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How patent function integration with R&D influence the value of patents

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Abstract

Patent strategies are endogenous to firm appropriability. However, to what extent does firm's R&D teams' engagement with patent experts influence the value of patents? We estimate the relationship between firm's R&D use of patent functions on patent value in Biotech firms. Controlling for characteristics of scientific team, firm effects, and other patent value indicators, we find that having a firm specific (in-house) internal patent function is a driver of patent value. In addition, we find that the way in which patent functions create patent value differs dependent on whether the firm has internal patent function or not. In-house patent functions create value through narrow patents, whereas, firms with no in-house patent function create valuable patents by the use of broader scoped patents. Our results point to a strong effect of firm specific patent functions, but also explain how firms with no in-house patent function mitigates and generate valuable patents by focusing on broader patents. The findings emphasize that managerial decisions on organizational setup of patent functions are critical for firm success in creating valuable patents and adds to the literature on how patenting are endogenous to firm appropriability.

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Patent strategies are endogenous to firm appropriability. However, to what extent does firm's R&D teams' engagement with patent experts influence the value of patents? We estimate the relationship between firm's R&D use of patent functions on patent value in Biotech firms. Controlling for characteristics of scientific team, firm effects, and other patent value indicators, we find that having a firm specific (in-house) internal patent function is a driver of patent value. In addition, we find that the way in which patent functions create patent value differs dependent on whether the firm has internal patent function or not. In-house patent functions create value through narrow patents, whereas, firms with no in-house patent function create valuable patents by the use of broader scoped patents. Our results point to a strong effect of firm specific patent functions, but also explain how firms with no in-house patent function mitigates and generate valuable patents by focusing on broader patents. The findings emphasize that managerial decisions on organizational setup of patent functions are critical for firm success in creating valuable patents and adds to the literature on how patenting are endogenous to firm appropriability.

Introduction

While a steady increase in patent filings by 1 or 2 digit percentages yearly provide a strong indicator of firm's increasing focus on improving performance by IPR[1] protection, there is still little research done focusing on how scientific inventions actually is transformed into patented inventions. Much literature on patented inventions has investigated the inventors' characteristics, e.g. star scientist, in explaining patent value (Giuri et al., 2007;Zucker, Darby and Armstrong, 2002;Gittelman and Kogut, 2003). An implicit assumption in this literature holds that inventions become commercially valuable simply by patenting them as they appear from research departments. However, recent research on the role of patent functions indicate that patent experts have explanatory power in predicting firms innovative output; Somaya, Williamson and Zhang (2007a) found, based on a study of 101 Fortune 500 companies in 5 industries, that both management team member's patent law expertise and number of internal patent exprts is a significant predictor of firm innovation performance (measured as the number of patents), in the same line Ernst and Fischer (2014) showed that the integration between patent functions and R&D in firms are explanatory for new product development performance. This research informs us on the importance of having the patent function integrated in R&D, however, besides the collaboration being predictor on outcome in terms of the number of patents, we have little knowledge of how the integration between R&D and the patent function influence the individual patent. Most importantly whether the collaboration between R&D and patent function also add to the value of individual patents? In this paper we explore this question, by analyzing how the collaboration between R&D and patent function influence patent value.

[1] IPR= Intellectual Property Rights (here also used interchangeably as IP).Even though a wide range of IP rights are available (Patents, Design rights, Copyrights, Trademarks etc.) this study is focused on patents and how patent agents interact with R&D during product development.

We test our ideas in an empirical study using detailed inventor data, as well as firm specific IP organizational and patent expert data obtained via survey and interviews, linked to patent data in a sample of companies from the biotech industry. Biotech firm's profitability depends highly on their ability to develop new drug candidates that are eventually commercially valuable; patent expertise is therefore an unavoidable and very important input to their business. Our main findings are 1) that internal patent experts is a critical factor in building patent value, and 2) that firms with no internal patent function generate valuable patents using a broader technological scope, while firms with internal patent functions generate valuable patents by the use of narrow scoped patents.

