Make-or-Buy Decisions in Patent Related Services

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1 Introduction

Recent research argues that the management of intangible assets is a key to firms' long-term success and requires specialized management techniques and a distinctive set of skills (Rivette & Kline 2000, Standfield 2002, Granstrand 1999). It is further argued that the active management of firms' intellectual capital is as a prerequisite for securing (future) profits making IP-departments an indispensable part of firms' strategic planning efforts (Lev 2004, Reitzig 2004). Despite this widespread acknowledgement of the importance of intellectual property management as corporate function little attention has been paid to the actual organization of IP related services within firms. Among the few publications containing brief studies of the organization of IP-departments are Taylor & Silbertson (1973), Granstrand (1999) and Pitkethly (2001).

While these studies provide a first systematization of the tasks of IP-departments and delineate their integration in the corporate environment in general, they do not cover a widely observed phenomenon in this area. Many firms are very active in the acquisition of intellectual property rights (IPRs) but do not maintain IP-departments large enough to handle the resulting administrative workload. In particular, many firms which are regularly seeking patent protection for their technical inventions do not employ educated patent professionals at all and rely exclusively on the services of external contractors, i.e. patent attorneys. In total, the share of patent applications at the European Patent Office (EPO) which has been filed via patent attorneys (as opposed to firms' IP-departments or individual applicants) increased steadily over time and exceeded 80% in 2000 (see Figure 1).

INSERT FIGURE 1 ABOUT HERE

Clearly, a firm's decision between maintaining a sufficiently large IP-department and purchasing a certain share of the services necessary for the management of its IPRs on the marketplace is driven by economic and strategic considerations. The management literature contains different theoretical frameworks dealing with the economic underlyings of such make-or-buy decisions. These approaches have been applied and tested in various different settings (Shelanski & Klein 1995, Poppo & Zenger 1998, David & Han 2004). It should be noted though, that despite the existence of numerous empirical studies covering make-or-buy decisions little is known about the explanatory power of these approaches in situations where the decision applies to human-capital driven business services. Early studies of the make-or-buy decision of human-capital driven services focused on the decision between maintaining own sales forces or relying on independent sales representatives (Anderson & Schmittlein 1984, John & Weitz

1988). More recent studies cover a broader area of services (Abraham & Taylor 1996, Houseman 2001) but do not exploit the full range of available theoretical approaches.

Moreover, most of the empirical literature on make-or-buy decisions is based on the Transaction Cost Economics (TCE) framework developed by Williamson (1975, 1985). In the light of numerous critiques of TCE (Ghoshal & Moran 1996, David & Han 2004) recent research advocates an integration of different theories to a comprehensive theoretical framework (Poppo & Zenger 1998). In particular, it has been argued that TCE and the increasingly important Resource Based View (RBV) are broadly complementary approaches (Mahoney & Pandian 1992). In this paper, I apply TCE and RBV to the make-or-buy decision of patent related services and test hypotheses derived from both of them jointly using panel data covering 107 European firms over eight years.

Focusing on the organization of patent departments, this paper pursues two major goals. In a first step, the organization of IP departments is briefly presented in order to highlight the most important features of their tasks. Further, it is argued that operative tasks like the drafting of patent applications are subject to outsourcing while tasks of strategic importance are, in general, kept inside the firm. The paper provides first descriptive statistics on alternative filing agents for patent applications at the European Patent Office (EPO). The dataset I use is unique in the sense that it contains the information who filed the application (corporate IP-departments, external patent attorneys or individual inventor-applicants) for all EPO patent applications filed between 1978 and 2002.

The second goal of the paper is to derive testable hypotheses on the determinants of the degree of outsourcing considering both arguments from TCE as well as RBV. In order to analyze the determinants of the degree of outsourcing on the corporate level and to test this hypotheses, a panel of 107 European firms containing a broad set of variables including their patents, firm size and R&D expenses is analyzed. The results from a negative binomial panel regression support the derived hypotheses and imply that both TCE and RBV have explanatory power when confronted with the make-or-buy decision of patent related services simultaneously. This finding supports previous literature arguing for an integration of the two approaches.

The remainder of the paper is structured as follows. Section 2 illustrates the major tasks of an IP-department based on informal interviews conducted with several executives of IP-departments. A discussion which of these tasks can be outsourced to external attorneys is included. In section 3, the make-or-buy decision is discussed in the light of different theories on vertical integration focusing on TCE and RBV. Section 4 presents the data used for the empirical analysis and presents descriptive statistics. In section 5, the specification of the econometric model is presented and the estimation results from a negative binomial panel regression are discussed. Finally,

Section 6 concludes and discusses the need for further research.

