in formal standardization expect for a paper written by Blind & Mangelsdorf (2010). On the relationship between these two strategies almost no research has been conducted. Blind and Thumm (2004) reveal a negative relationship between the patent intensity of firms and their involvement in standardization but provide no insights in the relationship of motivations. Only Blind (2008) tries to link strategic patenting motives with the standardization activities of firms. Nevertheless, the direct interrelationship between strategic motives to patent and to participate in formal standardization has not been investigated yet.

However, Somaya (2012) highlights the upcoming relevance of regarding patent strategies not separately but in the framework of other appropriability strategies. Thus, connecting patent strategies with strategic consideration about participating in standardization committees is a necessary step in order to promote a more integrated research approach regarding appropriability strategies. Consequently, this paper tries to help closing this gap of research and to provide the starting point for a generation of new research.

We regard the options of patenting and standardizing in the framework of open

and closed business models in order to be able to analyze these options on the firm level. This is necessary since it can be assumed that the decision whether to patent (and to market the protected invention via a proprietary standard) or to propose an invention, respectively knowledge about the invention, into formal standardization process is made on invention level. Ehrhardt (2004) puts it as follows: "Should the company try to establish its technology as a proprietary standard or should it allow a more or less open access to its technology, encouraging competitors to participate in the market with compatible products?" (p.278). This consideration will be the origin for our conceptual model, which depicts a sequential decision tree regarding the options of patenting and standardizing. This decision tree helps to gain an impression of the interaction between the two options on the invention level. Subsequently, we abstract from the invention level to the firm level in order to derive some hypotheses about the strategic behavior of the firm regarding patenting and standardization which can be tested by empirical means. Though, it has to be mentioned that there are other possibilities to cope with a firm's IP, most important secrecy.

However, we exclude secrecy in our analysis due to the following reason: Proper information on firms favoring secrecy as protection strategy can only be received by conducting a survey among a representative random firm sample.[1] While we can identify firms that actually apply for patents or which are active in standardization and ask for their reasons to use these instruments, this is not possible for secrecy. With respect to patenting and standardization, we can use different databases which allow us to construct a universe in order to conduct a representative survey. So, in order to test our conceptual model empirically using the data at hand, we exclude the option of secrecy due to data constraints.

Accordingly, the remainder of this paper is structured as follows. First, we model the interaction between patenting and standardization strategies in form of a decision tree on the invention level based on a conceptual model. Thereupon, we develop some hypotheses regarding the interaction of the patenting and standardization strategies on the firm level which are represented by motives and barriers to participate in formal standard-setting organizations (SSOs) as well as motives and barriers to patent. Afterwards, the sample for the empirical part is introduced. Then, the motives and

1 E.g. Arundel (2001) used data on 2849 R&D-performing firms, a representative sample on innovative companies, which allowed him to compare the use of the protection strategies "secrecy" and "patenting".

barriers are ranked according to their importance and significant differences between SMEs and large firms are exposed. Subsequently, we show the results of the correlation analyses to test our hypotheses. The final part of this article summarizes the findings, gives some suggestions of possible upcoming research on the topic of strategic interaction of patenting and formal standardization and stresses the limitations of our research.

2. Conceptual Considerations and Hypotheses

In this section, we connect the decision process regarding the proper exploitation of an invention with the strategic decision whether to implement an open or closed business model. The decision whether to patent an invention or to propose it (with or without patent protection) into a formal standardization process is part of firms' innovation strategy which is not only related to patent management, but intellectual property management in general. Moreover, this decision is connected with the business model a firm chooses. First, we give a short review on the literature regarding open and closed business models. Afterwards, we develop a decision tree describing the interaction of firms' patenting and standardization strategies on the invention level. Finally, the connection of the conclusions of the decision tree with strategic considerations regarding different business models on the firm level and the integration of the literature regarding motives and barriers to patent as well as to participate in formal standardization, respectively, allows us to develop four hypotheses.

As foundation, we rely on the growing literature on business models: Recently, there has been much scientific work on the advantages of different business models, especially with respect to strategic intellectual property management (e.g. see Rivette and Kline, 2000; Teece, 2010; Zack, 1999). One key question within the examination of business models is whether it should be a closed or open one.[2] More specifically, the question is whether the firm should share its (protected or unprotected[3]) intellectual property with others in the framework of shared platforms such as standard-setting organizations or if it should protect its intangible assets by applying for intellectual property rights (IPR) like patents and try to establish de facto standards (see e.g. Ehrhardt, 2004; Eisenmann, 2008).

Within the framework of our study, we regard preferring patenting respectively participation in formal standardization as special strategies of closed respectively open business models. Patents give temporary property rights to the patentee like using the invention exclusively or just prohibiting its use by competitors. The patent

2 Here, open business models have to be distinguished from open innovation. While open innovation refers to the opening of the whole R&D process, open business models in this context only means to share the knowledge about the final invention e.g. in the framework of formal SSOs.

3 Even if the invention is protected by a patent, there is the possibility to bring it into formal standardization process by agreeing to FRAND (i.e. Fair, Reasonable and Non-Discriminatory) or RF (i.e. Royalty Free) licensing terms.

holder can exploit its patented technology to gain some revenues out of its monopoly position on the product market or generate revenues by licensing it out to firms active in the product market (see e.g. Grindley & Teece, 1997; Hall & Ziedonis, 2001). Thereby, patents provide incentives to invest in research activities. This function can be seen as traditional purpose of the patent system. However, motives to patent have become more strategic and firms increasingly apply for patents due to reasons such as blocking innovation processes of competitors or gaining a better position in negotiations about R&D cooperation (Blind et al., 2006). Consequently, if the prevalent strategy in a firm is to patent all new inventions, it is setting the base for running some form of closed business model.

The opposite is true for firms which bring their inventions into some kind of platform or standardization process and thereby share their knowledge with others. Especially formal standards "come near to being a classical public good" (Blind & Thumm, 2004, p. 1584; see also e.g. Kindleberger, 1983; Swann, 2000, 2010) and make essential information on the new technology and even the technologies themselves – depending on the licensing regimes – available for everyone who is interested to implement it. Thus, standards help to gain broad diffusion and may therefore lead to wide acceptance of technologies (Blind, 2006). In this context, James et al (2013) state, that "firms may publicly disclose information in an effort to encourage others to develop complementary technologies, to foster coordination across an ecosystem, or to facilitate the establishment of technical standards" (p. 1134). It follows that firms which prefer to bring their innovative technologies into formal standardization processes instead of seeking for patent protection run some kind of open business model.

In this connection, we assume that the preference of patenting an invention (and therefore setting the base for implementing a closed business model) outweighs the preference of participation in formal SSOs (and therefore the implementation of open business models). This is due to the fact that there is no possibility to long for patent protection for the invention once it has been revealed in a standardization committee, equal to other forms of publication, and thus is considered as state-of-the-art. Then again, patented inventions can be introduced in the standardization process (e.g. Berger et al., 2012; Rysman & Simcoe, 2008). Consequently, we predict, that the decision about

patenting an invention precedes the decision about standardization. Since informal instruments such as the implementation of technical solutions or keeping information on the invention secret are not regarded in this paper, we focus on the patenting option as special form of the intellectual property management. We can therefore illustrate the decision process by a simple decision tree, which is depicted in FIGURE 1[4].

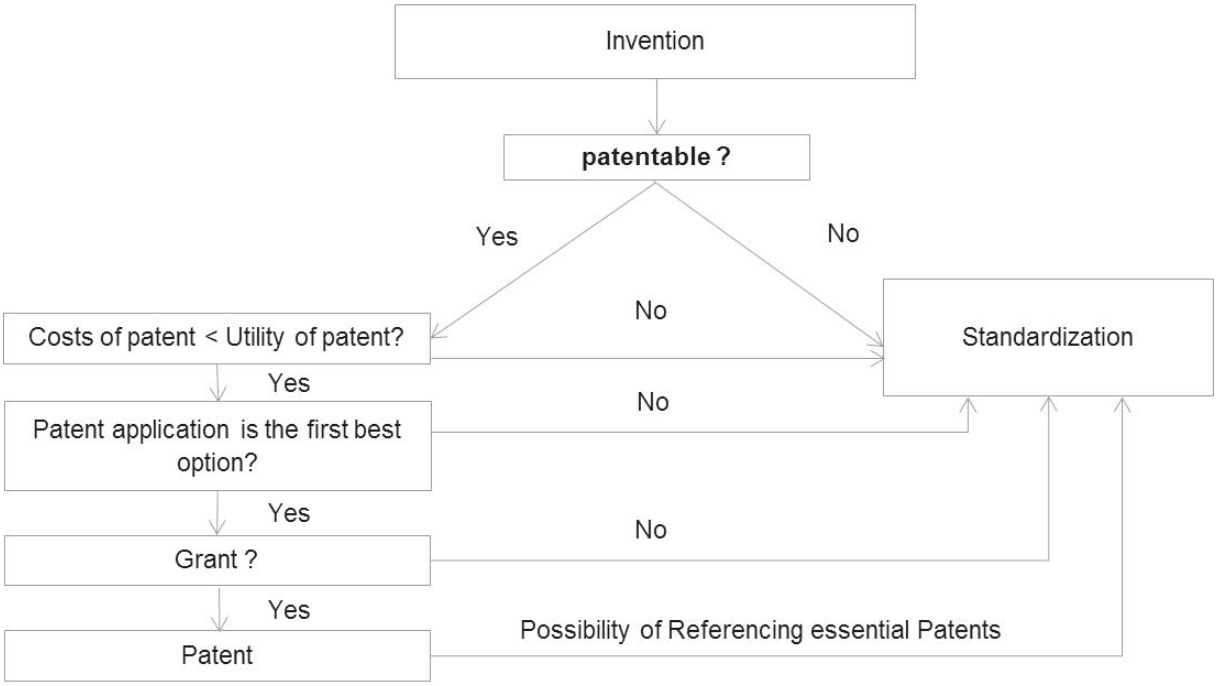

FIGURE 1: Decision tree regarding patenting and standardization

The decision tree depicts the decision process concerning the use of the instruments of patenting and formal standardization on invention level. The model thus pictures the sequence of decisions which are made by a firm in order to decide on how to use the inventions or new knowledge properly. It consists of four successive decision steps regarding patentability, utility-cost-ratio, application and grant decision. First, the question occurs whether or not the invention is patentable at all. In most countries, it has to meet the criteria of "novelty", "utility" and "inventive step" (see e.g. German Patent Law §§ 1, 3, 4; European Patent Convention Art. 52, 54, 56; United States Code Title 35, §§ 100, 102, 103). If the firm believes that the invention cannot comply with all of these requirements, the option of proposing the knowledge behind an invention

4 The decision tree is based on a figure in Barrett (2002). In contrast to Barrett's figure, our decision tree contains the option "standardization" and excludes the options "defensive publication" and "trade secret" since the focus of our analysis is different.

into a standardization committee will make sense for the first time. Otherwise, the next step focuses on the utility of the patent: Are the cost of an application higher than the expected utility? Costs for example are expenses for the application or lawyers' fees, while possible gains of owning patents are revenues of the products based on the patents, revenues of licensing contracts to third parties or indirect gains by blocking competitors. If a patent is seen as profitable, firms still need to consider whether they prefer other possibilities to deal with their invention which may generate higher profits, even if the utility-cost-ratio of patenting is positive. Hereupon, in case of patenting being the most profitable option, the firm applies for a patent at the responsible patent office. This time not employees of the firm but patent examiners of the patent office review the criteria of "novelty", "utility" and "inventive step" and then decide about granting the patent After the patent is granted – or even before – the firm may have the option of disclosing the patent as so called "essential patent" for a standard (see e.g. Bekkers et al., 2011 on the determinants of patents to become essential). Summing up, we assume a sequential decision process according to this conceptual model: Firms decide about the possibility and profitability of patenting the invention on each of the four steps and only if the patenting decision is negative at one of them before the final granting decision, firms consider whether to propose the unprotected knowledge or invention for integration into a formal standard or not.

In order to develop and test some hypotheses regarding the proposed interaction of patenting and standardization strategies, we have to abstract our considerations to the firm level in the following based on the assumption that the law of large numbers can also be applied to firms' inventions. As mentioned before, there is a lack of theoretical as well as empirical literature on the relationship between patenting strategies and the strategic participation in formal standardization bodies on firm level. However, the motives and barriers to participate in formal standardization as well as to patent, respectively, can be regarded as underlying characteristics of firms' standardization and patenting strategies. Thus, we have a look at the (also limited) literature on motives and barriers for the usage of the two instruments for the development of our hypotheses.

First, the relationship between the motives to patent and to participate in formal standardization processes is reviewed. Blind et al. (2006) identify five groups of motives

to patent: protection motives, blocking motive, reputation motives, exchange motives as well as incentive motives. On the other hand, Blind and Mangelsdorf (2010) cluster different motives to participate in formal standardization in five groups: knowledge seeking, market access, technical solution, regulation and company interests. We assume that there are some links between the motives to participate in formal standardization and the motives to patent. As firms with unprotected technological knowledge may be reluctant to join formal standardization bodies due to the danger of losing the control over their knowledge assets, we expect the protection motives to patent to be positively correlated with the motives to participate in formal standardization. Positive correlations are also expected between the exchange motives to patent and motives related to knowledge transfer for participating in formal standardization. Furthermore, we assume positive correlations of the motives to participate in formal standardization with the reputation motives to patent because participating in SSOs may improve a firm's image and visibility. Only the blocking motive to patent might be negative correlated with motives to participate in formal standardization since firms that try to block competitors by patenting might not be interested in working with them in the framework of formal standardization. In general, we expect the positive interrelations to outweigh the negative.

In addition to the motives to patent and to participate in formal standardization, we also have to regard the barriers for patenting and getting actively involved in standardization. Unfortunately, there has been conducted even less research on this topic than on the motives. Cohen et al. (2000) find "relationships between reasons not to patent and firm size" (p. 15) in their study. Small firms refrain from patenting due to possible litigation costs. Thus, especially costs aspects seem to be an important issue for small firms. The problem of limited resources for SMEs in matters of the protection of intellectual property is confirmed in a paper by Olander, Hurmelinna-Laukkanen and Mähönen (2009). They rely on the results of eight case studies. On the other hand, the "SME access report to European standardization" (Vries et al., 2010) asserts that the majority of SMEs typically lack strategic thinking and lack practical resources (time, money and knowledge). Obviously, cost reasons seem to play an important role for small enterprises in both, patenting and standardization decisions. Regarding the utilization of the options patenting and standardization, all the mentioned arguments

point to the conclusion that it is much easier for large firms to apply for patents as well as to participate in standardization compared to SMEs. Thus, we derive our first two hypotheses:

H1a: Since various advantages of patents can be appropriated easier by large firms than by SMEs, the motives for patenting are rated higher by large firms compared to SMEs. On the other hand, the barriers to patent are more important to SMEs due to their smaller capacities.

H1b: Since influencing the standardization process, and thus having benefits by participating, is easier for large firms than for SMEs, the motives to participate in SSO are rated higher by large firms compared to SMEs. In contrast, participation barriers are more important to SMEs due to their smaller capacities.

According to the consideration that the motives and barriers of the two instruments display firms' underlying strategies, strong commonalities of these strategies are reflected by a high share of strong connections between the motives for the two instruments as well as the barriers for both. Moreover, some similarities between firms' standardization and patenting motives as well as standardization and patenting barriers are expected due to aspects mentioned before. We quantify these connections by analyzing the share of significant positive correlations of two appropriate correlation matrices in the empirical part of the paper. Thus, a high share of significant positive correlations between the motives for both instruments and the barriers, respectively, are expected. Conversely, we assume a relatively low share of significant positive correlations between the barriers to patent and the motives to standardize as well as the barriers to standardize and the motives to patent which we also get hold of by the assistance of two further correlation matrices. These latter two matrices display the possible differences between patenting and standardization strategies. Therefore, the shares of significant positive correlations are expected to be relatively low compared to the first matrices. Thus, the third hypothesis is as follows:

H2: The share of significant positive correlations between the motives and the barriers of the two instruments is significantly higher than the share of significant positive correlations between the motives of the one instrument with respect to the barriers of the other.