The remainder of the paper is organized as follows: In the second section we consider how the choice of organization of patent function is made within the larger system of innovation processes in firms. We then discuss the patent expertise and R&D interaction decision itself and motivate the definition of R&D and patent function used in our study in this section we also briefly introduce what characterizes patent experts. This is followed by our hypotheses regarding the internal patent function driving valuable patents and the moderating effect from patent scope. Our empirical analysis follows, and we conclude with a discussion of implications, limitations, and managerial implications of the research.

Theoretical background and hypotheses

Organizing the interface between scientist and the patent function

During research and development important decisions must be made in respect to how the patent function should be integrated: Do we wish to hire an internal versus an external patent expert?

What kind of engagement would we prefer the patent expert to have in the R&D project? What should the objectives of the patent expert be? These questions are interrelated and the answers might change over time but will always have an impact on the degree to which a patent expert becomes involved in and influences the outcome of the R&D project.

Previous research show that firms decide on different forms of patent function organization. Particularly the normative patent literature shows a wealth of cases exemplifying notable variances in the way firms organize the involvement of patent function and R&D (Granstrand, 1999;Manfroy and Gwinnell, 1997;Petrash, 1997;Morrison and Germeraad, 1997;Laento, 1997;Daniele, 1997b;Daniele, 1997a). For example, Gwinnel and Manfroy (1997) explain how a spin-off from Kodak Eastman establishes its patent function, which meets with the R&D personnel at several occasions, first to establish and identify potential patents, thereafter to initiate filing process, as well as having patent experts involved at firm steering meetings to ensure a strong focus on patents at important times during the R&D process. In the case study presented on Avery Dennison (Morrison and Germeraad, 1997) the focus of the patent function changed over the years. At first the R&D division managed their own patent portfolios, including the decision making on patent scope, filing and patent-administration. Later on a patent function was established including three patent teams covering each of three technological areas. The reasoning behind this organizational change was to get the patent function closer to the ongoing R&D projects, with specialized patent experts.

While the qualitative, case-based literature has presented insights into individual patent functions, recent quantitative studies have approached the complex system of patent functions in three studies. Reitzig and Puranam (2009) base their study on the Resource Based View

exploring the relationship between patent capabilities and patent value. In a quantitative study of 30 R&D intensive firms in 8 industries they show that patent-specific appropriation capabilities are manifest and that their value lies in the way they are organized across organizational functions, resulting in an inverse u-shaped effect of functional specialization upon patent value. Somaya, Williamson & Zhang (2007b) show that having internal patent experts employed have a positive effect on the number of patents in the given firm and most recently Ernst and Fischer (2014) added to this stream of literature by showing the importance of the patent function in regards to new product performances. Furthermore, in a study conducted using the entire population of IP active Danish firms, Alkaersig, Beukel and Reichstein (2015) finds that firms IP operations can be characterized in four different IP archetypes: First, a rookie which is a firm that conduct IP ad-hoc and does not participate in the market for IP. The dealer, a firm which deals ad-hoc with IP, but does engage in exchanging IP in the market. Third, a strategist, firms that has an IP strategy that is aligned (or even sometimes co-developed) with firms other business strategies and operations, and fourth, strategic dealers which are firms that are strategically planning IP and often participates in in- and out-licensing, as well as other markets for IP. These firms also structure their innovation and commercialization activities very differently in terms of patent experts (Alkaersig et al., 2015), whereas the strategists and strategic dealers use patent experts often and beneficial, rookies and dealers less so. This detailed empirical literature documents large differences regarding the level of interaction, organizational relationship between the patent function and R&D, ascribed obligations to each department, and deliberate reasoning behind organizational structure. These studies therefore point in the direction of patent functions being of importance, however, without linking the organization of patents directly to the individual patents. This study will remedy this. However, to understand

why and by which means that a patent function can have influence on patent value, we initially study the persons which works as patent experts.