2 Outsourcing of IP-Related Business Services

2.1 IP-Management in Corporations

The acquisition, maintenance and exploitation of legally enforceable and codified intellectual property rights is assumed to be a very important task of the IP management within firms. IPRs are legal institutions protecting intangible assets which are in general the result of an inventive or creative activity against unwanted use or sale by others. The most important IPRs are trademarks, copyrights, utility models and patents. Each of these formal property right is quite different from the others in terms of protectable subject matter and the scope of available protection: On the one hand, *creative and non-technical* property like names, symbols and representations which identify products or firms as well as artistic and literal work can be protected by trademarks in the first and by copyrights in the latter case. On the other hand, *technical* inventions can be protected by utility models and patents. For a more detailed survey of formal IPRs confer Bainbridge (2002).[1] Additionally, firms also possess intellectual assets which can hardly be protected by legal institutions like patents or trademarks. Such assets include for example a firm's reputation, human capital or tacit knowledge accumulated during its lifetime (Harvey & Lusch 1997).

The organizational implementation of the IP management largely depends on the specific nature of the assets to be managed and the possibilities to protect them: The management of assets which cannot be protected by formal property rights at all is generally conducted within organizational units being primarily concerned with knowledge management tasks and the management of a firm's human resources (Backler 1995, Teece 1998, Wiig 1997). Due to its different nature and the associated legal complexity, the task of acquiring and managing legal property rights like patents is generally organized in separate corporate departments (Zedtwitz et al. 2004). Previous studies of legal activities within firms suggest that IP-related tasks involving legal institutions are carried out in two separate corporate departments according to the distinction made above: Trademark and copyright related services are generally performed within firms' legal departments while patent related tasks are performed within separate 'patent departments' or 'IP-departments' (Pitkethly 2001, Granstrand 1999).[2] This separation can be attributed to different educational requirements for admission

[1] There is a variety of other mechanisms to protect and to exploit intellectual property which do not rely on legal institutions They include, among others, secrecy, lead time and organizational skills unique to a firm. See Levin et al. (1987) and Cohen et al. (2000) for further details.

[2] In the following, the terms 'patent department' and 'IP-department' are used interchangeably.

in relevant courts and patent offices. Different organizational ties of the two departments to other units of the firm are a further cause for this separation as well. While copyrights and trademarks have close connections to the marketing department, utility models and patents are in general closely related to the R&D-department of a firm. The remainder of this paper focuses on the management of IPRs protecting technical inventions which are generally carried out in specialized IP-departments.

INSERT TABLE 1 ABOUT HERE

Based on Pitkethly (2001) the tasks of patent departments can be classified according to two criteria (see Table 1). First, patent related services may differ in their *strategic importance* for the firm.[3] Second, patent departments have to perform tasks which are *related to competitors and competition* (external) and tasks which are not (internal). For example, the pure drafting and filing of a patent application at a patent office or the administration of an existing patent portfolio (essentially paying renewal fees in time) and the implementation of national laws concerning the remuneration of employees which inventions are exploited[4] relate very little to competitors and are of low strategic importance to firms (lower left field of Table 1). Further, there are activities of IP departments which relate to competitors but are still more operative than strategic (upper left field of Table 1). Among them is the conduct of litigation cases (both defensive and aggressive) which includes preparing and submitting pleadings to courts, attending hearings and trials. Further, these tasks comprises also the gathering of patent information as well as product-clearing duties (final check whether own products infringe on third-party patents). Contrary to these somewhat repetitive and well-structured operative tasks IP-departments also perform services which are of high strategic importance for firms. They include activities which are linked to competitors like technology/ trend scouting or long-term patent portfolio planning (upper right field of Table 1). The latter is seen as vital especially for firms' success in industries which are characterized by patent thickets and the exchange of patents in large numbers as bargaining chip within wide-spread cross-licensing agreements (Hall & Ziedonis 2001, Ham Ziedonis forthcoming). Further, there are also activities which are not directly tied to competitors but also of long-term importance (lower right field of Table 1). These mainly deal with linking employees of IP-departments to wide-spread R&D-

[3]The term 'strategic' is used to highlight differences between activities which are clearly operational and affect future performance of firms very little and activities which consequences might have a distinct impact on future performance (Porter 1996).

[4]In most European countries employers are obliged to compensate employees whose inventions are exploited. Harhoff & Hoisl (2005) contain a thorough treatment of this topic.

activities of a firm in order to provide unrestricted communication channels between inventors, researchers and patent professionals.

2.2 Make-or-buy Decisions Concerning Patent Related Services

It is a widely observed phenomenon that firms purchase intermediate goods and services necessary for the manufacturing of their final products in the marketplace rather than producing them in own facilities. Despite numerous theoretical and empirical studies of this *make-or-buy* decision (see Perry (1989), Shelanski & Klein (1995) and David & Han (2004) for surveys of the literature), little is known on the outsourcing of human capital intensive services. In particular, despite the widespread acknowledgement of its importance, no study analyzed the outsourcing of patent-related services. Before applying established theories on make-or-buy decisions to the outsourcing of IP-related services, this subsection concisely delineates tasks which might be subject to outsourcing and tasks which are generally performed within the firm. The findings presented in this subsection are largely based on insights from explorative interviews conducted with the heads of the IP-departments of Siemens AG, Infineon AG, Linde AG, Mannesmann Plastics GmbH, Webasto AG and Frankotyp Postalia AG as well as an administrative member of the German Chamber of Patent Attorneys.