Furthermore, the conceptual considerations indicate that the decision about patenting precedes the standardization decision on the invention level. According to the fundamental restriction that patent protection for an invention is no longer possible after disclosing it – like publishing it in journals – in formal standardization process, the decision about patenting precedes the decision whether to disclose the content within a formal standardization process or not. As stated before, we assume that the patenting and standardization strategies are mirrored by the motives and barriers of the instruments on the firm level. Referring to these motives and barriers, the relationship between the barriers to patent and the motives to participate in SSOs is expected to be relatively strong, since barriers that rule out patent protection might influence the standardization decision positively. On the other hand, the relationship between the barriers to participate in formal standardization and the motives to patent is expected to be weaker or even not existent. This is due to the fact that the decision whether to patent or not has already taken place when it comes to the decision about possible standardization activities. Thus, the latter is expected to have no impact on the patenting decision. A higher share of significant positive correlations between the barriers to patent and the motives to participate in formal standardization compared to the share of significant positive correlations between the barriers to participate in formal standardization and the motives to patent indicates that the proposed sequence of the decision tree is right. Consequently, we derive our last hypothesis:

H3: The share of significant positive correlations between the barriers to patent and the motives to participate in formal standardization is significantly higher than the share between the barriers to participate in formal standardization and the motives to patent since the decision to patent precedes the decision about participating in formal standardization and thus reasons not to patent are expected to promote motives to join standardization activities.

3. Data and Ranking of the Motives and Barriers

In order to test the previous developed hypotheses, we rely on survey data gathered from German firms in 2011 which are either at least active in patenting or participate in formal standardization processes at the national SSO in Germany. Besides general questions about the number of employees and the sector, the question catalogue consisted of four main blocks: Motives to participate in formal standardization, barriers to participate in formal standardization, motives to patent and barriers to patent. All items are rated on a five-point-likert-scale by the participants. Our following analysis is founded on the responses to these four sets of questions, which provides us with solid data on the interrelation between standardizing and patenting strategies.

The data was collected in the framework of the study "The Interrelation between Formal Standards and Patents"[5]. Overall, 721 answers of German standardizing or patenting firms were received. These answers equate a response rate of about 6 percent of the 13,000 firms that were contacted. The response rate among firms that are active in standardization as well as patenting (1,750 firms) is about 14%. All firms with missing information on some of the motives or the barriers to patent and to participate in formal standardization as well as firm size are excluded from the analysis. Thus, 440 observations remain in the sample. 256 of these firms, which is more than 50% of the reduced sample, are active in patenting as well as in formal standardization as depicted in TABLE 1.

TABLE 1: Sample distribution by activity level

Level of activity	Active in patenting and formal standardization	Only active in patenting	Only active in formal standardization	Not active in both
Number of firms (n=440)	256	218	42	13
Percentage	58%	29%	10%	3%

5 The survey was conducted by the Chair for Innovation Economics of the TU Berlin and was funded by the DIN German Institute for Standardization and the Federal Ministry of Economics and Technology of Germany (BMWi). In order to reach all companies, which are active in patenting or formal standardization, different ways of contacting were used: All companies active in writing formal standards (about 7,000 firms) were contacted by DIN e.V., whereas all companies that had at least applied for one patent since 2003 (6,500 firms) were contacted by the Chair for Innovation Economics via mail.

Moreover, there is an equal size distribution within the sample: 60% of the firms have less than 250 employees and are therefore defined as "small- or medium sized enterprises" (SME)[6]. 40% have more than 250 employees and are referred to as "large firms" in the following. In fact, this distribution does not reflect the actual size distribution of firms for Germany, where small and medium-sized enterprises represent the vast majority. That is, our sample is biased towards large firms.

The distribution of the sample by sector and firm size is shown in TABLE A1 in the appendix. There are nine manufacturing sectors with 346 firms (79%) as well as three services sectors with 94 (21%) firms. Most respondents belong to the mechanical engineering sector (88 firms), followed by the electrical engineering sector (78 firms). In contrast, there are only few firms active in constructing motor vehicles (20 firms) or in the construction sector (12 firms) within the sample. In most sectors, the distribution is slightly skewed towards the SMEs which is consistent with the overall distribution of the sample. The exception is the motor vehicle sector, where 70% belong to the group of large firms.

In the following, we analyze the importance of the motives and barriers for both instruments. We distinguish between SMEs and large firms in order to test hypothesis 1 by conducting t-tests. First, we have a look at the motives and barriers to patent. The questionnaire listed 16 specific motives as well as 15 barriers to apply for a patent and the participants were asked to assess them. The items were constructed according to the limited literature on this topic (e.g. Blind et al., 2006; Cohen et al., 2002). Mean values of the different motives and barriers are presented in TABLES 2 and 3. At first glance, it can be stated that the importance of the motives to patent disperse very much, i.e. there seem to be a few very important patenting motives being the main reasons for firms to apply for patents. Looking at the motives in detail, there are two very important groups of motives to apply for a patent: Traditional protection motives such as "Protection against imitation" or "Legal security (securing priority status)" on the one hand and strategic reasons such as "Differentiation from competitors in markets" or "Preservation of own technological development scope (freedom to operate)" on the other hand. "Strengthening of market position/hedging of market shares" is most important to SMEs and large firms, but large firms assess this item significantly higher

6 According to the definition of the European Commission, companies with less than 250 employees are seen as small and medium-sized enterprises (SMEs).

than small firms.

Regarding the difference between SMEs and large firms, it can be stated that the latter assess a higher importance to most of the motives to patent than SMEs. Only "Earning of royalties" is more important for SMEs than for large firms, but the difference in the assessment is only marginal.

TABLE 2: Ranking of motives to patent

Motive	Mean all (N=440)	Mean SMEs (N=262)	Mean large firms (N=178)
Strengthening of market position / hedging of market shares***	4.22	4.09	4.41
Protection against imitation***	4.18	3.97	4.47
Differentiation from competitors in markets***	4.10	3.94	4.33
Preservation of own technological development scope (freedom to operate)***	3.73	3.51	4.06
Legal security (securing priority status)***	3.67	3.53	3.87
Improving corporate image	3.52	3.48	3.57
Preventing competitors from entering the market	3.38	3.30	3.49
Increasing corporate value	3.27	3.25	3.30
Enhancing position in business cooperation	2.41	2.37	2.47
Exchange potential (e.g. cross-licensing)***	2.31	2.16	2.52
Earning of royalties	2.28	2.29	2.26
Use of patents as an internal performance indicator***	2.16	2.05	2.32
Employee motivation (e.g. salary by patent applications)***	2.08	1.95	2.27
Bringing your own patented inventions into the standardization process	1.97	1.94	2.02
Preventing the integration of certain specifications in standards	1.96	1.96	1.96
Easier access to capital markets (e.g. for the acquisition of equity or credit collateralization)	1.89	1.88	1.91

Asterisks indicate the level of significant differences: *p<0.1; **p<0.05; ***p<0.01

A look at the barriers to patent reveals that cost and time reasons are most relevant for firms not to apply for a patent. Furthermore, the preference of transferring research results into standards is ranked last but one. Thus, firms rarely think of bringing a patentable invention into standardization process instead of patenting it, which goes well together with the assumptions of the decision tree that the patenting decision precedes the standardization decision.

SMEs seem to assess a higher importance to the barriers than large firms. Only

two of the barriers are rated higher (even if not significantly) by large firms, whereas nine barriers are significantly more important to SMEs. This is especially true for time and cost efforts which are big issues for smaller firms. These findings confirm the statement of hypothesis 1a that motives are rated higher by large firms compared to SMEs while the opposite is true for the barriers to patent.

TABLE 3: Ranking of barriers to patent

Barrier	Mean all (N=440)	Mean SMEs (N=262)	Mean large firms (N=178)
An application is too costly regarding the resources deployed***	3.34	3.54	3.06
The legal costs of defending a patent are too large***	3.32	3.50	3.06
An application is too time-consuming regarding the resources deployed***	3.15	3.31	2.92
The scope covered by patent protection is not wide enough	3.00	3.03	2.95
Proofing novelty of the invention is to provide too difficult***	2.94	3.09	2.71
Secrecy as an instrument for the protection of intellectual property is used preferably	2.90	2.94	2.83
The extent of the information published in the patent is too high*	2.87	2.95	2.75
Uncertainty of previously granted, relevant patents***	2.70	2.85	2.49
Implementation of technical solutions (e.g. by increasing product complexity) is used preferably	2.59	2.54	2.67
Lack of qualified personnel within the company***	2.56	2.72	2.34
Uncertainness if the invention has already been published in scientific journals***	2.53	2.67	2.33
Uncertainness if the invention was already integrated into consensus, commissioned or informal standards***	2.34	2.46	2.16
Publication of research results (defensive publishing) is used preferably	2.05	2.10	1.99
The transfer of research results into standards (consensus, commissioned or informal) preferably is used preferably	1.93	1.95	1.90
Compensation of employees for using their inventions due to contractual agreements	1.89	1.84	1.95

Asterisks indicate the level of significant differences: *p<0.1; **p<0.05; ***p<0.01

Next, the motives and barriers to participate in formal standard-setting organizations are introduced. The development of the items is mainly based on the items used in the paper of Blind and Mangelsdorf (2010). It has to be mentioned that we are only interested in formal consensus standards which are developed in a voluntary standardization processes in the framework of committees of SSOs. In contrast, obligatory regulations that are enacted by law as well as informal industry standards of consortia are not addressed here. This is due to the fact that regulating standards have a regulatory character and industry standards often are very similar to proprietary innovations, because they are protected by IPR and the standardization process in consortia are in general neither open nor consensus based (Blind, 2006). Thus, only motives and barriers for the participation in formal SSOs were considered in the questionnaire and are used in our analysis.

There are different reasons for firms to participate in the standardization process within committees of SSOs, e.g. influencing the development of a standard, reducing R&D costs by gaining knowledge within the committees or opening markets for own technologies. In order to get a differentiated picture of the importance of these miscellaneous motives and barriers, the attitude towards 19 motives and 14 barriers regarding participation in formal standardization[7] has been queried in the questionnaire and respondents were asked to assess them. The rankings for the motives and the barriers to participate in formal standardization processes are shown in the TABLES 4 and 5. Again, it is differentiated between SMEs and large firms.

The importance of the motives to standardize disperses much less compared to the motives to patent. Especially two groups of motives are very important: First, creating a qualitatively good and fitting standard, which includes motives like "Creation of a well-engineered standard" and "Addressing technical problems in the standardization committees", seems to be a very important reason to participate in the formal standardization process. Second, firms rate more strategic motives like "Prevention of standards that contradict own interests" or "Gaining competitive advantage by being more knowledgeable" very highly. The integration of own IPR in standards and gaining interoperability with suppliers seems to be of less importance, however.

7 Formal standardization in this context means participating in committees of the following SSO's: DIN, DIN DKE, CEN, CENELEC, ISO, IEC, ETSI and ITU.

TABLE 4: Motives to participate in formal standardization

Motive	Mean all (N=440)	Mean SMEs (N=262)	Mean large firms (N=178)
Creation of a well-engineered standard**	3.70	3.60	3.85
Prevention of standards that contradict own interests*	3.64	3.55	3.76
Gaining competitive advantage by being more knowledgeable	3.53	3.53	3.54
Legal certainty on new science and technology fields (e.g. reducing the risk of liability)*	3.51	3.44	3.63
Addressing technical problems in the standardization committees and controlling the technology development**	3.51	3.41	3.66
Industry-appropriate design of regulations**	3.46	3.34	3.65
Certainty of technological development scope***	3.38	3.23	3.60
Generation of new knowledge in standardization committees	3.28	3.31	3.24
Favoring the diffusion of own technologies through standards (Opening of markets)***	3.23	3.10	3.42
Increasing the firm's reputation by participating	3.21	3.18	3.26
Prevention of regulations	3.17	3.09	3.28
Observing technical knowledge of other firms	3.14	3.15	3.13
Reduction of R & D costs through knowledge gain in the standardization process	3.11	3.11	3.11
Prevention of market power of proprietary de facto standards	3.10	3.10	3.11
Reduction of trade barriers**	3.05	2.94	3.21
Preventing the integration of intellectual property rights of other firms in standards**	2.95	2.85	3.11
Making contacts with potential partners for future economic projects*	2.88	2.92	2.83
Promoting of interoperability with suppliers of complementary products	2.64	2.55	2.76
Integration of own intellectual property rights in standards	2.57	2.60	2.53

Asterisks indicate the level of significant differences: *p<0.1; **p<0.05; ***p<0.01

The differences between SMEs and large firms are significant for 9 out of the 19 items and almost all of the items are rated higher by the group of larger firms than by the SMEs. Only the items "Generation of new knowledge in standardization committees", "Observing technical knowledge of other firms", "Integration of own intellectual property rights in standards" and "Making contacts with potential partners for future economic projects" are more important to SMEs than for large firms, albeit only the difference for the latter is significant. Nonetheless, this indicates that SMEs

participate mainly in SSOs in order to get access to knowledge and to cooperate with other firms. On the contrary, large firms join standardization processes primarily to influence standards.

TABLE 5: Ranking of barriers to participate in formal standardization

Barrier	Mean all (N=440)	Mean SMEs (N=262)	Mean large firms (N=178)
Participation is too time-consuming regarding the resources deployed	3.76	3.82	3.67
The process of standardization takes too long	3.63	3.66	3.59
Participation is too costly regarding the resources deployed**	3.50	3.59	3.35
Lack of personal / organizational ties to standards setting organizations	2.88	2.95	2.79
Administrative barriers (contact and participation process are too complex and not transparent)**	2.86	2.97	2.70
There already exist a sufficient number of consensus, commissioned or informal standards for our purposes	2.82	2.86	2.77
Secrecy as an instrument for the protection of intellectual property is used preferably	2.76	2.83	2.66
Contributed technological knowledge is not sufficiently well protected in standards	2.68	2.75	2.58
Lack of possibility to implement own technological content in standards.	2.67	2.73	2.57
Interests of the company are adequately represented by association representatives in standards committees	2.52	2.45	2.62
Too many property rights (e.g. patents) hamper the process of standardization*	2.47	2.56	2.34
Product or service of our company is difficult to standardize*	2.38	2.47	2.25
Lack of specific standards committees	2.36	2.40	2.31
Publication of research results (defensive publishing) is used preferably	2.20	2.25	2.13

Asterisks indicate the level of significant differences: *p<0.1; **p<0.05; ***p<0.01

Looking at the 14 barriers to participate in formal standardization presented in TABLE 5, especially time and cost reasons are responsible for firms to stay away from standardization processes. Therefore, the most important barriers to stay away from formal standardization are very similar to the highest ranked barriers to patent. This is another hint that there could be an underlying connection between patenting and

standardizing strategies. On the other hand, there seem to be enough committees with different focal points because the items "Product or service of our company is difficult to standardize" as well as "Lack of specific standards committees" are of lower importance.

Regarding differences in the assessment between SMEs and large firms, only "Participation is too costly regarding the resources deployed" and "Administrative barriers" are significantly different on the 5%-level, but almost all items are rated higher by the SMEs.

Pertaining to hypothesis 1b, the results verify this hypothesis in most instances. Only specific reasons to participate that are related to knowledge-seeking and thus to the replacement of own R&D effort (see Blind and Mangelsdorf, 2010) are more important to SMEs than to large firms. In contrast, almost half of the motives to participate in SSOs are assessed significantly higher by large firms. Regarding the barriers to participate, especially the cost aspects refrains SMEs to join SSOs which is significantly different for large firms.