Characteristics of patent experts and their role in technological innovation

A first step in understanding the role of patent experts in technological innovation is to look at their background, and thereby the competencies they complement R&D with, similarly to the profiling made of inventors in for example Giuri et.al (2007). To our knowledge no large scale study has analyzed the characteristics of patent experts. In this research 122 patent experts were identified working for the sampled firms, 52% held a PhD in natural science (examples being Biochemistry, Chemistry, Molecular Biology, Human Biology) whereas "only" 33% of the patent experts employed in patent law firms held an PhD and 53% a Masters degree. In addition, 65% of the in-house patent experts and 86% of the patent experts in the patent law firms had passed an European Patent Attorney (EPA) examination, which requires a prior scientific degree as well as practical experience with patent work. The EPA qualification is demanding and in 2009 only 37% of the candidates passed the EPA examination, keeping in mind that many of these patent experts already have obtained a PhD degree before entering the EPA-programme and still failing, indicate that the EPA examination is by no means easy obtainable. Patent experts in other words, are well educated in their field of expertise (patent law) and often have an additional relevant natural science background enabling in-depth understanding of science and technology issues.

The role played by patent experts in a firm depends on the nature of the assignments performed by the patent experts these can be of different nature. Two different assignments performed by patent experts have been identified; Patent experts working with the focus on 'protection' or/and a focus on 'innovation' (Alkaersig et al., 2015;Knight, 2013). The assignment relating to

'protection' focuses on securing IP protection for new products. The patent expert discusses the invention with the R&D scientists, the patent expert maps the surrounding patent environment, ensures that the new product has freedom to operate (FTO) meaning that the invention can enter the market without infringing any third party patents and the patent expert hands in patent applications in which the scope of the invention which protection is applied for is determined. A patent application which later when the product is marketed is used to keep competition away (Knight, 2013). When the patent expert has its assignment focused on 'innovation' related assignments, the patent expert searches for knowledge input to the discovery/invention process. The available knowledge in patents is different from that of scientific journals, and experience with patents is needed to understand and translate the knowledge gathered in patents into the scientific 'language' of the scientists. Patent expert might then be part of suggesting the direction of firms innovation activities, identifying areas in which recombinations with firm's current technological platform might be preferential (Knight, 2013;Beukel, 2013).

The innovation process, core capabilities and the patent function

So far few attempts have been made to theoretically and empirically link a firm's usages of patent experts, during R&D, with innovation outcomes. To understand the contribution of the patent function we must consider its role in developing and scoping a commercial innovation. In the innovation literature the classical view has emphasized a linear sequence going from invention to innovation to diffusion (Schumpeter, 1934). Recent literatures, particularly since Kline (1986) and Quinn (1985) have emphasized non-linear, feedback rich, and iterative qualities of the innovation process (Braunerhjelm and Svensson, 2006). Quinn (1985) emphasizes that the innovation process is *"full of surprises"* implying that the innovation process is chaotic, whilst, still containing feedback loops. The close connection between a non-linear understanding of

innovation and resource based view has spurred research on forward and backward feedback loops in many different aspects of innovation, ranging from linkages between product development and production (Sanchez, 2009) to anticipation of user reactions (von Hippel, 1988). On this basis the innovation literature recognize a process that encompasses both the creation of new technical inventions and their appropriation into valuable products. Collaboration among different stakeholders during the development and appropriation process is recognized (e.g. marketing, production, technical and sales departments) as contributing to the commercial success of new products (e.g. Chesbrough, 2003;Baldwin, Hienerth and von Hippel, 2006;Jeppesen and Laursen, 2009;Laursen and Salter, 2006;Poetz and Schreier, 2012;Poetz and Prugl, 2010). In spite of this common understanding of the innovation as being a feedback-rich process, an important construct remains neglected; namely the interactions between R&D and patenting, a patenting function which could be viewed as adding value by bringing an additional set of capabilities into play.