To begin with, Knight (2001) and Pitkethly (2001) find that in IP-departments operative activities (see Subsection 2.1) are almost exclusively executed by educated patent attorneys while strategic issues are primarily handled by senior IP managers having a heterogeneous educational background. The outsourcing of patent related services carried out by the interviewed firms directly reflects this division of labor: While all firms maintain patent departments of a certain size, the range of tasks performed within these organizational units is quite heterogeneous. In each of the interviewed firms, IP-departments exist and coordinate short-term patenting activities (analysis of the patentability of inventions, drafting of applications or pursuing application process at the patent offices) with long-term plans and R&D-projects of the firm (product development, evaluation of patent portfolio, competitor screening). For this purpose they employ staff serving as interface between the firms' inventors and its patent attorneys (in-house or external). However, the extent to which operative tasks actually are performed internally and how many educated patent attorneys are employed for this purpose varies considerably among firms. One interviewed firm processes none of the operative tasks in-house and assigns all drafting, application and litigation tasks to external patent attorneys. It employs only staff responsible for strategic planning and the coordination of assignments to its contractors. Other firms follow a 'no-outsourcing'-strategy and do all work internally. They employ a sufficient

amount of patent attorneys for this purpose. These firms rely on external contractors only if own capacities are not sufficient to cope with workload peaks. Additionally, intermediate implementations with the patent department constantly processing only a certain percentage of the total workload internally and outsourcing the remaining part can be observed, too.

Despite this differences in the scope of activities performed by IP-departments, the interviews did not reveal a clear pattern of explanation for this variance. Only one firm argued that the outsourcing of operative tasks like the drafting or filing of applications to patent attorneys whose services are charged on an hourly basis (with charges ranging between 125 EUR and 510 EUR per hour with an average of 255 EUR according to the German Chamber of Patent Attorneys (N.n. 2004)) is significantly more expensive than performing these tasks in-house.[5] Unfortunately, it was not possible to obtain estimates of the savings associated with vertical integration from this particular firm. The estimates of potential cost disadvantages resulting from outsourcing to external attorneys provided by other firms ranged from 0% to 20% compared to maintaining a completely endowed patent department (including overhead and non-attorney staff) capable of providing comparable services. The interviewees also agreed that below a certain critical size in terms of yearly applications it might, in general, be more cost effective not to employ patent attorneys in-house at all and to outsource all operative tasks.

2.3 Legal Constraints to Vertical Integration

Before finally discussing potential determinants of the degree of outsourcing, I present a brief summary of the legal regulations of the EPC concerning the representation of applicants at the EPO. In particular, I show that applicants are not allowed to represent themselves in proceedings before the EPO and are obliged to employ an external attorney under certain circumstances.

As general rule of the European Patent Convention *'no person shall be compelled to be represented by a professional representative in proceedings established by this Convention'* (Art. 133 (1) EPC). However, this holds only as long as the *state of residence* or the *principal place of business* of a natural or a legal person is in a contracting state of the EPC.[6] If this is the case, natural persons can act for themselves and legal persons can act through employees in all proceedings before the EPO. Although any party – regardless of their residence and nationality – may file European patent applications

[5] Contrary to the services of fully qualified lawyers which tariffs are – at least partially – regulated in most countries, the EPC sets no fixed tariffs for the services of professional representatives at the EPO.

[6] Currently the EPC counts 36 contracting members, see `http://www.european-patent-office.org/epo/members.htm`, latest visit on March, 22^{th}, 2005.

without employing a professional representative, the general no-representation-rule of Art. 133 (1) EPC is restricted within the EPC. According to Art. 133 (2) EPC, applicants who have neither their residence nor their principal place of business in an EPC state must be represented for all acts except for the act of filing patent applications. Further, joint applicants, proprietors, opponents and interventionists must be represented regardless of their residency or their principal place of business (Art. 133 (4) EPC combined with Rule 100 (1) EPC). These regulations also apply if the EPO acts as receiving office for PCT (Patent Cooperation Treaty)-applications (Euro-PCT 302-304).[7]

If representation is required applicants can either be represented by *professional representatives* or by *legal practioners* in application proceedings before the EPO (Art. 134 (1) EPC and Art. 134 (7) EPC). The requirement to act as a professional representative is an admission to the list of professional representatives maintained for this purpose by the EPO (Art. 134 (1) EPC). Admission to this list is currently granted to legally trained professionals holding a scientific or technical degree which have passed the European Qualifying Examination at the EPO and have their place of business in a contracting state of the EPC (European Patent Office 2003). Additionally to these professional representatives[8], applicants can be represented by legal practioners instead of professional representatives, too. In order to act as representative in proceedings before the EPO legal practioners must have their place of business in a contracting state of the EPC and must be entitled to act as a professional representative in patent matters which is the case for fully qualified lawyers in most contracting states. According to the interviews conducted within this research project, however, fully qualified lawyers are almost never authorized by applicants to act as professional representative before the EPO. The reason for this is seen in their lack scientific resp. technical education which is a key qualification of any patent attorney.