Concluding, this chapter analyzed the importance of several motives and barriers to patent and to participate in formal standardization. Some first commonalities between these instruments are revealed, indicating similarities between the underlying strategies. Empirical analyses in the next chapter help to test our hypotheses 2 and 3 derived by the decision tree. Therefore, correlation analyses are applied in order to get statistically reliable results.

4. Results of the Correlation Analyses and Discussion

After having identified the differences in the assessment of the various motives and barriers in particular between large firms and SMEs, we focus on the general relationship between patenting and standardization strategies. Therefore, we return to the hypotheses 2 and 3 of the conceptual part of our paper: Is there an interrelation between the patenting strategy and the standardizing strategy of firms (H2) and is there a particular order within the decision process (H3)? The relationship is quantified by the following four correlation matrices between motives and barriers[8]:

- Motives to patent and motives to participate in formal standardization (1)
- Barriers to patent and barriers to participate in formal standardization (2)
- Barriers to patent and motives to participate in formal standardization (3)
- Barriers to participate in formal standardization and motives to patent (4)

We use the share of significant positive correlations of each correlation matrix as measure for the strength of interrelation between the different sets of motives and barriers in order to test our hypotheses. Moreover, two-group proportion tests are conducted in order to identify significant differences regarding the shares of significant positive correlations between the correlation matrices. TABLE 6 shows the shares of significant positive correlations for the four correlation matrices using the full sample.

TABLE 6: Share of significant correlations of the correlation matrices and significant differences between these matrices.[9]

Correlation matrix	(1)	(1)/(2) Difference	(2)	(2)/(3) Difference	(3)	(3)/(4) Difference	(4)
Share of significant correlations based on all observations (N=440)	56%	-	56%	***	35%	***	14%
Share of negative correlations among significant correlations	0%	-	0%	-	0%	-	23%

Asterisks indicate the level of significant differences: *p<0.1; **p<0.05; ***p<0.01

8 As stated before, we assume a general pattern in the innovation strategy of a company according to its underlying business model and therefore analyze structures on the firm level, although we know that the decision about patenting is made on the invention level.

9 Correlations were calculated by pairwise correlation method. The tables with the results of the four correlation matrices are not shown here and are available upon request.

There should be a high share of significant positive correlations between the motives (matrix 1) as well as the barriers (matrix 2) of both actions in order to approve the premise of the decision tree, namely that there are underlying similarities between the strategies regarding patenting and participating in formal standardization. Results confirm this expectation as 56 % of the correlations for matrix 1[10] and matrix 2[11], respectively, are significant. Moreover, these shares are much larger compared to the matrices 3[12] and 4[13]. The two-group proportion test reveals that the share of significant correlations of the matrices 1 and 2 is significantly higher than the shares of the matrices 3 and 4. It has to be mentioned that for the full sample all of the significant correlations of matrix 1 and matrix 2 are positive. These high shares of significant positive correlations indicate that there are strong links between reasons to patent and reasons to participate in formal standardization. We find the assumption of an integrated decision process and thus our hypothesis 1 confirmed.

Furthermore, the decision tree suggests that the decision about patenting an invention precedes the decision of participating in formal standardization. Hence, a relatively large amount of significant positive correlations between barriers to patent and motives to participate in standardization (matrix 3) should be observed on firm level, because reasons against patenting an invention are expected to be strongly connected with arguments to join a formal standardization process. On the other hand, comparatively few correlations between barriers to participate in formal standardization and motives to patent (matrix 4) are expected to be significant because the reasons not to participate in formal standardization should not influence the patenting decision. According to the decision tree, the latter has already taken place when it comes to the decision about formal standardization. The results depicted in TABLE 6 support this hypothesis: While 35 % of the correlations of matrix 3 are significant, the same is true only for 14 % of the correlations of matrix 4. Also, the two-group proportion test indicates that the share of significant correlations of matrix 3 is significantly higher

10 i.e. 169 out of 304 correlations between the motives to patent and the motives to participate in formal standardization are significant at the 1%-level.

11 i.e. 117 out of 210 correlations between the barriers to patent and the barriers to participate in formal standardization are significant at the 1%-level.

12 i.e. 101 out of 285 correlations between the barriers to patent and the motives to participate in formal standardization are significant at the 1%-level.

13 i.e. 31 out of 224 correlations between the barriers to participate in formal standardization and the motives to patent are significant at the 1%-level.

than the share of matrix 4.

While all the significant correlations of the matrices 1, 2 and 3 are positive, 23 % of the significant correlations of matrix 4 are negative. This result points to the conclusion that there is no clear direction in the interaction between barriers to participate in formal standardization and motives to patent. In fact, there seem to be only few significant links between these sets of variables which are quite ambiguous. Thus, firms seem to lay their focus on patenting an invention first and a negative decision may lead to introducing inventions and ideas in formal standardization processes. We therefore can regard hypothesis 3 as verified.

Finally, we examine the differences between the shares of significant correlations for SMEs and large firms. We did not postulate any hypotheses regarding differences in the underlying strategies for these two groups. In order to expose possible features of the patenting and standardization strategies of small and large firms in an explorative way, we present the results of the correlation analyses for these groups in TABLE 7.

TABLE 7: Share of significant correlations of the matrices and significant differences between the proportions of SMEs and large firms.

Correlation matrix	**(1)**	**(2)**	**(3)**	**(4)**
Share of significant correlations for SMEs (N=262)	44%	37%	32%	8%
Share of significant correlations for large firms (N=178)	18%	27%	7%	7%
Two-group proportion test for significant differences between SMEs and large firms	***	**	***	-

Asterisks indicate the level of significant differences: *=10%; **=5%; ***=1%

In compliance with the results for the full sample, the shares of the matrices 1 and 2 are higher than the shares for the matrices 3 and 4 for both, SMEs and large firms. However, there are some peculiarities. Comparing the results of matrix 1 and matrix 2 for large firms and SMEs, it becomes obvious that the shares of both matrices are significantly higher for SMEs. Thus, small firms seem to have more similarities between their reasons and barriers to use both instruments compared to large firms. This may be due to the fact that they see patenting and standardization as substitutes since they have only the resources to pursue one option. Large firms, in contrast,

may see a complementary relationship between these options which might lead to less significant correlations in all matrices. Additionally, SMEs exhibit much more significant correlations for matrix 3 than for matrix 4, which proves the assumption of a subsequent decision process. With reference to large firms, these matrices show only very small shares of significant correlations.

Summing up, we can state that hypotheses 1 and 2 are verified at least with respect to the full sample. The high share of positive significant correlations between the sets of motives and the sets of barriers indicate a strong relationship between patenting and standardizing strategies. Also, the decision about patenting in SMEs seems to precede the decision of participating in formal standardization as there are many significant links between barriers to patent and motives to participate in formal standardization but only few between barriers to participate in formal standardization and motives to patent. However, hypothesis 3 is only confirmed for SMEs and has to be rejected when large firms are regarded separately. In contrast, large firms seem to separate the decisions about patenting and standardizing and thus seem to follow different aims by applying the different options.

5. Summary and Conclusion

Our research on the general similarities of patenting and standardization strategies can be seen as a basis for future investigations on this interesting topic. For this purpose, we embed the decision process regarding the question whether to patent or to standardize an invention in the framework of existing literature on the openness or closeness of business models. We believe that firms favoring patents follow a more closed business model, while firms that prefer to open up by participating in SSOs follow an open business model. Thus, we connect the decision on invention level with the general firm strategy with respect to patenting and standardization. We model a decision tree that pictures the sequence of decisions on the invention level when it comes to determine whether to patent an invention or bring it into formal standardization process. This model in combination with the literature on reasons to patent and to participate in standardization serves as a starting point for our empirical analysis. Thereupon, we develop three hypotheses which are tested by means of t-tests and correlation analyses. More precisely, we rank the several motives and barriers to patent as well as to participate in formal SSOs and, further, we use the shares of significant positive correlations of four correlation matrices as a measure for the strength of the interrelation between the four sets of variables.

The results are in general consistent with our hypotheses: While large firm rate most of the motives to patent and to participate in formal standardization higher than SMEs, the opposite is true regarding the barriers. This is a strong indication for hypotheses 1a and 1b. Moreover, there are high shares of significant positive correlations between motives to patent and motives to participate in formal SSOs as well as between the barriers for these options. We conclude that there are underlying similarities of firms' strategic behavior regarding patenting and formal standardization and thus consider hypothesis 2 as confirmed. However, for large firms only few significant links between the motives are observed. Moreover, we observe a high number of significant positive correlations between barriers to patent and motives to participate in formal SSOs, whereas the share of significant correlations between barriers to participate in formal SSOs and motives to patent is comparatively low. As opposite to the other matrices, some of the significant correlations of the latter are negative. This results

point to the conclusion that the decision about patenting precedes the decision about the participation in formal SSOs. This supports hypothesis 3 since reasons not to patent are clearly connected with reasons to participate in standardization process, but not the other way around. Again, this result is true for SMEs but not for large firms.

Regarding IP management, these results have some major implications. First, the barriers to use patents, but also to participate in SSOs, are more meaningful for SMEs than for large firms. On the contrary, the incentives for both are higher for large firms than for SMEs. Thus, SMEs might have other ways to cope with their IP. One solution might be to keep inventions confidential. Secrecy is an informal instrument which was excluded in this paper due to methodological issues. Moreover, the degree of similarities regarding firms' patenting and standardizing strategies seems to be dependent to firm size. While large firms show lots of differences between the reasons to patent or to standardize an invention, SMEs seem to have a lot of similarities in this matter. Therefore, it can be assumed that large firms find patenting and standardization to be complementary tools. In contrast, they seem to be substitutes for SMEs.

Also, these first results provide some policy implications. Policy makers who focus on promoting patents might also consider fostering firms' involvement in standardization in order to diffuse the knowledge, in particular of SMEs, in a more open way compared to patents. Moreover, only the barrier "Interests of the company are adequately represented by association representatives in standards committees" is rated higher by large firms than SMEs. This indicates that SMEs think their interests are not adequately represented in standardization by the representative of their association. Thus, it is even more important to lower the entry barriers in SSOs for SMEs.

As mentioned above, our analysis is a starting point for further research on this topic and some possible improvements should not remain unmentioned. Due to the great amount of different motives and barriers, factor analysis could be of assistance in order to reduce this array and reveal hidden structures in the sets of motives and barriers. Future investigations should quantify the impact of the two instruments on each other more precisely by conducting multiple regression analyses and controlling for other influencing factors than firm size. Especially sector differences should be investigated in more detail as sectors such as information and communication

technologies differ in their standardization strategy from other sectors.

Yet, another limitation is the level of analysis. We only can observe the reasons to participate in formal standardization as well as to patent on the firm level. Admittedly, as there might be different strategies for different inventions, analyses on the invention level might be needed. However, we assume a general pattern on firm level either to go for patents or not. The same is true for the participation in formal standardization bodies.

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7. Appendix

TABLE A1: Sample by sector

Sectors	Size classes		
	SMEs (percent of observations per sector)	**Large firms (percent of observations per sector)**	**Observations per sector**
Manufacturing sectors:			
Mechanical Engineering	64 %	36%	88 observations
Chemistry (incl. Biotech. & Pharma)	65 %	35%	26 observations
Consumer Goods	58 %	42%	33 observations
Metal Production	52 %	48%	46 observations
Electrical Engineering	58 %	42%	78 observations
Motor Vehicles	30 %	70%	20 observations
Rubber and Plastics	48 %	52%	23 observations
Construction	67 %	33%	12 observations
Manufacturing Others	60 %	40%	20 observations
Service sectors:			
Trade and Sales	56 %	44%	27 observations
Professional, scientific and technical Services	69 %	31%	49 observations
Service Others	83 %	17%	18 observations
Total	**60 %**	**40 %**	**440 observations**

Is Strategic Patenting Still in Vogue? - A Reassessment of Motives to Patent a Decade After the Patent Surge

4

Abstract

Patenting strategies have become a major aspect of a firm's technology strategy. The following study examines the changes in the importance of different motives to patent over the last decade. It builds up on the study of Blind et al. (2006). They find that especially strategic patenting motives (e.g. using patents as bargaining chips, improving technological image/corporate value or use patents as an incentive instrument) have become important reasons to apply for a patent. One decade after this study, we discover that such strategic motives have significantly lost in relevance while the traditional market-related patent motives (strengthening the market position and protection against imitation) remain most important. We also show that other appropriability instruments such as secrecy, utility patents and design patents have gained significantly in importance among patent active firms. Finally, we find some indication that firms tend to use a more integrated patent strategies than a decade ago by conducting a factor analysis.

Content

1. Introduction

There has been an unprecedented surge in the number of patent applications during the late 1990s which, however, was not accompanied by a rise in the R&D expenditures of firms (Blind & Thumm, 2004; Blind et al., 2006). As a result, there have been a lot of research papers on firms' motivations for patent applications in order to investigate the factors which have led to this observed rise in the number of patent applications (see e.g. Arundel et al. 1995; Cohen et al., 2002; Duguet & Kabla 1998; Pitkethly, 2001). In the case of Germany, Blind et al. (2006) cope with this phenomenon by investigating data collected in 2002 on several motives to apply for patents. Mainly, they find that new strategic motives such as improving technological image, increasing firm value or using patents as bargaining chips have increased in importance.

Even though actual studies (e.g. Somaya, 2012) underline the continuous relevance of research on patent strategy, there have been – to our knowledge – no subsequent studies analyzing changes in the assessment of the patenting motives since Blind et al. (2006). This is where our paper starts.

Besides, the utilization of other appropriation instruments might also have changed over time. As a matter of principle, patent strategies and other appropriability strategies should not be analyzed independently (Somaya, 2012; p. 1087). Thus, we consider the utilization of other IP related instruments, such as secrecy, lead-time advantages or copyrights, in our analysis as well.[1]

We compare the data used by Blind (2006) from 2002 with data gathered in 2011. Applying the method of propensity score matching, we get two comparable samples and can therefore identify changes in the assessment of motives to patent and instruments to protect IP over time.

Furthermore, changes in firms' assessment of the different motives to patent might also alter the interplay between these motives. Consequently, our article not only analyzes the changes in the relevance of motives to patent over time, but also searches for new structures using the method of factor analysis.

The remainder of the paper is structured as follows. First, we give a summary on

1 In their 2003 working paper for example, Bar-Gill and Parchomovsky (2003) show that the combination of narrow patenting and the publication of the related R&D information is a dominant strategy in cumulative industries to increase a technologies momentum.

the previous research on patents as an appropriation method for returns on innovation efforts as well as on the research on motives to patent. By analyzing the results of the most important empirical studies, we develop hypotheses for the empirical part of the paper. Second, the data used for the empirical analyses is introduced. Third, we analyze the relevance of instruments to protect intellectual property (with special emphasis on patenting) as well as motives to patent. We also want to identify changes in the assessment over time. Therefore, we compare our findings to the results of Blind et al. (2006). Subsequently, we conduct a factor analysis to analyze changes in the interrelation of patent strategies. Finally, we discuss the results as well as the limitation of our paper and possible future research.

2. Literature Review and Hypotheses

According to the resource based view of the firm, patents can be seen as a relevant resource for a firm's profitability (Grant, 1991). In case of the pharmaceutical industry, Markman et al. (2004) show that patents can enable firms to achieve a sustainable competitive advantage as they confer relevant technological knowledge, provide a temporarily monopoly and are characterized by imperfect substitutability. In dynamic and highly competitive markets, patents are a crucial resource for the success of a firm (Arora et al., 2001). Owing to that, a variety of patent motives have emerged over time (see for example Blind et al., 2006; Somaya, 2012).