The literature on capabilities shows how different capabilities and resources when combined create firm value (Teece, 1997) and secure appropriation (Rivette and Kline, 2000;Reitzig and Puranam, 2009;Moran and Ghoshal, 1999). When firms choose whether to establish an internal patent function or keep external IP experts only, it is assessed as a specialization question. The answer to this focal issue ultimately concerns the degree to which specialization of patent experts in combination with having them in close proximity to firm's R&D is beneficial in developing valuable patents. Fox (1998) proposes, in line with specialization theory, that there is a difference as to whether the firm has an internal patent function handling the patenting process in firms. He emphasizes that the internal patent function has the benefit of knowing the firm's technologies and businesses and can thereby increase performance of the patents. Therefore

based on a specialization argument, that the potential value derived from specialized resources along with other resources in the firm is higher than that of these that are non specialized (Dierickx and Cool, 1989;Teece, 1986;Mowery, Oxley and Silverman, 1996;Powell, Koput and SmithDoerr, 1996), the internal patent expert will be more likely to hand-in patents resulting in higher value. Furthermore, because of daily presence the internal patent expert is capable of putting attention to the elements critical to the team and directing own work towards this (Simon, 1997). Based on the mechanism of specialized resources and attention we would expect the following when considering the use of internal patent functions as part of R&D.

Hypothesis 1: A firm with in-house specialized patent function produces patents of higher value.

Technological scope and the patent function

The tactics and strategies of firms patenting behavior has been said to be endogenously effecting the appropriation from patents (Pisano, 2006), however, the exact way in which the firms patenting tactics are influential remains unanswered. Below, we identify one of the main mechanisms, which firms at the level of the individual patent can influence, and hypothesize in which direction either a firm with an internal patent function will act as opposed to firms that do not have an internal patent function.

One influential dimension when considering patent value is that of patents scope, early Lerner (1994) showed that the breadth of patents in a firms portfolio of patents influence the valuation of firms, that having broader patents is more valuable. How patent scope at the level of the individual patent generates value are however unresolved. The technological scope of a patent is closely related to the decisions made during the patenting application process where the patent examiner at the local patent office challenges the scope claimed by the inventor (Merges and

Nelson, 1990). During the examinations process, the patent function in a firm ‘negotiate’ on the site of the inventor, while the patent examiner is the public domains ‘negotiator’ and the outcome of the examination process is determined by each party’s argumentation and, or understanding of supporting data or prior art. In this respect the initial patent application can be drafted and argued by the firms patent function both broadly and narrowly, given the strategy for the patent application, thereby resulting in an indefinite number of potential outcomes at a continuum between a narrow and a broad patent (Knight, 2013). A broad patent application is a patent application where related technologies are claimed as part of the patent application, and narrow when the claims are minimized to cover only parts of the invention (Knight, 2013). For example if the invention discovered is that one type of sulfurs is effective for one type of cognitive disease. However, instead of only arguing for this one type of sulfurs positive influence, a claim of any sulfur could be applied for, or claiming a broader range of cognitive diseases (Beukel, 2013). There are a number of reasons for pursuing a broader patent scope, as patents are applied early in the R&D process, the actual end product, in our example, a drug, will not be fully defined, therefore claiming related technological areas in an early patent application could be preferential, to try and secure the technological space in which the final specification of the invention might fall into (Knight, 2013;Alkaersig et al., 2015). On the other hand, as patent examiners are focused at specifying the claims as close as possible to the actual invention, a patent function claiming related technologies will therefore be resource demanding, in the sense that additional data might need to be conducted, and arguments further outlining the reasoning in the conversation between patent office and patent function could start to drag. On the other hand a narrow patent scope, where the boundaries of the patent more precisely covers the one the invention, supports an easier ‘negotiation’ between patent office and patent function. Narrow

patents might also be easier to defend in court as claims that are narrowly defined give raise to fewer misunderstandings in terms of technological scope protected. An in-house patent function have daily access to specialized knowledge concerning firms strategy and technologies, and would therefore given the benefits of applying for narrow patents, be enabled to generate value from more narrow patents. In contrast we would expect, that firms with no patent in-house function, would lack the specialized knowledge, and use a different strategy of generating valuable patents, namely that of broader patents as they then can work for supporting a greater technological space for maneuvering in the future. Our second hypothesis is therefore, that:

Hypothesis 2: A firm with in-house specialized patent function produces patents of higher value applying for narrow patents, whereas a firm with no in-house specialized patent function produces patents of higher value by applying for broader patents.