3 Theoretical Background and Hypotheses

Due to their strategic importance firms' make-or-buy choices have undergone careful examination yielding a variety of different approaches explaining outsourcing activities. Picot et al. (2005) give a comprehensive overview of different explanations of this boundary decision. In particular, the authors discuss alternative approaches especially from a Neoinstitutional Economics perspective including Property Rights Theory, Transaction Cost Economics and Principal Agent approaches. Despite this variety of

[7] A PCT filing is not a patent application, but grants the filing party the option to launch patent applications in up to 124 PCT signatory countries within 30 months of the filing date (World Intellectual Property Organization WIPO 2002).

[8] In the following these persons are called patent attorney for reasons of simplicity.

alternative explanations, I focus on approaches analyzing the characteristics of transactions taking place and the resources involved in these transactions.

Since the early work of Coase (1937) it is well known that transaction, coordination and contracting costs must be considered in explaining the extent of outsourcing. Later, Transaction Cost Economics (TCE) were developed by Williamson (1975, 1985) which meanwhile provide a widely tested theoretical framework for the analysis of firms' make-or-buy choices. Within this approach the relative costs of contractual versus internal exchange are analyzed. TCE argues and empirically finds that these costs and the associated make-or-buy decisions are largely determined by transaction-specific characteristics like the frequency and uncertainty of the occurrence of the exchange of goods as well as the specifity of the assets involved (Williamson 1975, Klein et al. 1978, Picot 1991, Shelanski & Klein 1995). In particular, the presence of assets specific to the transaction might require costly contracts safeguarding from opportunistic behavior of external parties making vertical integration a preferred governance structure (Williamson 1975, 1985, Grossman & Hart 1986). A more detailed discussion of alternative organizational forms of vertical integration can be found in Picot et al. (2003, Chapter 6). The arguments of TCE can also be applied to the exchange of transactions in which the most important assets are human capital or organizational assets and not tangible assets. However, few previous studies empirically analyze the outsourcing decision in these cases and carry over the arguments of TCE to this problem. Existing studies rely largely on survey data and find economies-of-scale, wage savings which can be realized by outsourcing, volatility of a firm's demand and the availability of specialized skills offered by outside contractors in the marketplace to be good explanations for the reliance on external business support (Abraham & Taylor 1996, Houseman 2001). In particular, Houseman (2001) highlights the fact that the most important reason for using flexible staffing arrangements by outsourcing human capital intensive tasks to external contractors is the need to accommodate and to smooth fluctuations in workload. However, in a previous study, Anderson & Schmittlein (1984) did not find a significant influence of the frequency and uncertainty of sales on the integration of sales forces using data from the electronic components industry.

Despite the dominance of TCE in organizational studies a debate continues regarding its actual empirical validity. David & Han (2004) give a comprehensive assessment of the empirical support for TCE in a systematic analysis of 63 empirical studies which the authors identified in the *ABI* and *EconLit* databases. The support for TCE in these articles which according to David & Han (2004) contained 308 statistical tests of core TCE is rather ambiguous. Overall, only 47% of these tests could support hypotheses derived from TCE in a significant way, 43% produced insignificant results and 10% were statistically significant in the opposite direction to the theory.

Along with these mixed empirical results, more recent approaches – especially from the strategic management literature – doubt that the connection between contractual cost and the make-or-buy decision of a firm is a direct consequence of asset specifity and potential opportunistic behavior (Ghoshal & Moran 1996, Poppo & Zenger 1998). While TCE analyses the conditions of *exchange* between firms these younger approaches rather focus on the quality of *resources* within a firm and derive implications for its optimal boundary choice. The Resource-Based View (RBV) considers that a company's resources include all assets, organizational characteristics, processes, aptitudes and information controlled by that company and its employees (Wernerfelt 1984, Barney 1991). These resources are derived from practical and theoretical knowledge acquired through experience and formal learning (Prahalad & Hamel 1990). The basic assumption of the RBV is that competitive advantage is a direct consequence of a firm's possession of scarce resources which are of strategic value, hard to imitate, not easily transferred and distributed heterogeneously among firms (Barney 1991, Peteraf 1993, Rumelt 1991). While most empirical work testing the RBV is focusing on the relationship between the resources of a firm and its performance (Gautam et al. 2004), it is also possible to derive hypotheses concerning the boundary decisions of firms (Poppo & Zenger 1998). The decision whether corporate tasks and hence the resources necessary for the provision of these tasks are kept within the firm or whether they are transferred to external contractors should be made with regard to their strategic value for the firm. Valuable resources should be kept within the firm, while less valuable resources should be outsourced to external providers (Amit & Schoemaker 1993, Mahoney & Pandian 1992, Prahalad & Hamel 1990).