As patenting motives are part of a firm's patent strategy the term "patent strategy" or the broader definition "intellectual property strategy" has to be clarified. Pitkethly (2001) defines intellectual property strategy as "the use of IP, either alone or in combination with other resources of the firm, to achieve the firm's strategic objectives" (p. 426). Somaya (2012) notes that "patent strategies ultimately affect firm value and performance through the appropriability outcomes they generate" (p. 1087).

Given the assumption that strategic patenting motives are used to "achieve strategic objectives" and increase "firm value and performance", we differentiate between traditional market-related and strategic motives to patent (see Blind et al., 2006).[2] The traditional market-related motive describes the use of patents in their original function as a protection instrument.[3] This allows firms to protect the unique sets of resources from imitation, which gives them the opportunity to achieve a first mover advantage[4] (Lieberman & Montgomery, 1988; Markman et al., 2004). Based on that protected unique set of resources, firms may achieve a sustainable competitive advantage due to a higher freedom to operate, an earlier establishment of distribution channels, higher customer loyalty and reputation (Barney, 1991).

Besides the traditional market-related motives, a multitude of strategic patent motives has been derived, described by Blind et al. (2006) as "the decision to patent

2 The categorization/classification of patent strategies varies between different studies (see for example Somaya (2012); Pitkethly (2001)). As we build up on the study of Blind et al. (2006), we use the same definition to make our findings comparable.

3 According to Blind et al. (2006: 659), the exact wording is "protection from imitation"

4 At least theoretically, patents can lead to a first mover advantage. As discussed by Lieberman and Montgomery (1988), this might only be true for certain industries (e.g. pharmaceutical).

- despite the significance of the protection motive" (p. 656). According to the literature review of Blind et al. (2006), the usage of patents as blocking instruments, bargaining chips, for licensing or incentive and reputation tools are most prominent strategic patenting motives.

As a blocking instrument, patents can be used to create market entry barriers (Grant, 1991) and to raise rivals costs[5]. In this regard, the literature often differentiates between two general blocking strategies: offensive and defensive (see e.g. Blind et al., 2006; Somaya, 2012). Offensive blocking characterizes a strategy where patents are used to attack, alienate and reduce the room of action from actual and potential competitors (Blind et al., 2006). For the purpose of defensive or offensive blocking, a patent does not even have to be granted, because the application process can be strategically used to increase the pendency time and therefore reduce the room for potential competitors to maneuver (Hegde et al., 2009).

Defensive blocking describes a strategy in which "firms patent in order to prevent their own technological room to manoeuvre being reduced by the patents of others" (Blind et al., 2006; p. 657). Somaya (2012) argues that firms often face the problem of high sunk costs when exploiting new business opportunities in dynamic and rapidly evolving industries. This problem gets even more intensified due to the fact that firms are often unaware of the underlying patent structure and the patent portfolios of potential competitors which they are exposed to. In order to decrease potential hold-up risks and get access to external technologies, some firms have "ramped up" their patent portfolios (Hall & Ziedonis, 2001). Besides that, Shapiro (2001) suggests the usage of patent pools as well as cross licensing agreements to avoid such "hold up" problems, which we also consider as instruments within the realms of a defensive patent strategy.

A prominent example illustrating the effectiveness of a defensive patent strategy is the case of Polaroid and Eastman Kodak discussed by Rivette and Kline (2000). Kodak ignored the Polaroid patent thicket, which they had created around their "instant-photography business", when they entered the same market. As a result, Kodak was convicted guilty of infringing Polaroid´s patents. The compensation paid by Kodak was about $925 million. Furthermore, Kodak had to close manufacturing plants and buy

5 For instance by building patent thickets or patent fences (Shapiro, 2001).

back the sold products based on the infringed technology (Rivette & Kline, 2000). Hall and Ziedonis (2001) find that the Polaroid case was an important turning point for firms' strategic patent management as they became aware of the far-reaching consequences which the infringement of others patent rights might have.[6]

Related to the defensive use of patents is the purpose of using patents as an exchange instrument. Especially in sectors with fast growing cumulative technologies patents are relevant to avoid hold-up problems and obtain access to external technologies (Hall & Ziedonis, 2001). In the case of patent disputes within the computer software industry, Noel and Schankerman (2013) show that a larger patent portfolio improves a firm's bargaining position as patents can be used as "bargaining chips" for dispute settlement. In addition, patents enable R&D collaborations by making a firm's knowledge accessible and assignable (Peeters & Pottelsberghe de la Potterie, 2006)[7].

The potential of patents to generate licensing revenues has become highly relevant in some firm´s patenting strategy. IBM, for example, generated substantial licensing revenues of over $10 billion between 1993 and 2003 (Parchomovsky & Wagner, 2005). Likewise, Texas Instruments raised its royalty incomes from $200 million in 1987 to $600 million in 1995 (Arundel & Kabla, 1998).

Closely related to their exchange function is the usage of patents as an indicator for the underlying technological resources and capabilities of a firm to create new knowledge (Bogner & Bansal, 2007[8]; Markman et al., 2004). Therefore, the function of patents as a signaling instrument to reduce information asymmetries is a highly important ancillary effect as discussed by Long (2002). In line with that, Rivette and Kline (2000) point out that "patents can help companies communicate their asset picture and earnings potential to investors and the financial community" (p. 8). This, however, can be crucial especially for small and medium-sized enterprises (SMEs) in order to attract potential investors and put themselves in a better negotiation position (Rassenfosse, 2012).

The signaling function of patents also works within a firm. Scientific and

6 Hall and Ziedonis (2001; p. 109) describe this as the "demonstration effect".

7 In their 2006 article, Peeters and Pottelsberghe de la Potterie (2006) find that more patent active firms are characterized by a more "outward-orientated innovation strategy".

8 The authors use patent data (patent citations) to analyze a firm's underlying knowledge capabilities ("knowledge impact", "internal knowledge management", and "knowledge management capture"). By doing so they show that patent data can be used to gain insights about a firm's capabilities.

technological output is hard to measure while a granted patent implies that the patented invention is "new" (hence not "state-of-the-art"), contains an inventive step and is characterized by an industrial application. Thus, patents can be used as performance indicator regarding the output of the R&D process. Consequently, R&D employees that are more productive according to this indicator can be rewarded and patents can serve as an internal incentive instrument (Blind et al., 2006; Neuhäusler, 2012).

Regarding the relevance of different patenting motives, Blind et al. (2006) compare research results of several well-known surveys regarding motives to patent conducted up to 2003. Except for one study, all investigations find the traditional motive to apply for a patent to be the most important one, followed by the strategic blocking motive. The detailed comparison of these empirical studies can be read in Blind et al. (2006). We focus on recent studies published after 2006 in the following. Veer and Jell (2012) investigate whether there are different motivations to apply for a patent for different kinds of applicants (single inventors, small firms, large firms, and universities). Among all applicants, they find the traditional motive (prevention from imitation) to be most important, followed by the offensive blocking motive and securing freedom to operate. In contrast, the relevance of the other motives (signaling and licensing) was rated much more inhomogeneous.[9] Graham and Sichelman (2010), primarily focusing on start-ups, find that patenting for protection reasons is most important to the survey participants. Rassenfosse (2012) comes to the same results. He finds that protection from imitation and freedom to operate are the most important reasons for firms to patent.[10] However, maintaining the freedom to operate is significantly more important to large firms than to SMEs. Strategic motives, such as the usage of patents to attract potential investors and the usage of patents in the view of licensing, are regarded as less important. Additionally, SMEs find both motives as significantly more important than large firms.

In the next sections, we develop several hypotheses regarding changes in the assessment of patenting and other instruments to protect intellectual property as well as the changes in the assessment of the different motives to patent over time by using the insights of this literature review.

9 For further information please refer to: Veer & Jell (2012).

10 In the study respondents had to rate five different motives to patent according to their relevance: "imitation", "secrecy", "freedom", "investors", "licensing" (Rassenfosse, 2012).

Hypotheses

As the literature review revealed, strategic patenting has become an important aspect of management strategy. Hall and Ziedonis (2001) find for some industries – for example semiconductors - that firms spend extensive resources on the development of their patent portfolios, although patents are not regarded as essential to secure a firm's innovative output. The authors describe this phenomenon as "patent paradox". In line with this, Schwiebacher (2013) shows that firms have to face more and more fragmented patent landscapes[11] affecting their innovation behavior. Following this line of thought, we refer to the considerations of Heller (1998), who describes the situation where scare resources are underused, as the "tragedy of the anticommons"[12].

Having in mind that patenting is a resource intensive process (Somaya, 2012) and that the validity of a patent is often quite uncertain (Lemley & Shapiro, 2005), the cost-benefit-ratio of patents often seems to be debatable. Consequently, firms might focus on patenting inventions, which bring the highest reward at the market, have a core function for their business and hence need to be protected. Patent applications, which base on more strategic reasons (e.g. signaling inventiveness to possible investors), might be put aside due to limited resources and decreasing utility. Thus, we conclude the following hypothesis:

H1: Strategic patenting motives have become less important due to the decreasing utility of solely strategic patents.

While hypothesis 1 states that the relevance of strategic patenting has decreased over the last decade, we assume that the traditional reasons to patent can still be regarded as highly important. Strategic patenting stems from a clearly intended strategy which often has an aggressive aftertaste. Most firms do not have the resources or capabilities to pursue such strategies. Those patentees rely on patents because they are aware of patent related risks and just want to protect their inventions.

11 The author describes this phenomenon as "fragmented/heterogeneous IP ownership".

12 The author defines the tragedy of anticommons as a situation in which "multiple owners each have a right to exclude others from a scarce resource and no one has an effective privilege of use." (Heller, 1998; p. 698)

H2: Traditional patenting motives are still highly important because they protect firms from patent related risks (i.e. trials)

According to the logic of the "tragedy of the anticommons", firms have to use more integrated patent strategies. This means that different reasons to apply for a patent fuse more and more together in the decision making process. Hence, one patent application fulfils more than one strategic function. Blind et al. (2006) identify five different patent motives: protection, blockade, reputation, exchange and incentive. Under the condition of decreasing rents from patenting, firms have to rethink their patent strategies. Somaya (2012) states that an "effective patent strategy requires the prioritization of patent-related activities toward specific sets of technologies, and the allocation of resources to acquire, reinforce, and employ the required patent rights" (p. 1090). As a result, we propose that firms combine different strategies and therefore use a more integrated patenting approach, which is displayed in stronger correlations between diverse motives to patent.

H3: Firms tend to implement a more integrated patent strategy.

While the hypotheses above addressed potential changes of firms' patenting behavior, they excluded the relevance of other instruments to protect a firm`s IP. Studies show that there are plenty of other strategies which might substitute patents as a protection instrument (i.e. lead-time advantage or secrecy; see Blind et al., 2006). While the marginal utility of patenting seems to decrease, firms might tend to use additional instruments to protect their IP. Hence, our fourth hypothesis is formulated as follows:

H4: Additional instruments to protect a firms' IP have increased in importance.

In order to test this set of hypotheses, the third chapter compares the results of 2002 and 2011 with a special focus on the four hypotheses mentioned above.

3. Data and Methodology

The main goal of our research approach is to identify changes in the assessment of various motives to patent over time. We rely on data of two different surveys which were conducted among patenting German firms in 2002 and 2011. The dataset of 2002, used as a basis for the analysis in Blind et al. (2006), consists of responses of 532[13]. The firms within the dataset are responsible for more than 40 per cent of all German applications at the European Patent Office or via PCT procedures in 1999 (see Blind et al., 2006)[14]. The data from 2011 was collected in the framework of a study funded by the Federal Ministry of Economics and Technology and a sample of 587 patenting firms was achieved[15]. Furthermore, we exclude all observations with missing data on variables that we use in our analysis, which leaves us with 519 firms. Despite a moderate response rate, our sample covers about 24 per cent of all patent applications of German firms at the DPMA, EPO and WIPO (PCT approach) between 2003 and 2009.

TABLES 1 and 2 display the size and sector distributions of both samples. The classification of sectors basically follows the taxonomy of Blind et al. (2006)[16]. We analyze seven industrial branches, grouped according to NACE codes: chemistry (20) (including biotechnology (no separate NACE code available) as well as rubber and plastics (22)), mechanical engineering (28), motor vehicles (29), construction (41-43), electrical engineering (26 and 27) and metal production (24).

The distribution of firms over the seven sectors differs between both samples. While the sample from 2002 has "a bias to higher responses from large firms" (Blind et al., 2006; p. 660), the recent sample bears a higher number of small-and medium sized firms and therefore represents the German manufacturing landscape more adequately.

This may be due to the fact that the requirements for a firm to be faced with the questionnaire are much looser for the participants in 2011 (one patent application within six years) than in 2002 (three patent application within one year).

13 About 1.500 firms were contacted which applied for at least three patents at the European Patent Office (EPO) in 1999. Thus, the response rate was about 33 per cent.

14 For further details regarding the dataset please see Blind et al. (2006).

15 In this study, all active patenting German firms (about 6,500) were contacted and asked to complete the questionnaire. The response rate was about 9 per cent. As active firms, we identified every firm that has applied for at least one patent between 2003 and 2009.

16 In contrast to Blind et al. (2006), we merge chemistry, biotechnology and rubbers/plastics as these are quite similar industries and thereby, we get higher number of observations per sector.

TABLE 1: Sector and size distribution of unbalanced sample 2002

Sector	Observations	Percent	Average number of Employees
Mechanical Engineering	118	22.18	2084
Chemistry/Rubber & Plastics/Biotech	118	22.18	4011
Consumer Goods	20	3.76	2641
Metal Production	48	9.02	1368
Electrical Engineering	113	21.24	7033
Motor Vehicles	68	12.78	20022
Construction	47	8.83	3529
Total	**532**	**100.00**	**5954**

TABLE 2: Sector and size distribution of unbalanced sample 2011

Sector	Observations	Percent	Average number of Employees
Mechanical Engineering	147	28.32	1008
Chemistry/Rubber & Plastics/Biotech	78	15.03	5075
Consumer Goods	56	10.79	1165
Metal Production	68	13.1	893
Electrical Engineering	128	24.66	5454
Motor Vehicles	23	4.43	40284
Construction	19	3.66	2367
Total	**519**	**100.00**	**4511**

Due to these differences in size and sector distribution, it is not straightforward to compare our recent data to the sample from 2002. Also, we do not have exclusively identical firms in both samples and therefore miss a panel structure.

This misbalance of different sector and size distributions among the two samples might create a potential bias. Leiponen and Byma (2009) show that small firms regard patenting as rather unimportant as they benefit less from the patent system in comparison to larger firms. Arundel and Kabla (1998)[17] and Mansfield (1986)[18] provide evidence that the propensity to patent can differ significantly between sectors.[19] On a more granular level, Blind et al. (2006) show that firm size and sector dependence are assumed to have an influence on the assessment of motives to patent as well as the

17 The authors also find that firm size has a significant impact on the propensity to patent.

18 As the author shows not just the propensity to patent differs between sectors but also the relevance of patents in case of the invention development process and the commercialization of the invention.

19 For further information regarding the importance of patenting in different industries refer to the literature review of Mazzoleni and Nelson (1998).

importance of different appropriability instruments.

In order to cope with this possible sample selection bias, we conduct a propensity score matching (PSM) to attain comparable, balanced samples. The comparability of both samples is based on a vector of covariates (firm size and sector affiliation) which are used to achieve a better balance between the samples.

PSM is a statistical method to analyze the effect of a treatment on basis of two groups (treated and non-treated). The main challenge for such an analysis is the generation of two comparable groups which only differ by their treatment, which, in our case, is the time-difference between the two samples. In order to achieve such groups, PSM matches treated group members with non-treated group members who are very similar regarding several characteristics (Heinrich et al. 2010).