Methods

Data

An original data set of 66 biotech firms working with drug discovery, that have been or still are active in Denmark is used in this analysis. These 66 biotech firms contain the full population of drug discovery firms in Denmark during the time period of 1989 and 2005. During this timepriod they applied for 594 patents which are the unit of analysis for our estimation. The first biotech firm was established in 1989, thereafter several firms were established during the 1990ies (32% of the sample) and a majority in the 2000s (67%). Patents are of strong importance in the Biotech industry (Cohen, Nelson, Walsh 2000; Wolfson, Emerson, 2008) which is why this industry has been chosen for this study. Biotech firms are also strongly science based firms, exemplified in the literature as firms from this industry have a strong relationship between patent citations and

scientific publications (Verbeek, Debackere and Luwel, 2003). As a result interactions between patent function and R&D are expected to be especially pronounced in biotech firms.

The data analyzed in this paper is compiled from 3 different sources, a survey, EPO/OECD patent citations database (Webb, Dernis, Harhoff and Hoisl, 2005) and from SCANBIT-database, a proprietary database that has been the basis for a number of peer reviewed publications (Valentin, Jensen, 2007; Valentin et al, 2007; Valentin et al, 2008).

The data collected for this paper contains each firm's IP-activities, its IP organization strategy including the individual internal and external Patent expert's activities and engagement within R&D during the period from 1989 to 2005. Since all data on the firms IP organization strategies and characteristics of their Patent experts engaged in the interaction with scientists are manually collected both from patent databases, CV databases, company surveys and validated by firm representatives, using time series is crucial. First, all Patent experts, both externally and internally related to the firms were identified in patent applications as well as via international CV databases (mainly Linkedin). The data gathered, a list of patent experts identified working with the firm, was then sent to each individual firm after they had confirmed over the telephone to validate this data. In the email as well as over the telephone the firm patent representative was also asked to identify the work obligations the given Patent expert had in relation to R&D work. The respondents chosen to validate the data gathered about the individual patent experts (both internal and external), as well as answering questions concerning the obligations of the patent experts were selected due to their seniority in the firm (information available in the data gathered). On average the respondents had been employed in the focal firm for more than 6 years. There were no respondents that did not want to participate in the study, most likely do to several reasons: the patent experts are not experts often contacted for surveys, the survey was

very short only asking the organization of patent experts engagement in R&D, and as most firms only have had few patent experts employed over the period, it seemed a very reasonable task.

The second source of data was the OECD/EPO patent citation database covering all patent applications published by European Patent Office and World Intellectual Property Organization, under the Patent Co-operation Treaty (PCT) (Squicciarini M., Dernis H. and C., 2013), prior versions of this dataset has been used in other pear reviewed articles (Harhoff and Hoisl, 2007;de Rassenfosse and de la Potterie, 2009).

Measures

Dependent variable

Patent value

The dependent variable for patent value is the cumulative number of forward citations to each patent, which is the convention in approximating patent value (Harhoff, Narin, Scherer and Vopel, 1999). As patent citation data is truncated we use a 5 year citation window.

Independent variables

Internal patent function

To measure whether the firm had an internal patent function, a dummy variable (INT_IP) is created based on the survey the variable equals 1 when the firm has engaged one or more internal patent experts and 0 otherwise.

Patent scope index

Patent scope is measured using conventional method of international patent classifications (IPC), we follow the measure proposed by Lerner (Lerner, 1994), for each patent application p, the patent scope is defined as the number of 4 digit IPC the patent is assigned to and normalized according to the maximum scope value of the patents in the same group, a group being defined by technology and year of filing of the patent application:

$$Patent\ scope_p = n_p; n\{IPC_1^4; \dots\ IPC_i^4;\ IPC_j^4; IPC_n^4\}\ \&\ IPC_i^4\ \neq IPC_j^4$$

Controls

We have three sets of controls, patent, firm and inventors specific. Of patent specific controls we control for claims, number of backward citations and number of non patent related backward citations, the year of patent application as well as the size of the patent family. In regards to firm factors we control for firmsize by controlling for number of active R&D projects, firmtype, it being a firm focused at small or large molecules. In regards to the inventors we employee a control counting the number of inventors engaged in the invention, as well as whether the inventors uses an external non-specialized patent function as well.