In the following, hypotheses concerning the degree of outsourcing of patent related services are derived considering implications from both TCE and RBV. It can be assumed that the tasks of drafting and filing patent applications are rather homogenous with regard to the specifity of the human-capital involved – even if they relate to different technologies. In fact, the interviewees pointed to the fact that every patent application needs a specialist in the according technical field and that it is virtually impossible to distinguish between applications which require more specific knowledge than others. As consequence, I focus on the characteristics of the demand for services rather than on the specifity of the assets involved which are essentially human capital (the knowledge of the individual drafting the application).

It is clear that firms differ in their demand for patent related services not only in absolute terms (frequency) but also in terms of fluctuation of their demand (uncertainty). Based on the characteristics of the demand for services, hypotheses predominantly reflecting insights from TCE can be derived with regard to the outsourcing of patent applications.

Demand for patent related services. Considering the frequency of patent applications, an essential question with regard to the make-or-buy decision is the degree to which economies of scale or problems of critical size are present. In the case of IP-departments, it is reasonable to assume that it is not cost-effective for smaller firms (patenting below a certain level) to provide a full range of patent related services in-house. The interviews imply that even if smaller firms might be able to employ and fully use the capacity of a full-time patent-expert, much of the day-to-day work would be routines like tracking procedural events and paying renewal fees. Really complex problems would then be outside the experience of the in-house staff and the firm would be better off relying on external experts in these cases. Smaller firms might therefore decide not to maintain an own IP-department at all. A plausible hypothesis considering the relation between the demand for patent services and the degree of outsourcing in general is that:

H1: *The higher the demand for patent related services, the lower is the share of outsourced applications.*

Volatility of the demand for patent related services. As noted above, it is not only the frequency of the relevant transaction which has to be considered when analyzing make-or-buy decisions of business services but also the steadiness of the flow of work. An uneven demand for organizational services may entail a variety of costs, including costs associated with carrying more workers on the payroll than are needed during low-demand periods and also costs associated with varying size of the regular workforce. Previous work found that firms contract out peak load work rather than hiring additional staff even if an outside contractor's per-unit charges are higher than in-house production cost in order to smooth work load of the regular workforce (Abraham & Taylor 1996, Houseman 2001). There is no reason to doubt this argument in the case of IP-departments, therefore Hypothesis 2 is formulated as follows:

H2: *The higher the volatility of the demand for patent related services, the higher is the share of outsourced applications.*

While the hypotheses derived above reflect only firm specific characteristics of the demand for patent related services the following hypothesis examines the relationship between a firm's outsourcing behavior and the relevance of the involved resources for the firm.

Importance of Patents. Given that the relevance of patents as a means to protect intellectual property varies considerably across different industries (Cohen et al. 2000,

Levin et al. 1987, Gottschalk et al. 2001), the RBV implies that the degree of outsourcing of patent related services should reflect these differences. Since outsourcing comprises the transfer of own resources to external contractors a hypothesis based on the RBV can be derived easily. From a resource-based perspective firms should focus on resources of high strategic value and therefore should outsource tasks requiring resources which are of low strategic value (Prahalad & Hamel 1990, Gilley & Rasheed 2000). In the case of patent departments, the importance of building and maintaining the resources necessary for the acquisition and the administration of patent portfolios clearly is depending on the importance of patents within the industry a firm belongs to. Following this argumentation a third hypothesis is formulated as:

H3: *The share of outsourced patent related services is lower for firms which are active in industries where patents are assumed to be of high importance.*

The subsequent empirical analysis tests these three hypotheses simultaneously relying a large dataset containing information from patent and firm-level data. The subsequent section contains a brief description of the data and presents descriptive statistics.

4 Data and Descriptive Statistics

4.1 Data Source and Variables

The data used for the empirical analysis was collected from two sources: The patent data was obtained from the comprehensive *Online European Patent Register* provided by the European Patent Office at `http://www.epoline.org`. This publicly available database covers published European patent applications as well as published international patent applications (PCT) seeking patent protection in one or more member states of the European Patent Convention. It provides not only bibliographic data but also procedural information covering all legal decisions made in the life of an individual patent application. The data covers the time period from the foundation of the European Patent Office until now and is an image of this data as provided by the EPO on March, 31^{st}, 2003. It contains 1,266,506 patent files with application dates ranging from June, 1^{st}, 1978 to July, 25^{th}, 2002. Additionally, firm-level information like the number of employees, R&D-expenses and industry classifications had been obtained from Compustat's *Global Vantage Database* for 107 European firms for the years 1993 to 2000.