In case of the PSM, we estimate the propensity score for each observation in the two datasets by conducting a logistic regression with sample affiliation as the dependent variable (treatment variable) and a set of different explaining variables that might be characteristic for the sample affiliation: the number of employees as well as dummy-variables for each sector. Having calculated the propensity score, we are able to conduct the matching. Therefore, we apply a nearest neighbor matching without replacement which uses a so-called caliper. This caliper can be seen as some kind of tolerance level of the maximum propensity score distance of two matched observations. It reduces the risk of bad matches and is calculated as the standard deviation of the estimated propensity score multiplied by 0.25 (see Rosenbaum & Rubin, 1985). Consequently, we get two balanced samples, comprising 411 observations each, which we use to conduct our comparative statistical analyses. One has to keep in mind that we do not conduct the propensity score matching in order to cope with the issue of the classical treatment effect, but rather to show that the structures of our samples are comparable.

Having coped with the problem of possible selection biases, we take a look at the distribution of our balanced samples. The results are displayed in TABLES 3 and 4.

First of all, it can be noted that now the number of firms per sector is very similar between the two samples and both samples are equally large. Likewise, the difference between the mean of employees between both samples has diminished.

TABLE 3: Sector and size distribution of balanced sample 2002 – PSM

Sector	Observations	Percent	Average number of Employees
Mechanical Engineering	116	28.22	2084
Chemistry/Rubber & Plastics/Biotech	77	18.73	3396
Consumer Goods	20	4.87	2642
Metal Production	46	11.19	1369
Electrical Engineering	110	26.76	7097
Motor Vehicles	23	5.60	37754
Construction	19	4.62	5302
Total	**411**	**100.00**	**5764**

TABLE 4: Sector and size distribution of balanced sample 2011 - PSM

Sector	Observations	Percent	Average number of Employees
Mechanical Engineering	101	26.28	700
Chemistry/Rubber & Plastics/Biotech	77	18.73	3453
Consumer Goods	20	4.87	60
Metal Production	45	11.19	152
Electrical Engineering	126	28.71	5455
Motor Vehicles	23	5.60	40285
Construction	19	4.62	2367
Total	411	100.00	4875

However, the average number of employees per sector has changed, especially in the sample from 2011. As we have more difference in the sector-affiliation than in size between the unbalanced samples, the propensity score matching allows the difference in size between the sectors to grow in order to level the differences between the observations per sector in the balanced samples. Since running our analyses with the unbalanced samples does not change the outcome of our statistical analyses, we do not see this fact to be problematic and believe that our results regarding the changes in the assessment of instruments to protect IP as well as the motives to patent are correct.[20]

20 For the sake of simplification, we do always refer to the balanced sample within the text. All results of the unbalanced samples can be looked up in the appendix.

4. Empirical Results and Discussion

After the sample description in chapter 3, the results are presented in the following sections. First, we examine changes in the importance of patents among other instruments to protect intellectual property and, second, identify changes in the importance of motives to patent by means of two-sample t-tests.

Descriptive Results – Changes Over the Last Decade

For the analysis of the relevance of patents among other protection instruments, we use information on the assessment of a five-point-likert-scale by which the questioned firms were asked to rate the importance of each instrument[21]. To ensure the comparability of the samples (2011/2002), the same items were used in both the questionnaires. For the analysis of the changes in the relevance of instruments between 2011 and 2002 a two-sample t-test was conducted. The results are provided in TABLE 5.[22] With exception of patents and trademarks, all instruments have changed significantly in relevance during the last decade. Regarding the relevance of patents to protect a firm's IP, TABLE 5 reveals that patenting has remained the most important formal protection instrument for patenting firms compared to other formal instruments (trademarks, utility-patents, design-patent and copyrights). Nevertheless, lead-time advantage is still more important than patenting even if patenting has caught up in importance.

While the relevance of patents and trademarks has not changed, the importance of other formal instruments like copyrights and especially utility and design patents has increased significantly in importance within the last decade. This catch-up of other formal instruments over the last nine years indicates a broader use of instruments to protect intellectual property and therefore leads to the verification of hypothesis number 4. Also, secrecy has gained significantly in importance, indicating that non-disclosing inventions is becoming more and more essential for patenting firms.

21 The scale ranges from 1 ("not important) to 5 ("very important").

22 For the results of the unbalanced sample please see TABLE A1. Since there are no differences compared to TABLE 1, the results are regarded as robust.

TABLE 5: Ranking of protection instruments (balanced samples, N=411)

Instrument	2011 (mean)	N=	2002 (mean)	N=	Change (%)	t-test
Lead-Time Advantage	4.17	371	4.35	401	-4.32	↓***
Patent	4.14	409	4.08	405	1.47	→
Secrecy	4.13	373	3.55	397	16.34	↑***
Trademark	3.54	336	3.54	390	+/- 0	→
Utility Patent	3.27	350	2.54	401	28.74	↑***
Design Patent	2.31	264	1.77	364	30.51	↑***
Copyright	2.32	352	1.97	354	17.77	↑***

The mean is derived from a five point Likert-scale: 1 (= very unimportant) till 5 (= very important)
*** p< 0.01, ** p < 0.05, * p < 0.1

In order to get a deeper understanding of the motives to patent, firms were asked about twelve different patent motives, which they should rate by importance on a five-point-likert-scale[23]. Again, we analyze changes in the relevance of the motives between both samples by using a two-sample t-test. The results are itemized in TABLE 6[24].

TABLE 6: Ranking of motives to patent (balanced samples, N = 411)

Motive	2011 (mean)	N=	2002 (mean)	N=	Change (%)	t-test
Strengthening of market position / hedging of market shares	4.35	408	3.81	392	14.17	↑***
Protection against imitation	4.30	407	4.24	405	1.42	→
Preservation of own technological development scope	3.81	403	3.95	397	-3.67	↓*
Improving corporate image	3.54	403	3.82	405	-7.91	↓***
Preventing competitors from entering the market	3.49	401	3.86	400	-10.60	↓***
Increasing corporate value	3.28	402	3.40	405	-3.66	↓*
Enhancing position in business cooperation	2.39	398	2.74	392	-12.77	↓***
Exchange potential	2.30	399	2.27	386	1.32	→
Earning of royalties	2.20	398	2.24	407	-1.82	→
Use of patents as an internal performance indicator	2.13	398	2.36	398	-10.80	↓***
Employee motivation	2.08	399	2.69	398	-29.33	↓***
Easier access to capital markets	1.85	398	2.10	384	-13.51	↓***

The mean is derived from a five point Likert-scale: 1 (= very unimportant) till 5 (= very important)
*** p< 0.01. ** p < 0.05. * p < 0.1

23 The scale ranges from 1 ("not important) to 5 ("very important").

24 For the results of the unbalanced sample please see TABLE A2 As there are no differences compared to TABLE 2, the results are regarded as robust.

Except for the motives "protection against imitation", "exchange potential" and "earning of royalties", all patent motives show significant changes over time. Regarding their relevance, "strengthening of market position/hedging of market shares" and "protection against imitation" are the most important motives to patent. However, the first motive is the only one among all motives that has significantly increased in importance. The relevance of the protection motive stayed constant on a very high level. In contradiction to these traditional and directly market-related motives, most strategic motives have lost in importance.

Nevertheless, the preservation of the own technological development scope, the improvement of the corporate image, the prevention of competitors from entering the market and the increase of the corporate value are still regarded as relevant because they are rated at least "medium-important" on average. The less important motives, especially the use of patents as an internal performance indicator, employee motivation and the easier access to capital markets, have experienced the highest loss in importance. With respect to the results presented above, we can confirm our first hypothesis: Strategic patent motives have become less relevant over the last decade. In contrast, traditional and directly market-related motives such as "strengthening of the market position/hedging of market shares" as well "protection against imitation" have increased in importance or at least stayed constant, what verifies our second hypothesis.

Factor Analysis - Changes in the Interaction of Patent Motives

In order to analyze changes in the interplay of the patent motives compared to Blind et al. (2006), who indicate five superordinate patent motives (protection, blockade, reputation, exchange and incentive), we conduct a factor analysis using the twelve patent motives displayed in TABLE 6. We use an orthogonal rotation (varimax) in order to test if the number of factors has changed. The sample adequacy can be regarded as very good according to the Kaiser-Meyer-Olkin measure (KMO = 0.79). The factor loadings after the rotation are illustrated in TABLE 7.

TABLE 7: Factor loadings of motives to patent (N = 392)

Variable	Factor 1	Factor 2	Factor 3
Improving corporate image	0,64	-0,03	0,3
Increasing corporate value	0,65	0,14	0,37
Use of patents as an internal performance indicator	0,73	0,26	0,01
Employee motivation	0,71	0,28	-0,07
Exchange potential	-0,02	0,78	0,15
Earning of royalties	0,23	0,67	-0,01
Easier access to capital markets	0,4	0,63	-0,03
Enhancing position in business cooperation	0,43	0,64	0,01
Protection against imitation	-0,09	-0,01	0,79
Preventing competitors from entering the market	0,29	0,06	0,56
Strengthening of market position / hedging of market shares	0,14	0,03	0,82
Preservation of own technological development scope	0,17	0,4	0,53
Eigenvalues	3,85	1,82	1,04
% of variance	32,16	15,32	8,65
Cronbach's alpha	0,72	0,72	0,67

Blanks represent factor loadings lower 5.

From the clustering of the items, three factors are retained, which explain 56.1 per cent of the variance. The motives to patent are condensed in the three factors as follows:

— *Incentive & Reputation:* improving corporate image; increasing corporate value; use of patents as an internal performance indicator; employee motivation.
— *Exchange:* exchange potential; earning of royalties; easier access to capital markets; enhancing position in business cooperation;
— *Blocking & protection:* protection against imitation; strengthening of market position / hedging of market shares; preventing competitors from entering the market; preservation of own technological development scope;

The "traditional" and directly market-related motives are grouped together in the blocking & protection factor. Moreover, two factors can be derived from the more strategic motives: the exchange factor, which highlights the exchange potential

regarding monetary aspects as well as the usage of patents within cooperation, and the incentive and reputation factor, in which the signaling and incentive functions are closely linked together. The importance of different factors is displayed in FIGURE 1.

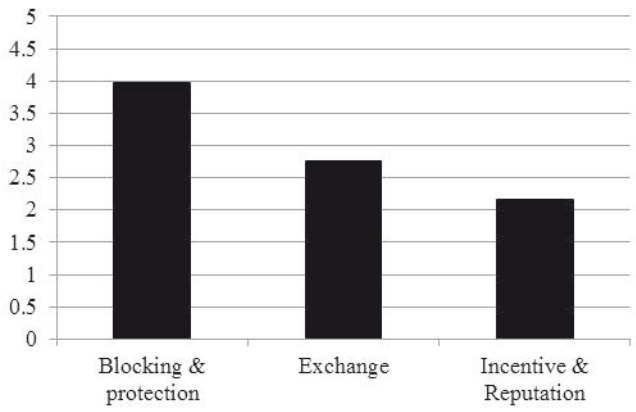

FIGURE 1: Importance of the clustered patenting motives (N = 392)

The blocking & protection factor is by far the most important factor, with a mean of 3.99, followed by the exchange factor (2.75) and incentive & reputation factor (2.18). In comparison to Blind et al. (2006), who indicate five superordinate patent motives (protection, blockade, reputation, exchange and incentive), we receive three factors from our factor analysis. These results point to a more integrated approach in firms' patenting strategies compared to 2002, as more motives to patent correlate higher with each other. Therefore, we can confirm our third hypothesis.

5. Summary and Conclusion

This paper constitutes a re-evaluation regarding the results of several empirical research studies on motives to patent which were published in the early 2000's. We explore changes regarding the relevance of patents and the assessment of several patenting motives of firms within the period from 2002 to 2011.

As theoretical foundation, we choose a resource-based perspective and pick up the concept of the "anticommons". We argue that the increasing competitive patent landscape as well as the resources and competences of a firm have an influence on its patenting motives and on the diversity of its patent strategy.

These theoretical considerations are of assistance in order to develop four hypotheses regarding possible changes in firms' patent strategies. Subsequently, the hypotheses are tested empirically and the results are manifold.

First, our statistical results suggest that the relevance of traditional and directly market-related patent motives has increased or at least stayed constant, while strategic patent motives have decreased drastically in relevance. We believe that this phenomenon is the result of a more fragmented patent landscape, which makes it harder for firms to maneuver within and therefore has a negative effect on the cost-benefit-ratio of patents. As a result, firms have to choose which patent strategy to pursuit. This is in line with findings of Somaya (2012). He states that firms have to prioritize their patent-related activities and the allocation of their resources involved.

Furthermore, we argue that this might lead to a streamlining process of patent strategies which result in more integrated patent behavior. The results of our factor analysis support this assumption by showing that the number of superordinate patenting motives decreases from five to three factors compared to the results from Blind et al. (2006).

Regarding the relevance of other instruments to protect a firm's IP, we show that patents are still the most important formal instrument. Nevertheless, the relevance of other instruments, especially utility patents, design patents and trademarks, has increased significantly. This supports our hypothesis that firms consider additional instruments to protect their IP as more important than a decade ago.

Finally, analyzing the changes in firms' patent strategies allows us to derive

some managerial as well as policy implications regarding the on-going discussion on strategic patenting. First, significant changes in the patent landscape are revealed. While a multitude of research studies has highlighted the increasing relevance of strategic patenting motives in the early 2000s', our results indicate that it might be necessary to overthink the general relevance of such motives. Second, on a more general level, the results point out that firms have reflected on their patent strategies and that an adjustment process has taken place, which steers the patent system back to its original functions.

One of the major limitations of our analysis is the missing panel structure. Even though we use a propensity score analysis to make both samples comparable, our analysis still implies a potential samples bias. Thus, further research should attend to this issue by analyzing changes in the motives to patent with panel data.

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7. Appendix

TABLE A1: Ranking of protection instruments (unbalanced samples)

Instrument	2011 (mean)	2002 (mean)	t-test
Lead-Time Advantage	4.19	4.36	↓***
Patent	4.15	4.08	→
Secrecy	4.10	3.58	↑***
Trademark	3.60	3.55	→
Utility Patent	3.34	2.55	↑***
Design Patent	2.47	1.73	↑***
Copyright	2.39	2.00	↑***

The mean is derived from a five point Likert-scale: 1 (= very unimportant) till 5 (= very important)
*** p< 0.01. ** p < 0.05. * p < 0.1

TABLE A2: Ranking of motives to patent (unbalanced samples)

Instrument	2011 (mean)	2002 (mean)	t-test
Strengthening of market position / hedging of market shares	4.37	3.80	↑***
Protection against imitation	4.33	4.26	→
Preservation of own technological development scope	3.82	3.96	↓*
Improving corporate image	3.54	3.82	↓***
Preventing competitors from entering the market	3.49	3.83	↓***
Increasing corporate value	3.28	3.41	↓*
Enhancing position in business cooperation	2.36	2.82	↓***
Exchange potential	2.35	2.30	→
Earning of royalties	2.20	2.30	→
Use of patents as an internal performance indicator	2.17	2.41	↓***
Employee motivation	2.11	2.72	↓***
Easier access to capital markets	1.89	2.14	↓***

The mean is derived from a five point Likert-scale: 1 (= very unimportant) till 5 (= very important)
*** p< 0.01. ** p < 0.05. * p < 0.1

The Interrelation Between Patenting, Secrecy and Strategic Publishing – Investigating the Role of Strategic Publications in Intellectual Property Management

Abstract

The proper protection and exploitation of inventions and intellectual property is a central task for firms in order to secure business success. While patenting is the most important formal instrument to protect own IP, secrecy is a well-known informal way to cope with it. A third opportunity is the strategic publication of firms' intellectual property. Each of these three opportunities has diverse advantages and disadvantages, thus an appropriate decision process regarding their utilization is necessary. Therefore, the paper firstly reviews the up-to-now conducted research on strategic publishing and its relationship to patenting and secrecy. Moreover, a brief empirical analysis shows that there are strong interdependencies between the application of patenting, secrecy and strategic publishing. We find that over 40% of the firms in our sample use all three instruments and, additionally, the likelihood of using strategic publishing seems to be connected with firm size. A closer look at six case studies gives first insights in the firm-intern interactions of the three instruments. It is revealed that strategic publishing is of special interest if the main goals are securing freedom to operate and creating state-of-the-art. Finally, embracing the results of the case studies as well as the findings of the theoretical and empirical part of the paper, a decision matrix on the invention level is developed which helps to choose the right instrument according to the aims of the invention. In conclusion, some managerial implications and policy recommendations are derived from the results of the paper.