Empirical model

In the empirical analysis below, we estimate patent value as a function of the variables featured in our hypothesis. Firstly, to understand how having access to a patent function internally in the firm is associated with patent value, and secondly, how this relationship is moderated by patent scope. We therefore estimate the following model:

$$Patent\ value_{pft} = \alpha + \beta_1(INT\_IP) + \beta_2(PAT\_SCOPE) + +\beta_3(INT\_IP \times PAT\_SCOPE) + \delta_{pft}$$

The outcome variable is patent value, the unit of analysis is patent (p) applied by firm (f) at a given time (t). We are concerned with Patent Value being influenced by firm and time level and employ a number of variables to control for this, presented by δ_{pft}, and cluster for the effects of the single firm behind the invention. Wald tests are applied to explore the differences in between the interaction effects. Given the nature of the patent value estimate, forward citations, being skewed towards zero we use a negative bionomial regression as estimation mode (Wooldridge, 2009). We apply robust estimators to avoid heteroskedasticity and perform VIF tests to check for multicollinearity.

Results

Descriptive statistics

In table 1 we present the descriptive statistics and the pairwise correlations.

--place Table 1 and 2 about here--

Several interesting features of our sample emerge from reading of this table. First, with respect to our dependent variable, forward citations on patents, resemble findings in prior studies using forward citations as dependent variable measure (e.g. Harhoff, Scherer and Vopel, 2003). In respect to our independent variable we find that 69.3% of patents used in this analysis are applied for while the firm had an internal patent function, documenting a trend towards employing internal patent expertise in this highly patent focused industry. At the same time we find that almost all firms were working with external patents experts (95.6%). A majority of firms are therefore engaging both internal and external patent expertise. External patent experts can have both a resource function in the sense that when the workload is too heavy assignments can be outsourced, and they can work as knowledge providers and sparring partners.

In table 2 the correlation matrix are presented. Few correlations are significant; none approaches a common 0.70 criterion for multicollinearity. We find a high correlation (.46) between firmsize and whether the firm has internal patent expertise. These results indicate that running the larger the firm the more likely that the firm have chosen to have internal expertise, this might very well be reasoned by economics of scale. In table 3 we present the results from the estimations, model 1 is the baseline model, in model 2 we introduce the dummy variable of whether an internal expert is employed in the firm, in model 3 we introduce patent scope, and in model 4 we introduce the interaction effect between internal patent expert and patent scope. The results presented in model 2 shows that having an internal patent expert in the firm is associated with higher patent value at a 1% significance level, confirming hypothesis 1. Model 3 shows that the direct effect of patent scope on patent value is not significant, however, this changes when the interaction effect between internal patent expert and patent scope is introduced in model 4. Model 4 shows that there is a negative interaction effect between internal patent expert and patent scope, indicating that when having an internal patent expert hired patent value is created by applying for narrower patents. In Model 4 the direct effect of patent scope shows to be associated with higher patent value. VIF is below 3 for all models. In Figure 1 we present a graphical representation of the interaction effect.

--place Table 3 & Figure 1 about here--

Robustness checks

We perform a number of robustness checks. First, as reported we have data on the organizational structure of how the patent expert is working with R&D. This categorical variable takes three measures, the patent expert is called upon from R&D when they feel a need, the firm has organized the interaction between patent agent and R&D in a formal stage gate model where R&D needs to engage with the patent expert

before proceeding with the innovation activities, or last that the patent expert takes active part in the drug discovery team. This variable is highly correlated with our main independent variable, internal patent expert (.86) and can therefore not be included in the model, due to high multicollinearity. However, replacing this variable with the internal patent expert shows that the higher degree of connection internally between the patent function and the R&D department, the higher the patent value. This indicates that it is the proximity and daily iterations between the R&D team and the patent expert that is important for generating valuable patents.