The information from both sources was merged in order to conduct a panel analysis of the outsourcing behavior of the firms. One of the major problems during this process was the aggregation of the patent data to the firm-level. In many cases, patents are

assigned to affiliate firms rather than to the corporate group. Due to the lack of a stringent coding of patent applicants and their affiliated firms by the EPO – which is indispensable for the aggregation of the data – the implementation of a simple automated aggregation routine has been impossible. In a tedious effort the affiliates of the firms in the sample had been consolidated manually using publicly available information on ownership relations from annual reports and specialized publications like Commerzbank (2003) and Liedtke (2003).[9] The subsequent matching of the patent and the Compustat data has also been done manually.

In the following, I briefly describe the variables computed from my two data sources before advancing to the presentation of the descriptive statistics of the data.

Representation during the application process. For each patent application in the EPO dataset it is known whether a patent applicant had been represented by (1) a patent attorney (2) his intellectual property department or (3) whether the application had been filed by an individual inventor representing himself. For less than 0.5% of all patent applications it is not clear whether the second or the third case applies. In order correct for this these cases are coded as (2) if the applicant filed more than 15 patent applications in a given year and (3) otherwise. This is based on the assumption that independent inventors rarely file more than 15 patents a year and therefore it can be assumed that the applicant is an organization representing itself.[10]

It is further possible to compute the share of outsourced patent applications based on this coding for the 107 firms in the panel by dividing the number of outsourced patent applications by the total number of their consolidated applications. The share of outsourced patent applications will be used as a measure of the degree of outsourcing of (operative) patent related services to external contractors. This notion was supported by the interviewed patent professionals who confirmed that the operative tasks of IP-departments largely consist of drafting patent applications. The share of outsourced applications is the dependent variable in the empirical test of the derived hypotheses.

Total number of yearly patent applications. The total number of yearly patent applications PA_{it} is computed for each firm i and year t based on the cleaned applicant coding explicitly assigning patents hold by affiliates to its parent company. The number of yearly applications is used to measure the demand for patent related services, i.e. the frequency of the transaction of interest.

[9] A complete list of the firms in the sample and the consolidated affiliates can be obtained from the author upon request.

[10] Responsibles at the EPO confirmed the assumption that the field on representatives is left empty only if no external attorney has been involved in the filing of the application.

Technical diversity of patent applications. In addition to a mere count of the number of yearly patent applications the technical diversity of the applications filed by applicant i is taken into consideration as a control variable, too. Technical diversity is operationalized as

$$BREADTH_{it} = 1 - \sum_{k=1}^{30} s_{ikt}^2$$

where s_{ik}^2 is the percentage of applications filed in technological area k (out of 30 different technological areas[11]) for a given patent applicant i in year t. This measure of technological breadth is in the spirit of similar measures based on patent citations which have been first proposed by Trajtenberg et al. (1997).

The breadth index measures whether the applications filed by an applicant are concentrated within few technological fields or whether the applications are rather equally distributed among different technologies. $BREADTH_{it}$ will be high, if an applicant is active in a wide range of different technological fields and low, if most applications filed are concentrated in a few fields. The breadth index is included in the empirical analysis in order to capture a possible impact of different technological scope of the patent applications of a firm on the make-or-buy decision.

Volatility of patent applications. In order to account for changes and fluctuations of the filing activity of patent applicants a volatility measure of their applications is computed as

$$VOLA_{it} = \frac{\sqrt{\sum_{j=t-4}^{j=t}(PA_{ij} - \sum_{j=t-4}^{j=t} PA_{ij}/5)^2}}{\sum_{j=t-4}^{j=t} PA_{ij}/5}.$$

With PA_{it} being the number of patent applications filed by applicant i in year t, this is simply the standard deviation of the applications of the preceding five years normalized by the average number of patent applications of the five preceding years. This measure corresponds to the empirical coefficient of variation (CV) on a five year basis. Since given fluctuations in absolute terms are more relevant to smaller applicants than to bigger ones, the use of this normalized measure is appropriate to ensure comparability.

Firm Size. Firm size is measured as the number of employees of the firm (in thousands) which has been obtained from Compustat's *Global Vantage* database.

[11] The categorization is based on the OST-INPI/FhG-ISI technology nomenclature (see Organisation for Economic Co-operation and Development 1994, p. 77).

R&D-Expenses per Employee and R&D-Expenses per Patent. Yearly expenses for research & development for firm i in year t (R_D_{it}) are obtained from Compustat's *Global Vantage* database, too. R&D-spending is normalized by the number of employees to avoid confounding the R&D effect with the size effect. Further, R&D-expenses per patent are computed in order to control for differences in the patenting behavior among firms.

It should be noted that the information on R&D-spending is missing for some cases since in most European jurisdictions firms have only recently been obliged to publish detailed information on R&D-activities. When R&D data is missing a dummy variable is included so that the estimated R&D-coefficient will not be biased by selection issues.