Content

1. Introduction

"Knowledge of companies is prone to leakage, spill over, imitation and mobility" (Somaya, 2012, p.1085). Dealing furthermore with highly complex innovations, short production and product cycles, global markets and strong multinational competition, the role of intellectual property management and strategies as a key factor for success of modern firms is – without doubt –further increasing.

Regarding formal protection of intellectual property, a current phenomenon is the continuous and versatile observed increase in the number of patent applications over the last 25 years (WIPO, 2013). But not only formal instruments such as patents are the key to success. It is widely agreed that the combination of different instruments to cope with intellectual property, such as patenting, secrecy and strategic publishing (also called "defensive publishing) form a good composition to counter today's competitive challenges (e.g. Johnson, 2004; Peters et al., 2013; Ponce, 2007). This assumption is supported by the fact that there is also a noticeable increase in the number of strategic publications (Johnson, 2004; Henkel & Lernbecher, 2008). These findings are first indications of the rising importance of intellectual property management and consequently the question occurs if there are strategic interdependencies between these tools to protect and to cope with intellectual property.

The motives for knowledge protection and thus the motives to use certain instruments are diverse. Even within patenting, there are manifold motives such as blocking, preventing imitation, building fences and thickets, earning licensing income, avoiding litigation, motivation of R&D personnel, measuring performance, attracting inventors and improving a firm's image or reputation (e.g. Blind et al., 2006; Cohen et al.; 2002, Somaya, 2012). These and other strategic goals can also lead to the use of alternative instruments such as secrecy or strategic publishing depending on the main aim regarding the exploitation of an invention. For example, exclusive rights may be less important to the inventing firm for certain inventions, while freedom to operate in the future is the key goal. In this context, a study on application information data of the European Patent Office has found that some patents are filed simply to block patenting by others and ensure freedom to operate for the own interest (Guellec et al., 2012). Also, de Rassenfosse et al. (2008) have found that securing freedom to

operate is the second most important motive for patenting firms in a survey among patent applicants at the European Patent Office. However, strategic publishing can be superior to patenting in such situations (Adams & Henson-Apollonio, 2002; Henkel & Lernbecher, 2008). The growing importance of strategic publications is also found by Henkel & Lernbecher (2008). They examined the prevalence of strategic publishing in Germany empirically. Almost all (22 out of 23) of the technology-related firms in the DAX 30 group were interviewed and members of the German Electrical and Electronic Manufacturers' Association (ZVEI) were surveyed on the subject. Albeit these analyses are not representative and reflect only a small number of industrial sectors, the results do reveal a clear picture for Germany: 71% of the DAX 30 firms that were questioned and about 37% of the ZVEI members use strategic publishing. These results point to a high relevance of strategic publishing within a firm's IP strategy.

Consequently, the focus of this paper is on investigating the role of strategic publishing within a set of different IP instruments and the remainder of the paper is structured as follows: After a literature review on the instruments of interest (namely patenting, secrecy and strategic publishing) in the framework of intellectual property management, we present the results of a survey among patenting and standardizing firms in Germany. It can be shown that patenting, secrecy and strategic publishing are not only applied in specific sectors and by large firms, but are widely used by firms of all sizes and sectors. Also, there seems to be a strong connection between these tools on firm level concerning their application as well as their importance. Moreover, the investigation of some case studies gives us deeper insights into the relationship of the instruments within a firm and helps to identify specific situations in which a certain instrument fits best. The findings of the theoretical and empirical part as well as the case studies are used in the next section to establish a decision matrix on the invention level. Finally, the findings of the paper are summarized and some managerial conclusions are drawn.

2. Literature Review

In order to stand today's economic challenges, a diverse and careful IP management is without doubt essential. The continuous increasing of patent applications – the number of granted patents worldwide has more than doubled since 2000 (WIPO, 2013) – is proving that patenting is still a valuable and essential instrument for successful intellectual property protection. However, we also observe a positive trend regarding the use of alternative instruments such as strategic publishing (Henkel & Lernbecher, 2008; Johnson, 2004). There are various reasons for firms to turn their IP strategy away from the "patent-everything-doctrine" and to consider other options. Mansfield et al. (1981) and Grabowski & Venon (1983) show that patent protection is not equally effective for all technology sectors. Also, patent protection sometimes is regarded as porous and unclear (e.g. Cohen et al., 2000; Lemley & Shapiro, 2005) and the patent protection process as a slow and highly expensive procedure (Somaya, 2012). Likewise, the growing amount of patent applications cannot belie the fact that the economic value of patents is concentrated in only a small fraction of all patents (Harhoff et al., 2003). Besides these aspects, various surveys show that numerous firms find patents to be quite ineffective (e.g. Arundel, 2001; Cohen et al., 2000; Cohen et al., 2002; Harabi, 1995; Levin et al., 1987; Sattler, 2003). Also, it is considered critically that patent protection leads to knowledge spillovers (e.g. Horstman et al., 1985; Reitzig, 2004). Finally, there is an imbalance in favor of predominantly large firms that gain the great majority of all patents – which raises the question for smaller firms of how fit-for-purpose their own, often very costly, patenting activities are. Correspondingly, the question might also arise for firms with large patent portfolios whether the benefits of further patent applications justify the associated costs or not.

One opportunity to overcome these issues of patenting can be to strategically publish inventions, knowledge or at least technical details. The approach of strategic publishing is an IP instrument that verifiably documents the existence and public accessibility of a technology. The proof of publication effectively protects the inventor's own freedom to operate, because third parties are unable to obtain exclusive rights with any subsequent patent applications ("lack of novelty" and "raise of inventive step", see e.g. German Patent Law §§ 1, 3, 4; European Patent Convention Art. 52, 54, 56;

United States Code Title 35, §§ 100, 102, 103). There are several advantages of this procedure compared to patenting. It entails very little effort and is thus often cheaper and faster than applying for patent protection at the Patent Office (e.g. Barrett, 2002; Boettinger, 2007; Buxbaum, 2001; Colson, 2001). Besides, the strategic publication of technical material in order to establish legally verifiable state-of-the-art status is an already exercised strategy within intellectual property rights management (e.g. Adams & Henson-Apollonio, 2002; Henkel & Lernbecher, 2008). This fact is underpinned by the example of IBM (Industrial Business Machines, Inc.), a firm that makes strong use of strategic publishing since 1958 (Bhaskarabhatla & Pennings, 2012) and is often regarded as a forerunner for the strategic use of publications. Baker & Mezzetti (2005) find that an in-house strategic publication is cited as prior art in about each sixth patent that has been granted to IBM between 1996 and 2001. The cases of IBM and other firms that make use of strategic publishing very frequently such as SIEMENS, MOTOROLA or XEROX (Johnson, 2004) show that strategic publishing is used widely at least among large firms. Another advantage of strategic publishing is that firms can signal strategic commitments to own research activities by disclosing technological knowledge and thus bring competitors to exit R&D competition or redirect their R&D efforts (Gill, 2008). Strategic publishing can also have the effect of advancing the searchable prior art considered by the patent office. Consequently, competitors may find it harder to obtain patents in the same technology domain (e.g. Baker & Mezzetti, 2005; Bar, 2006).

Moreover, strategic publications must not only be seen as a substitute for patents, but also as a complimentary instrument. Further developments in R&D and associated ideas can be protected where strong basic patent protection is already in place (Slopek, 2009). Having to renew the patent for each further development is beyond the financial means of many firms. Alternatively, related ideas can be published strategically and in that way effectively protected from patenting by third parties. A strategic publication can act as a "pre-publication" of a patent application to create prior art that is valid in sense of the novelty aspect but also regarding the requirements for obviousness in patent law. Therefore, by publishing the patent application after handing it to the patent office, the described content becomes prior art that acts novelty destroying and protects against the grant of obvious third-party patents even during the period in which the own patent application is held under lock by the patent office. Strategic

publishing can therefore strengthen the own position, representing a shield against the patenting strategy of competitors, who try to devalue the firm's patent by registering dependent patents (e.g. Colson, 2001; Johnson, 2004). Besides the abovementioned aspects, Peters et al. (2013) find that strategic publishing should also be considered as part of a comprehensive IP strategy in the following four cases: The firm derives more revenue from product-related services than from the product itself, products can be easily reverse-engineered or invented-around, it is not certain that trade secrets can remain secret or the firm is acting as a stand-alone business.

Next to the options of disclosing an invention and its technical details via a patent or a strategic publication, there is the alternative to keep it secret. However, this instrument can be a risky substitute. Trade secrets tend to leak out (Mansfield, 1985) and there is always the risk that some other party patents the invention in parallel. The widely criticized issuance of low-quality patents (e.g. Kahin, 2003) may lead to patents being granted on inventions that some earlier inventor considered being too trivial to patent. The "prior use" argument (see German Patent Law, § 12) may help out for Germany but it is very often not effective and may be quite costly (e.g. Somaya, 2012). On the other hand, the directive in patent law that inventions must be described completely can be a disadvantage in certain situations and may allow other parties to invent around patented invention. This aspect can make secrecy an attractive alternative (e.g. Arundel & Kabla, 1998; Horstmann et al., 1985; Ponce, 2007; Scotchmer & Green, 1990). Finally, there are several reasons especially for small and medium-sized firms to rely on secrecy instead of patenting an invention. High costs for patents, insufficient protection from infringement and thus missing effectiveness of patents as an appropriation mechanism or simply product piracy are possible reasons (e.g. Cohen & Klepper, 1992). Consistent with these arguments, Arundel (2001) finds that a higher percentage of firms in all size classes rate secrecy more important than patents regarding product innovations. It is assumed that the abovementioned disadvantages of patent protection such as piracy and the possibility for others to invent around lead to that result.

This overview on the advantages and disadvantages of the three instruments of interest makes clear that the appropriate application of an instrument is dependent to several factors as well as the situation of the firm. In the next chapter, an analysis

of the interplay of the three instruments on firm level is conducted, before six case studies shed light on the application of patenting, strategic publishing and secrecy within a firm. These insights are of assistance for the fifth part of the paper where a decision matrix on invention level is developed.

3. Empirical Results

As the theoretical part revealed, strategic publishing might be an alternative to patenting as well as keeping inventions secret. However, in order to see if strategic publishing is actually applied, we have a look at the connection between the three instruments on firm level based on a dataset of German firms. Therefore, we can rely on data from 2011 of a survey in the framework of the study "The Interrelation between Formal Standards and Patents"[1]. Altogether, about 13,000 firms were contacted and finally 721 answers were received from patenting and (or) standardizing German firms. In addition to general questions about firm-specific figures in 2010 (number of employees, turnover, R&D expenditures and the sector affiliation), the question catalogue contained several questions about different instruments to cope with intellectual property. In this connection, firms were asked if they have used various instruments between 2008 and 2010 and to assess the importance of these instruments on a five-point-likert-scale. Patenting, secrecy and strategic publishing are the relevant instruments for the subsequent analysis among these instruments. Thus, we exclude all observations that possess missing values regarding these items as well as the firm specific figures mentioned before and get a reduced sample of 331 firms.

The structure of the sample with focus on firm size and R&D intensity per sector is shown in TABLE 1. It becomes obvious that most of the firms are active either in the mechanical engineering sector or in the electrical engineering sector whereas there are only few firms in the sectors "Trade & Sales" as well as "Manufacturing Others" and "Service Others". Moreover, there is a high mean in the number of employees in the sector "Motor Vehicles" whereas the opposite is true for the sector "Rubbers & Plastics". Moreover, "Professional, scientific and technical Services" is the sector with the highest R&D-intensity on average, followed by "Mechanical Engineering" and "Chemistry (including Pharma/Bio)". On the contrary, the sectors "Consumer Goods", "Construction" and "Trade & Sales" invest comparatively few resources in research and development activities.

1 In the course of the INS basic investigation "The Interrelation between Formal Standards and Patents", all German firms active at the DIN, the German Institute for Standardization, were asked to answer the questionnaire (about 7,000 firms). Moreover, all German firms that have at least applied for one patent at the DPMA, EPO or via PCT procedure between 2003 and 2009 were addressed (about 6,500 firms).

TABLE 1: Sample distribution by sector regarding firm size and R&D-intensity (N=331)

	Firms per Sector	Average number of employees	R&D intensity (R&D expenditures/turnover)
Manufacturing sectors:			
Mechanical Engineering	84	1278	0.10
Chemistry (incl. Pharma/ Bio)	28	5882	0.11
Consumer Goods	34	787	0.02
Metal Production	30	1021	0.03
Electrical Engineering	66	1385	0.07
Motor Vehicles	13	40305	0.06
Rubber & Plastics	19	478	0.08
Construction	12	1618	0.02
Manufacturing Others	5	1037	0.04
Service sectors:			
Trade & Sales	7	35	0.01
Professional, scientific & technical Services	24	8324	0.18
Service Others	9	1227	0.05
Full sample	**331**	**3594**	**0.08**

After this overview on the distribution of the sample regarding size, R&D-intensity and sector affiliation, we turn to the application and importance of patents, secrecy and strategic publishing. TABLE 2 lists all instruments and gives an overview of the percentage of firms applying an instrument as well as the average importance of the instruments for the full sample and for different size classes.

The results reveal that patenting and secrecy are by far more widely used than strategic publishing with respect to the full sample. Likewise, the former two instruments are seen as much more important than the latter. However, 45% of all firms in our sample use strategic publications as instrument to cope with their intellectual property.

Another important issue is the application and importance of the instruments for different firm sizes. An eye-catching result is that almost all firms with more than 500 employees use patents as well as secrecy as instruments to cope with IP.

TABLE 2: Application and importance[2] of instruments to protect intellectual property for different size classes (N=331)

	patenting		secrecy		strategic publishing	
Number of employees	**% of users**	**Importance**	**% of users**	**Importance**	**% of users**	**Importance**
up to 20	70	3.61	76	3.76	35	2.50
21-100	79	3.75	87	3.99	36	2.26
101-500	89	3.97	89	4.09	43	2.50
501-1000	100	4.16	100	3.95	58	2.33
over 1000	100	4.55	98	4.05	63	2.50
Full sample	**87**	**3.98**	**89**	**4.01**	**45**	**2.42**

Moreover, the proportion of firms using an instrument seems to rise with firm size with regard to all three instruments. However, while there is a strong relationship between firm size and the importance of patenting, this is not true for secrecy and strategic publishing which seem to be independent from the number of employees. Thus, patenting is more important to large firms than to smaller ones which might lead to the higher application rate of this instrument for large firms. In contrast, the importance of secrecy and strategic publishing seem to be more or less independent from firm size as stated above. Nevertheless, big firms use these tools much more often than SMEs which may be an indication that these instruments are complementary options for patenting to them. This might especially be true for strategic publishing which is very unimportant compared to patenting and secrecy for all size classes. Finally, it can be stated for all instruments that the proportion of firms applying an instrument rises with firm size, while the importance of secrecy and strategic publishing seems to be independent from firm size.