Discussion and conclusion

This research has attempted to bring new evidence on determinants of patent value. That patent strategies are endogeneous to firm appropriability has been suggested (Pisano, 2006), however, the exact measures of how this is done are still a black box. In this paper we therefore analyzed the connection between how firms patenting tactics in the form of its IP organization is structured and the value of patents. Our results can be summarized as follows, the descriptive data analysis shows there is a variance in how firms choose to engage patent experts in the R&D process, over 2/3 of patents in this industry are created in teams where there is a patent expert inside the firm working on it. The choice of internal patent expert brings additional value to the resulting patents. The results show that having internal patent expert operating in the firm is associated with more valuable patents. We argue that the mechanisms which they bring value are that of specialization, a patent expert operating in-house, will have specialized knowledge of the firms technology and business which is beneficial in the patenting process. In contrast external patent experts operate with non-specialized knowledge, which limits their options in transforming the results from R&D into valuable patents. The findings therefore confirm that engagement of internal patent function do increase the value of the patents, an understanding

which has been proposed in a number of case studies and in normative patent literature (Granstrand, 1999;Manfroy and Gwinnell, 1997;Petrash, 1997;Morrison and Germeraad, 1997;Laento, 1997;Daniele, 1997b;Daniele, 1997a;Knight, 2013). Our findings also shed light on the ways in which internal patent experts can create valuable patents by utilizing a strategy of drafting patents that are narrower in scope, whereas external patent experts creates valuable patents by scoping them broader.

As with all studies, this study also presents a number of limitations. The cost of having an internal patent expert employed versus not having internal patent expert but utilizing external patent expertise is not included in the study. Therefore, whether the more valuable patents associated with organizing in one particular way, also benefits beyond the additional cost hiring and retaining such an employee would require is not answered in this paper.

Table and Figures

Table 1: Descriptive data

Variable	Mean	Std. Dev.	Min	Max
Patent value	.705	1.928	0	34
Internal patent expert	.693	.461	0	1
Patent scope	1.951	1.154	1	9
Claims	1.253	1.026	1	99
Backward citations	4.220	2.765	0	19
Non patent related citations	.777	1.951	0	20
Number of inventors	4.274	2.541	1	20
Active R&D projects	8.251	5.782	0	22
Firmtype	.562	.4943541	0	1
Size of patent family	6.103	3.917	1	29
External patent expert	.956	.196	0	1
Year period	2.177	.731	1	3