Industry Classifications. The firms contained in the sample are classified into six different industrial sectors according to their SIC-codes provided by Compustat's *Global Vantage* database.[12] Firms which do not belong to Chemistry/ Pharmaceuticals, Electronics/ Telecommunications, Engineering, Car Manufacturing (including subcontractors) or Medtech/ Biotech are classified as Miscellaneous.

From several survey-based studies conducted in the US (Cohen et al. 2000, Levin et al. 1987) and in Europe (Gottschalk et al. 2001) it is known that the importance and the use of formal IPRs to protect and exploit innovations largely varies across different industrial sectors. In particular, for German firms Gottschalk et al. (2001) present the relative importance for different industrial sectors showing that patents are most important to chemical/ pharmaceutical firms as well as to car manufacturers and their subcontractors. For engineering, electronics and telecommunication firms patents are as important as other means of protections while trading and service enterprizes rely on patents only to minor extent. These findings are in line with previous findings for the US (Cohen et al. 2000, Levin et al. 1987) and are assumed to be representative also for European firms.

Therefore, the industry classification of the firms is used as proxy for the importance of patents as a mechanism to appropriated returns from innovation within a industrial sector. This is based on the assumption that the importance of patents for a firm belonging to a certain industrial sector equals the average importance of patents within this sector.

4.2 Descriptive Statistics

Descriptive statistics on the total population of all patent applications at the EPO will be presented before advancing to the panel data set used in the multivariate analy-

[12]For reasons of brevity the matching table is not reported here. It can be obtained from the author upon request.

sis. The majority of all 1,195,724 patent applications at the EPO between 1978 and 2000 has been filed by patent attorneys (75.6%) while only 21.2% have been filed by firms' patent departments and negligible 3.17% by individual inventors not mandating a professional representative at all (see left part of Table 2). Restricting the sample to patents with priority filing at the EPO[13] changes these ratios only slightly (see right part of Table 2). Over time, the observed dominance of patent attorneys as filing agents increased steadily from slightly less than 60% in 1978 to 80% in 2000 (see Figure 1). Focusing on the outcomes of the application procedures, it is striking that inventors not relying on professional representation have much lower chances of getting their applications granted. Only 43.2% of their applications are granted compared to 65.0% for applications by patent attorneys and 67.8% for IP-departments; this ranking with IP-departments having highest grant rates is similar to considering EP First Filings only (see Table 2). The big difference in the grant rates of IP-departments/ attorneys and individual applicants can be explained by two facts: First, experienced professionals are able to sort out inventions with low chances of finally getting patent protection. Second, it can be assumed that trained patent professionals simply have superior application-drafting skills compared to individual applicants due to their education. This should raise the chances of fulfilling the office's requirements for a patent grant.

The duration of the application procedures (presented in brackets in Table 2) also depends on the filing agent interacting with the patent office during the application procedure. While representation by patent attorneys leads to longest average pendency times (4.2 years), decisions for applications filed by IP-departments and individuals are made quicker with pendency times of 3.9 years and 3.2 years respectively. These differences could easily be explained assuming more complex and longer communication paths in cases where patent attorneys represent the applicant and have to communicate both with the patent office and their client. However, discriminating applicants from different countries reveals that this explanation is myopic (see below).

INSERT TABLE 2 ABOUT HERE

INSERT TABLE 3 ABOUT HERE

[13] In these cases the applicant addresses the first (i.e. priority) filing of the patent application to the EPO. Some interviews suggested that the dominance of patent attorneys might be lower for priority applications at the EPO since firms might consider first filings more important and process them internally rather than transferring them to external attorneys.

Table 3 presents the degree to which applicants rely on their own IP-department or on an external patent attorney analyzing applicants from Europe, the US and Japan separately. Applicants from these areas account for 96.4 % of all applications filed between 1978 and 2000. There are considerable differences as 31.46% of all European applications are filed by IP-departments compared to 17.38% for US and only 0.41% for Japanese applicants. These differences can be attributed to legal regulations of the EPC requiring professional representation from applicants not having their state of residence or their principal place of business in an EPC member state (compare Section 2.2). However, according to prevailing case law any registered office in a contracting state of the EPC satisfies the *'principal place of business'* criterion of Art. 133 (2) EPC allowing non-European applicants to be represented by their own IP-department (Benkard et al. 2002). This fact explains that – despite the provisions of Art. 133 (2) EPC – 17.38% of the US applications can be filed by IP-departments. Japanese firms, however, do not employ IP staff in their European offices to a noteworthy extent. Computing the duration of the application procedures for applicants from different countries reveals interesting insights, too. For European applicants the duration of the proceedings is appr. 9 months shorter compared to non-European applicants (compare Table 3). Further, the increase in pendency times in cases where attorneys represented the application is only observable for non-European applicants. For European applicants there is almost no difference in the duration of applications filed by an attorney and applications filed by the IP-department.