There might not only be differences in the assessment of the instruments between different size classes but also between sectors. Thus, TABLE 3 shows the usage as well as the importance of the three instruments in order to see variations between the sectors. First of all, it becomes obvious that patenting is much more common in the manufacturing sectors compared to the service sectors. Also, it is more important to firms from manufacturing sectors, which is especially true for the metal production

2 The importance was assessed on a five-point-likert-scale ranging from 1 („very unimportant" to 5 „very important".

industry. The picture regarding the importance and usage of secrecy is quite similar. However, secrecy is much more often applied and more important for firms stemming from the service sector compared to patenting. The lower importance and application rate of strategic publishing compared to patenting and secrecy is confirmed for each of the sectors. Moreover, we find that 47% of the firms in the electrical engineering sector use strategic publishing. This is a quite high number compared to 37% in the German electrical engineering sector found by Lernbecher in 2008[3]. All in all, it can be stated that patenting and secrecy are more often applied and also more important than strategic publishing. Moreover, these findings are generally independent from firm size and sector affiliation.

TABLE 3: Application and importance of instruments to protect intellectual property for different sectors (N=331)

	patenting		secrecy		strategic publishing	
Sector	**% of users**	**Importance**	**% of users**	**Importance**	**% of users**	**Importance**
Manufacturing:						
Mechanical Engineering	93	4.06	90	3.98	46	2.48
Chemistry (incl. Biotech. & Pharma)	93	4.11	96	4.25	39	1.96
Consumer Goods	82	3.79	88	3.82	35	1.85
Metal Production	97	4.40	97	4.30	50	2.87
Electrical Engineering	92	4.15	92	4.27	47	2.41
Motor Vehicles	92	3.92	92	3.46	46	2.23
Rubber & Plastics	95	4.21	84	3.89	47	2.37
Construction	83	3.83	83	3.83	42	2.42
Manufacturing Others	80	4.00	100	4.80	40	2.20
Service:						
Trade & Sales	14	2.57	71	3.43	14	2.00
Professional, scientific & technical Services	67	3.29	75	3.50	63	2.92
Service Others	56	3.89	89	4.11	33	3.44
Full sample	**87**	**3.98**	**89**	**4.01**	**45**	**2.42**

3 Not excluding observations with missing values and thereby using the 653 observations with information of the usage of strategic publishing, we get an application rate of 35% for the full sample and 37% for the electrical engineering sector. This is due to the fact that our reduced sample is biased towards innovative firms, which tend to apply instruments to cope with intellectual property more often than others.

These insights lead to the question in which way the applications of the instruments interact. Thus, FIGURE 1[4] shows the distribution of the sample by different application combinations of the three instruments.

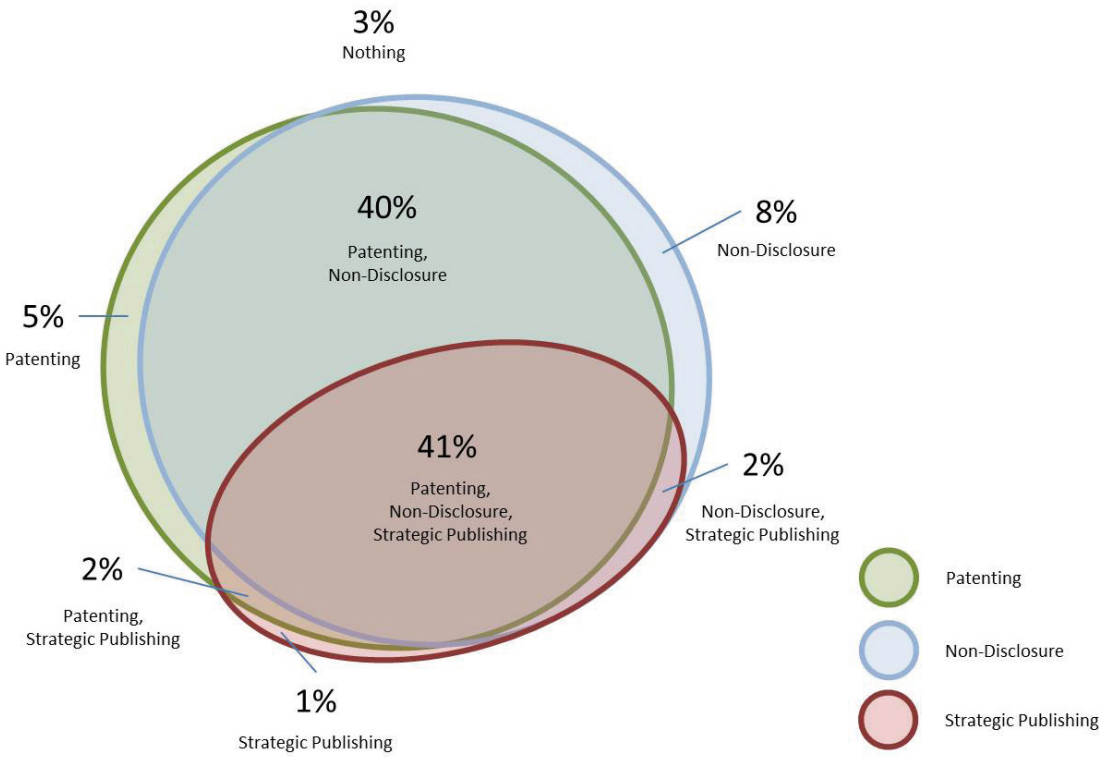

FIGURE 1: Distribution of firms by application of instruments(N=331)[5]

It becomes obvious that there are two main groups of firms with specific behavior regarding the protection of their inventions. 41% of the firms use all three instruments to cope with their intellectual property while about 40% of the firms apply for patents and keep inventions secret in order to protect their IP, but do not use strategic publishing. As we are particularly interested in the firms that use strategic publishing, we have a closer look at their behavior. As revealed in TABLES 2 and 3, 45% (149 firms) of the sample use strategic publishing. Furthermore, 91% of these 149 firms also use patents as well as secrecy and therefore follow a comprehensive IP strategy, while only two (respectively 1.3%) of these firms solely use strategic publishing to cope with their IP. Thus, it can be stated that almost all strategically publishing firms use a diverse set of instruments for their intellectual property management.

4 In order to see the actual figures that are basic for FIGURE 1, please see TABLE A1 in the appendix.

5 The sum of all figures equals 102% due to rounding errors. For exact figures see TABLE A1 in the appendix.

Consequently, strategic publishing seems to be an additional instrument, which is primarily used by firms that use patenting and secrecy as strategic tools for handling their IP. On the other hand, a large number of firms do not consider the instrument of strategic publications next to the options of patenting and secrecy. These firms may either not need strategic publishing in order to complement their IP strategy or they simply are not aware of this opportunity yet. In order to answer this question and to get a deeper understanding of the interplay of the three instruments, we analyze the results of six case studies in the next chapter.

4. Case Studies

The results of the survey revealed strong dependencies between the three instruments to protect IP on firm level. However, it is important to gain some insights of the interaction of the instruments within a firm in order to depict an adequate decision process on the invention level which is the main challenge in chapter five. Therefore, we can rely on the results of six case studies of German firms. The spectrum of firms ranges from a start-up with seven employees and a total of four pending patent applications to a multinational concern with more than 300,000 employees and about 4,700 patent applications per year. Furthermore, all six firms make use of patenting, secrecy and strategic publishing. TABLE 4 gives an overview on firm-size, turnover and sector affiliation of the firms as well as the role of the interviewed person within the firm. Afterwards, the firms as well as some specific statements of the interviewed persons are introduced.

TABLE 4: Information on the participating firms of the case studies

	Sector affiliation	Role of the interview partner	Number of employees	Turnover in 2012
Firm A	Multinational engineering and electronics firm	Vice President IP	over 300,000	over 46 billion EUR
Firm B	Automotive part supplier	Patent attorney	27,000	4.8 billion EUR
Firm C	Medical supplier	CEO	7	n/a
Firm D	Telecommunication	Head of IP	10,000	over 100 Mio. EUR
Firm E	Photovoltaic products	IP Manager	2000	over 100 Mio. EUR
Firm F	Automobile manufacturer	Patent attorney	over 550,000	192 billion EUR

Firm A is a multinational concern with main activities in engineering and electronics. The firm filed 4,700 patent applications (see TABLE 5) in 2012 and has more than 300,000 employees worldwide. The firm confirms that trade secret protection is suitable for process knowledge, but it does not make use of it a lot. For strategic publications, the firm uses a pin board near the premises where more than 1,000 publications per year are issued. Hence, they want their publications to be hard to find.

Firm B is an automotive part supplier with about 27,000 employees worldwide and 140 patent applications per year. Trade secrets are used if patent infringement is difficult to prove, e.g. for process knowledge. Also, the firm uses printed publications for strategic publishing that are published only in small editions. Therefore, these publications are hard to find for competitors.

Firm C is a start-up in the field of dental implants that has seven employees and applies for about one patent a year. Each patent application is published as a strategic publication right away after it has been filed at the patent office to extend the effect of the application to be prior art. It is emphasized that a published application is valid prior art, not only with regard to "novelty" but also in the sense of the "inventive step". So, similar patent applications are not patentable anymore if the patent application is published well-timed. According to the representative of firm C, secrecy is also important, especially for collaborations and the protection of process knowledge of rather small firms.

Firm D has about 10,000 employees and is working in the field of telecommunication. The firm applies for about 30-50 patents per year. Like firm B, it makes use of trade secrets if it is not possible to prove infringement. Furthermore, the firm uses online publications to create prior art.

Firm E belongs to the highly competitive photovoltaic industry and has about 2,000 employees worldwide. Besides, it applies for about 30 patents per year. The firm intensely uses trade-secret protection, i.e. every third invention is dealt with that way. The firm also uses strategic publications as low-number, printed publications that are hard to find for competitors.

Finally, firm F is one of the biggest automobile manufacturer with more than 550,000 employees worldwide and about 900 patent applications per year. Secrecy is rarely used, but then again the firm is issuing about 200-300 strategic publications per year. For this purpose, firm F uses printed publications, but without the aim of making them hard to find for competitors.

Since we are especially interested in the interplay of the three instruments within a specific firm, the usage behavior regarding patents, secrets and strategic publications for each firm is listed in TABLE 5. It becomes obvious that all six firms utilize a diversified IP strategy. However, all investigated firms prefer patenting before

using other instruments according to the interviews.

TABLE 5: Usage of IP instruments

	Patents applications	Utilization of secrecy	Strategic publications	Since when does the firm use strategic publishing
Firm A	4700 per year	Rarely	over 1000 per year	more than 20 years
Firm B	140 per year	If infringement is not provable; e.g. for process knowledge	5 per year	3 years
Firm C	1 per year	Arrangements of confidentiality, process knowledge	2-3 per year	3-4 years
Firm D	30-50 per year	If infringement is not provable	5-10 per year	more than 20 years
Firm E	30 per year	Almost every third invention	8 per year	2 years
Firm F	3300 per year	Rarely	200-300 per year	Not specified

Interestingly and contrary to the findings of the survey, the two largest firms (Firm A and E) use secrecy rarely, while the small and medium-sized firms use this instrument if an infringement is not provable for a technology, e.g. process knowledge. Thus, it can be assumed that firm D uses secrecy very often because the field of photovoltaic technology comprises a great amount of process knowledge and, additionally, the strong competition makes trade secret protection more attractive. Consistent with the results of the survey in chapter three, the use of strategic publishing seems to rise with firm size. Also, it becomes obvious that strategic publishing is not a new option but has been used by some firms for over 20 years.

Since strategic publishing is expected to be an additional tool for firms with a comprehensive IP management, we are particularly interested in the reasons for making use of this instrument. Thus, the motivations for the usage of this instrument are shown in TABLE 6. All firms agree that they use strategic publishing to create prior art and to secure freedom to operate for the future. Furthermore, firm A, C, D and F also use strategic publishing to prevent that competitors gain IP rights. Firms A, C and F agree at least partially that they publish to secure enhancements of already owned IP rights. Concluding, creating prior art and securing freedom to operate are the most common reasons if firms use strategic publications. Thus, strategic publishing

might be superior to patenting and secrecy when these are the main goals of the IP management of an invention.

TABLE 6: Motivations for strategic publishing

	To create prior art	To secure freedom to operate	To prevent that competitors gain IP rights	To secure enhancements of already owned IP rights
Firm A	yes	yes	yes	yes (as far as they are not patentable)
Firm B	yes	yes	no	no
Firm C	yes	yes	yes	yes
Firm D	yes	yes	yes	no
Firm E	yes	yes	no	no
Firm F	yes	yes	yes	partial

The results of the case studies as well as the insights of the empirical analysis in chapter 3 are the basis for the development of a decision matrix regarding the protection of an invention. Especially the case studies reveal the main motivations of firms to use strategic publishing, in particular creating prior art or securing freedom to operate. Among other things, these reasons will be considered on the different steps of the decision matrix. While the results of the survey give some insights of the basic interactions of the instruments on the firm level, the case studies help to approximate to the invention level on which the decision how to cope with an invention takes place. Therefore, this level of analysis is appropriate to develop and depict a proper decision process. Consequently, in the following chapter the level of analysis is changed from firm level to invention level in order to propose a detailed decision process.

5. Decision Matrix

In this section, we try to develop a decision matrix which depicts the different steps of the decision process regarding the exploitation and protection of an invention. This decision matrix is based on the results of the empirical part, the case studies and some existing models from the literature regarding the interplay of different IP Instruments. An overview on the literature, which contains models depicting such a decision process, is given in the following.

A first very basic model of the interrelation between patenting, secrecy and strategic publishing, which consists of two simple steps, is offered by Barret (2002). At the first step, firms have to decide whether the invention is a good candidate for trade secret protection or not. In the case of a positive decision, a trade secret is proposed. If not, the question occurs whether the costs of patenting exceed the benefits. In this case, the model proposes a strategic publication. However, if the costs are lower than the benefits, the invention should be prepared for a patent application.

Another work that investigates strategic publishing, patenting and secrecy is the paper "Defensive publishing by a leading firm" by Johnson (2004). He finds that strategic publishing is more likely to be optimal when a given invention is simple, not too technically challenging and easy to invent around. He argues that patenting and secrecy are unattractive in such cases, since patenting is unlikely to hinder a rival's access to a linked innovation, but still requires significant costs. Secrecy similarly does not thwart a rival's access and moreover leaves an unclear situation that might lead to high costs of litigation, i.e. to enforce freedom to operate if the invention is eventually patented by a third party.

Ponce (2007) offers a model based on the argument that patents are imperfect rights and may lead to inventing-around by competitors. He argues that this leads to the use of more trade secrets. Of course, secrecy leads to the possibility of duplicity and patenting by a third party, which may justify the use of strategic publishing.

These existing models give a general advice to the IP management of a firm and propose first answers to the question whether to implement alternative IP instruments. However, the decision process for the protection of a single invention or technology is not sufficiently represented in the existing models. Thus, we try to develop a more

detailed decision matrix according to the insights of the empirical part and the case studies.

For this purpose, we discussed possible strategic considerations that follow reported inventions with all interview partners of the case studies on the basis of a simplified decision matrix which is inspired by the model of Barret (2002). This procedure resulted in a very detailed decision matrix which is presented in FIGURE 2.