Table 2: Pairwise correlations

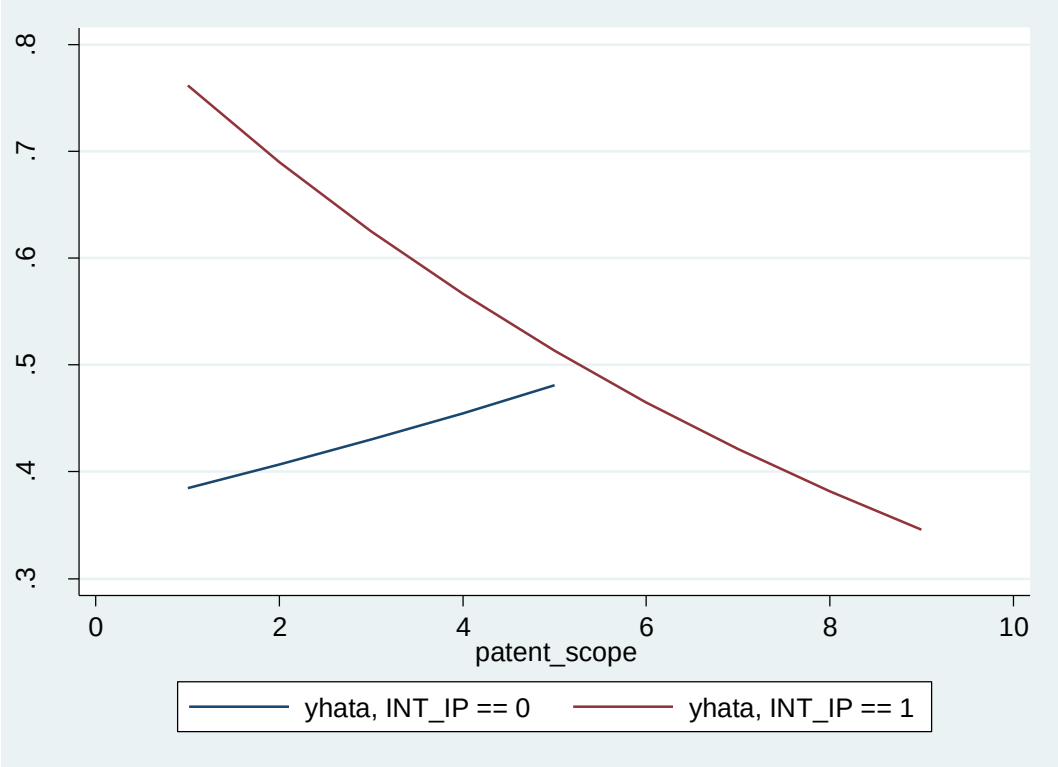
		1	2	3	4	5	6	7	8	9	10
1	Patent value	1.00									
2	Internal patent expert	0.08	1.00								
3	Patent scope	0.02	-0.02	1.00							
4	Claims	-0.02	0.04	0.05	1.00						
5	Backward citations	0.01	0.05	0.01	0.08	1.00					
6	Non patent related citations	-0.02	0.00	0.21	0.35	0.04	1.00				
7	Number of inventors	0.02	0.01	-0.05	0.01	-0.07	-0.02	1.00			
8	Active R&D projects	0.02	0.46	-0.04	0.05	0.06	-0.04	0.19	1.00		
9	Firmtype	0.03	-0.01	-0.02	-0.01	0.10	-0.01	0.11	0.30	1.00	
10	Size of patent family	0.03	0.00	0.20	0.10	0.07	0.01	-0.07	-0.05	-0.03	1.00
11	External patent expert	0.04	0.04	-0.07	-0.01	-0.01	-0.02	0.14	0.17	0.25	-0.05

Table 3. Results Negative bionomial regression, dependent variable is forward citations (5y)

Independent variables	Model 1	Model 2	Model 3	Model 4
Internal patent expert		0.760***	0.762***	1.211***
		[0.200]	[0.200]	[0.264]
Patent scope			0.018	0.186*
			[0.059]	[0.098]
Internal patent expert × Patent scope				-0.220*
				[0.132]
Claims	-0.009	-0.010	-0.010	-0.009
	[0.007]	[0.007]	[0.007]	[0.008]
Backward citations	0.017	0.023	0.023	0.029
	[0.025]	[0.025]	[0.025]	[0.026]
Non patent related citations	-0.012	-0.008	-0.011	-0.015
	[0.039]	[0.042]	[0.041]	[0.043]
Number of inventors	0.003	0.006	0.006	0.005
	[0.026]	[0.027]	[0.027]	[0.028]
Active R&D projects	0.007	-0.019	-0.020	-0.019
	[0.016]	[0.016]	[0.016]	[0.016]
Firmtype	0.190	0.299*	0.295*	0.324**
	[0.210]	[0.168]	[0.170]	[0.163]
Size of patent family	0.022	0.021	0.020	0.019
	[0.020]	[0.022]	[0.022]	[0.021]
External patent expert	0.674***	0.630**	0.633**	0.633**
	[0.236]	[0.253]	[0.255]	[0.250]
Year period 1		benchmark		
Year period 2	0.593***	0.792***	0.786***	0.803***
	[0.194]	[0.207]	[0.213]	[0.209]
Year period 3	0.540*	0.693***	0.690***	0.692***
	[0.280]	[0.256]	[0.256]	[0.253]
Constant	-1.755***	-2.291***	-2.313***	-2.711***
	[0.257]	[0.278]	[0.289]	[0.360]
lnalpha				
Constant	0.990***	0.922***	0.921***	0.913***
	[0.101]	[0.097]	[0.098]	[0.102]
Pseudo LL	-655.293	-649.258	-649.232	-648.451
No of Obs	596	596	596	596
Wald-Chi2	95.96956***	103.2831***	106.0714***	105.4243***

* p<0.1, ** p<0.05, *** p<0.01

Figure 1:



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