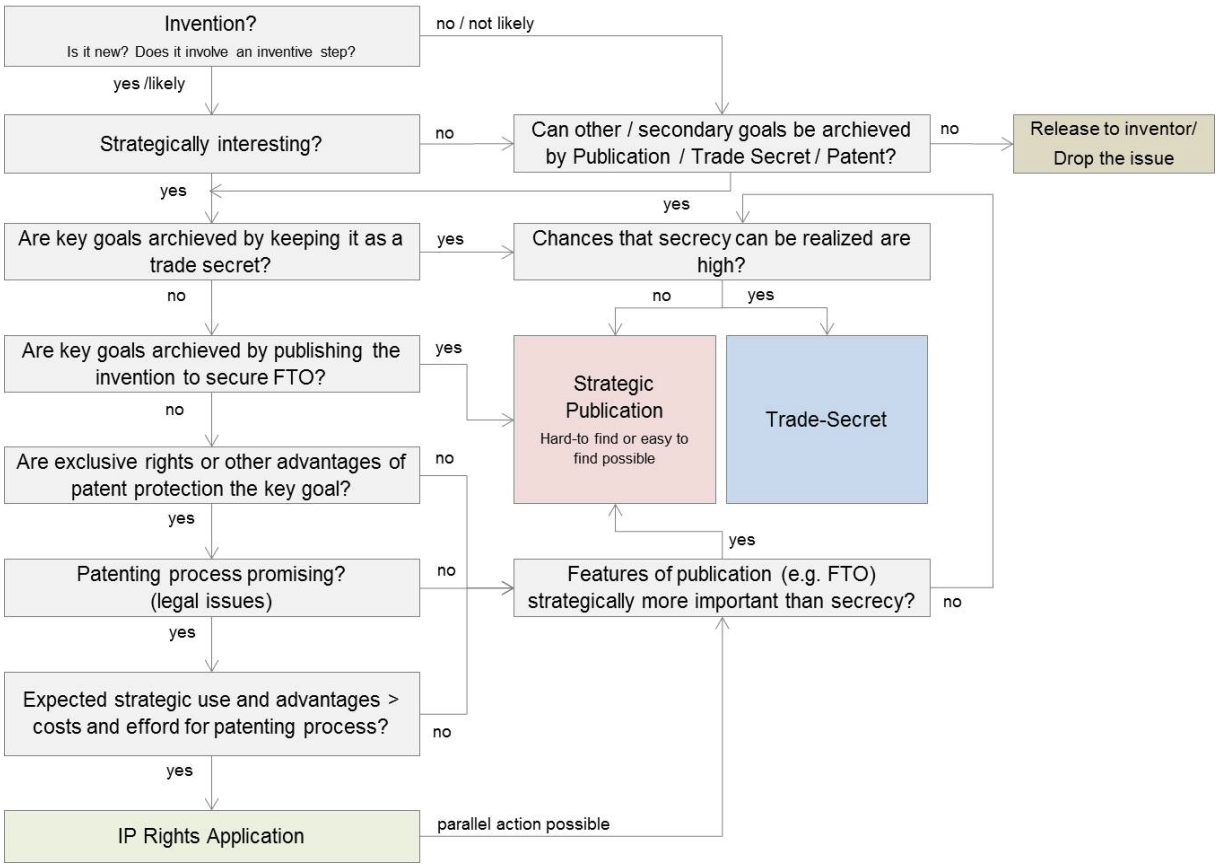

FIGURE 2: Proposed decision matrix

The decision matrix starts with an invention that is e.g. reported by an in-house inventor to the IP department of a firm. First, the question arises whether the described idea is new and if it involves an inventive step over the existing prior art. This is important in order to clarify if the invention dealt with might be patentable. Alternatively, it should be considered if secondary goals can and shall be achieved by dealing further with the topic. Examples are improving the reputation of a firm or bothering of competitors. Otherwise, it is proposed to release the invention to the inventor or to drop the issue.

The second question concerns the strategic importance of the reported invention

for the firm. In case that the idea is not strategically interesting, the issue can be dropped if, again, secondary goals are not of interest. Otherwise the model presents a set of steps which lead to the IP instrument that is best for the specific case dealt with.

Here it is initially important to know if the strategic goals are met best by keeping the invention secret. The strategic importance for the firm is hereby central but not the only important issue. The possibility to keep the invention secret must be assured or at least the chances that secrecy can be realized should be high. In case that keeping the invention secret is the key goal, but the invention is not a good candidate for this instrument of protection (e.g. it is quite possible that a competitor invents the same or the knowledge may leave the firm as "spill over" quite likely), other IP instruments should come to focus. A patent would lead to a widely spread publication since patents are searchable in a very common and easy way. Therefore, the model proposes that a more "quiet" strategic publication, which is hard to find, could be a better alternative. Comparing strategic publishing and secrecy, the first has the advantage that the user can decide how many details of the invention shall be disclosed. Of course, firms can use secrecy in cases where they do not want to disclose the invention at all. However, in contrast to secrecy, strategic publishing still guarantees a firm's freedom to operate and de facto secrecy may even be maintained since the information that is revealed can be restricted or substantially disguised (Hall et al., 2012).

If secrecy is not the key goal, the next step concerns the importance of freedom to operate. Here, a strategic publication is the instrument of choice if secrecy and exclusive rights are of less importance and freedom to operate shall be gained. On the other hand, if secrecy and freedom to operate are not the key objectives, but exclusive rights or other advantages of patent protection, one should ask if the patenting process is promising and if all legal issues are met. The patenting process can be very costly and interminable if the state-of-the-art in the field of the invention is extensive and the chances of getting a patent granted are very low. In this case, the model proposes to ask if secrecy or strategic publishing (e.g. to gain reliable freedom to operate) are second best opportunities and take the necessary actions.

Even if the patenting process seems promising after this decision, it should be asked if the expected strategic use and the advantages of a patent are higher than the costs associated with the patenting process at the final step. Only in that case,

the application for a patent is in this scenario the best solution. Otherwise, a strategic publication or secrecy should be considered as alternatives. Finally, a strategic publication can be executed in parallel to extend and fasten the effect of the pending patent application as full state-of-the-art if patent protection is the chosen instrument.

Concluding, the decision matrix depicts the different steps of the decision process regarding the intellectual property management of inventions. Strategic publications can be used as substitutes for patents as well as complementary options in this process while using secrecy eliminates the other options. These conceptual considerations and the developed decision matrix should be regarded as a first attempt to depict the connection between patenting, secrecy and strategic publishing on the invention level.

6. Summary and Conclusion

This paper is a first attempt to show the relevance of strategic publishing next to patenting and secrecy within a firm's IP strategy. Therefore, the paper consists of a theoretical part, an empirical part, the results of six case studies as well as a conceptual part. After the literature review, we present the results of a survey among German firms that focuses on the protection of intellectual property. We find that strategic publishing is an additional instrument for almost half of the firms that make use of patents and secrecy. In order to get deeper insights into the firm-intern usage of strategic publication, six use cases are conducted. All of the participants state that they use strategic publishing mainly in order to secure freedom to operate and to create prior art. Finally, we develop a decision matrix based on the insights of the empirical part, the case studies and some existing literature. This decision matrix is approved by the participants of the case studies and helps to make the right decision regarding the protection and exploitation of intellectual property according to the situation of the firm and the goal of the invention.

Accordingly, the paper presents some important managerial implications. Strategic publishing represents a cost-efficient, flexible and quickly available instrument if obtaining exclusive rights is not the main priority in a particular situation, but the actual aim is to safeguard the freedom to operate. Strategic publishing cannot compete with traditional property rights protection but in many situations it can supplement other instruments in order to improve the effectiveness and efficiency of these. The rising importance of strategic publishing as a complementary tool to cope with inventions and innovations is furthermore shown in the empirical part of the paper. The descriptive analysis shows that almost half of the firms in our sample use strategic publishing and moreover suggests that large firms as well as firms that already use one of the other two tools are more likely to use strategic publishing. Thus, particularly firms that already use patenting and secrecy to protect IP, but still refrain from using strategic publications, should think about changing their strategy.

At least for Germany, some political guidance comes along with the results. There have been several political efforts to foster the IP management of small and medium-sized enterprises (SMEs), mainly with the focus on patenting. However,

strategic publishing can be an alternative as shown by our paper. Consequently, politics should promote strategic publishing among SMEs more distinctly since especially cost and time reasons keep SMEs from patenting (e.g. Blind & Rauber, 2012; Cohen et al., 2000).

All these findings and results underline the importance of further research on the interrelation between patenting, secrecy and strategic publishing and confirm the significance of our decision matrix for firms that cope with the exploitation and protection of their inventions.

However, one has to keep in mind the limitations of our paper. First, our sample as well as the case studies exclusively consist of German firms. This limits the geographical implications of our results. Second, we develop a decision model on the invention level while our empirical analysis is conducted on the firm level. However, the case studies help to gap the bridge between firm level and invention level to a certain degree. Nevertheless, some more specific research on the importance of strategic publishing on the invention level is needed in order to verify and enhance our decision matrix. More empirical research on the topic of strategic publishing and its relevance for firms would be important, too.

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8. Appendix

TABLE A1: Distribution of firms by application ofinstruments (N=331)

Application of Instruments	Number of Observations	Percentage
no instrument	10	3.02
only patenting	16	4.83
only secrecy	25	7.55
only publication	2	0.6
patenting & secrecy	131	39.58
patenting & publication	6	1.81
secrecy & publication	6	1.81
all 3 instruments	135	40.79
Full sample	331	100

Conclusion

Summary and Main Results

This dissertation contributes to the fields of IP and standardization management. More precisely, it connects these streams by analyzing the similarities and differences of three specific instruments that are important when firms have to cope with new ideas or technologies: Patenting, standardizing and strategic publishing. First, standardization activities of firms are regarded before standardizing and patenting are connected and, in a last step, the alternative option of strategic publishing is introduced.

Accordingly, the first part of the dissertation shows that especially firms with successful innovations will start to participate in standardization committees of formal SSOs in the following years. The influence of firm size is also positive up to a certain point and basic patent protection seems to be another important factor.

Since the standardization process seems to be of special interest for innovative firms, the second part focuses on the standardization strategy of R&D-active firms, i.e. the relationship between participating in SSOs and implementing standard is examined. It becomes obvious that these kinds of firms have similar motives for both activities which are connected very strongly and thus follow an integrated strategy with respect to their standardization activities as whole.

The third part of the dissertation draws a bow between standardization and patenting strategies of firms. Strong commonalities indicate that both instruments are part of firms' management regarding knowledge and technical know-how. Moreover, these commonalities regarding the reasons to use patenting and standardization seem to be stronger for SMEs which indicates that they regard both instruments as substitutes. On the contrary, large firms seem to apply both instruments due to different reasons and thus regard them as complementary instruments. This might be due to

the fact that SMEs have limited resources which allow only using one instrument, while large firms can apply both instruments since they have enough money and personnel.

The loss of importance of strategic motives to patent is the main topic of the fourth part. Here, patents are compared to other instruments to protect IP and moreover the reasons to patent are analyzed. Patents still depict the most important formal instrument to protect IP, not due to strategic reasons but to the traditional protection motive.

Thus, the last part analyzes if strategic publishing of knowledge is an adequate alternative for firms which follow more strategic interest by disclosing part of their knowledge. It is shown that strategic publishing is an additional instrument for firms that patent and keep inventions secret. Strategic publications are of special interest when the main aims are to protect firms' freedom to operate or to influence the state-of-the-art.

Managerial Implications

The implications of the results of this dissertation for IP and standardization managers are manifold. First and foremost, both areas of management should be regarded as belonging together in the framework of innovation management and decision processes should be integrated within a firm. This is not least the case since standardization seems to be of special interest for innovative firms which is the main finding of the first part of this thesis. However, another insight is that a basic protection of knowledge and technical know-how is necessary when firms enter standardization in order to protect against spill-overs as there is a lot of knowledge exchange within the standardization process.

Since standards are the output of the standardization process, firms should follow an integrated strategy regarding implementing standards and the participation in standardization processes in order to achieve the goals of their standardization strategy which, again, should be integrated in the innovation strategy. According to the findings of the second part of the thesis, innovative firms seem to do this, at least intuitively.

The third paper reveals that the reasons and barriers for patenting and standardizing are very similar, at least for SMEs. These firms find the barriers to access both instruments to be higher than large firms, which is why they probably see these instruments more as substitutes since they only have the resources to use one of the instruments. On the contrary, the incentives for both instruments are higher for large firms, but the degree of similarities regarding patenting and standardizing motives seems to be lower compared to SMEs. Thus, large firms show more differences between the reasons to patent or to standardize an invention and it can be assumed that they find patenting and standardization to be complementary tools which they use both for different purposes.

Firms' patent strategies are particularly addressed in the fourth part of this dissertation. It becomes obvious that patenting remains very important compared to former empirical findings, but only to protect inventions against imitation and not to use patents in a more strategic way. Thus, firms seem to have abstained from the "patent everything doctrine" and turned to other ways for their strategic actions.

One of them is the option of strategic publication. Almost half of all firms that use patents and keep inventions secret use this instrument according to our empirical finding in the last part of this thesis. However, strategic publishing cannot compete with patenting when it comes to exclusively using an invention, but is more a complementary option, which is cheaper and faster than applying for a patent, if the main aim of an invention is to secure freedom to operate or to create state-of-the-art.

Summing up, firms should consciously think about integrating their departments for IP and standardization since there are many underlying commonalities. However, many firms do not recognize this interaction consciously and may therefore miss improvements and possible cost reductions by economies of scale and synergy effects. Moreover, an integration of other opportunities such as strategic publishing as an alternative in this comprehensive strategy regarding inventions and innovations is needed.

Policy Implications

Similarly, some proposals for policy makers can be derived from the results of this thesis. Most importantly, there are still many serious barriers for small and also medium-sized firms to adequately manage their intellectual assets and inventions. This is true for standardization as well as for patenting activities as revealed in part three of the thesis. Despite certain efforts to foster the development of small firms, both instruments seem still to be poorly used by SMEs compared to larger firms since the former have only limited resources and both activities are very time-consuming and expensive.

The fact that especially innovative firms enter standardization underlines the importance to enable this possibility to firms of all sizes since it seems to be a central platform not only to gain knowledge but also to place technical knowledge and ideas in order to influence standards and thus get access to markets.

Moreover, with respect to limited resources of SMEs, the strategic publication of research results and new ideas could be an alternative which is less costly and time-consuming. Thus, this opportunity should be promoted by political institutions and industry associations, so that especially SMEs get aware of it.

Limitations and Further Research

This dissertation has to be regarded as first step towards an integrated view on IP and standardization management. However, it is not a fully comprehensive overview regarding firm's possibilities to cope with inventions and innovations since some important instruments are not addressed in this work. While the option to keep inventions and knowledge secret is at least addressed in the last part of the thesis, other formal and informal instruments to protect or cope with IP such as utility models, lead-time advantage or complex product design are not investigated in this dissertation. Thus, further research that follows this dissertation should integrate other options and particularly investigate their connection to standardization activities since there are

almost no research articles.

Additionally, there is a lack of theoretical and conceptual literature on the relationship between instruments to protect the exclusive use of IP (such as e.g. patenting) and options that allow the use by others but which bring indirect advantages to the firm (such as e.g. standardization or strategic publishing). As a result, patenting is solely regarded in the framework of IP management which restrains to compare patents to other formal and informal instruments to protect the exclusivity of knowledge, while standardization is not seen as proper option in this framework. Therefore, future theoretical research papers should create a basis of literature for this integrated area of research.

Another issue of this dissertation is the level of analysis in the parts three and five. While the theoretical and conceptual considerations about the relationship between patenting and standardization (part three) as well as patenting, secrecy and strategic publishing (part five) are conducted on the invention level, the empirical analyses are undertaken on the firm level. While it is assumed that firms' behavior regarding single inventions can be expected to represent firms' strategy on the firm level due to the law of large numbers, some empirical research on the invention level is necessary to proof this assumption. Especially the connection between the technical know-how in patents and the knowledge of firms that is integrated in standards has to be analyzed more deeply, maybe also in form of case studies. However, I can tell about the difficulties gathering this kind of data from my own experience in the course of this dissertation.

Finally, I hope that the reader of this dissertation enjoyed and got some first insights of the fascinating relationship between different instruments to cope with IP and the various possibilities in the framework of firms' innovation management. Also, it would be great if this work motivates further studies on this topic and helps to foster the development of innovation management research.