Due to the observed influence of the origin of the patent applicant on the degree of outsourcing (which is to a great part caused by the regulatory framework of the EPC) the following analysis is limited to patent applications filed by European applicants only. Their choice on representation in application proceedings at the EPO is not influenced by the legal restrictions presented in Section 2.2. For the European patent applicants, Table 4 shows significant differences in the extent to which patent applications are processed internally across 30 technological fields.[14] It is striking that in fields in which patents are known to be important, e.g. fields related to chemistry, an above-average share of the applications is processed by internal IP-departments ((10) Organic Chemistry 62.02%, (11) Polymers 60.92% or (15) Petrol/ Materials Chemistry 61.69%). The weakest activity of IP-departments can be found in (30) Construction Technology (8.98%), (29) Consumer Goods (12.22%) or (23) Machine Tools (13.82%). These are fields in which patents are of minor importance.

INSERT TABLE 4 ABOUT HERE

[14]The categorization is also based on the OST-INPI/FhG-ISI technology nomenclature (see Organisation for Economic Co-operation and Development 1994, p. 77).

As laid out before, it is the goal of this paper to analyze the effect of firm-level characteristics on the decision to outsource patent services to external contractors. In order to conduct a multivariate analysis a balanced panel has been constructed. It contains both patent and firm-specific information on 107 European firms for the years 1993 to 2000, yielding a total of 856 observations. The choice of firms has largely been driven by the availability of both sufficient R&D-data and information on their affiliates. Firms entered the panel if both information is available for the years 1993 to 2000. This approach of 'exogenous stratified sampling' allows consistent and more powerful estimation than would be possible using a smaller random sample (Manski & McFadden 1981).

INSERT TABLE 5 ABOUT HERE

In total, the panel contains 107 firms with 38 being from Germany (36.7%), 17 from France (15.6%), 16 from the United Kingdom (14.7%) and 36 from other European countries (33.0%, see Table 5) which is in rough accordance with the share of patents filed by all applicants from these countries at the EPO. I first comment on the patent related variables computed from the Epoline.org-data which has been aggregated to firm-level before presenting the data drawn from Compustat's Global Vantage database.

The 107 firms in the sample account for 83,719 patent applications or appr. 13% of all patent applications filed at the EPO within 1993 and 2000. The average number of patent applications per year and firm in the sample is 97.8 with about 42.7% of these applications being processed by internal IP-departments (see Table 5). This relative low outsourcing rate of about 57.3% (compared to an average rate of 63% for all European applicants at the EPO) indicates that the sample slightly overrepresents firms relying on their own IP-department. Figure 2 shows the distribution of the yearly (a) count and (b) share of outsourced applications on a the firm-level for the 856 observations. As one might expect, large parts of the firms either outsource very little of their applications (indicating that they have sufficiently large IP-departments) or almost all of their applications (indicating that they do not employ patent professionals). The breadth variable has a mean value of 0.641 implying that most applicants file patents in several different technical classes simultaneously. However, the sample also contains extremes with a minimum breadth value of 0.067 (resulting from 29 patent applications in only two different technological fields filed by Kone OY, a medium-sized finish engineering firm) and a maximum of 0.923 (resulting from 104 applications filed by Degussa AG, a large German chemicals and materials company). The stream of applications on

average fluctuates about 35.6% around its 5-year-mean indicating a moderate volatility of the stream of patent applications.

INSERT FIGURE 2 ABOUT HERE

Firm size measured as the number of employees varies from 72 (Neurosearch A/S, a Danish biotech firm in 1994) to 466,942 (DaimlerChrysler in 1999) with an average of appr. 50,000 employees indicating that the sample mainly contains large firms. Since the reporting of R&D-figures has not been mandatory in Europe for the most of the observation period, information on R&D-spending is not complete for 55 firms in the sample. In total, R&-D-information is missing for 261 (29.5%) firm years. On average, firms spent 11,000 EURs per employee on R&D and about 8.67 Mio. EUR per patent.[15]

Further, the firms have been classified to six different technological fields according to their SIC-codes contained in the *Global Vantage* database. 29% of the firms had been classified as 'Miscellaneous' while the other firms could be classified unambiguously to a sector. A detailed overview of the distribution of the firms in the technological fields can be found in Table 5.

5 Multivariate Panel Analysis

5.1 Model Specification

The investigation of the outsourcing decisions made by the firms in the sample requires the analysis of data which is characterized by two features. First, the dependent variable is a count of those patent applications which have been outsourced to a professional representative by a particular firm in a given year. Second, there are repeated observations for the same firm in the data, i.e., the analysis has to deal with panel data. Following Hausman et al. (1984) a basic model of the count of outsourced patent applications out_{it} for firm i in year t assumes that the observed values follow a Poisson distribution with Poisson parameter λ_{it}:

$$out_{it}|\lambda_{it} \sim Poisson(\lambda_{it}). \tag{1}$$

Specifications of the form $\lambda_{it} = E(out_{it}|X_{it}) = \exp(X_{it}\beta)$ where X_{it} is a vector of regressors describing the characteristics of firm i in a given year t are considered in the following. Additionally, it is assumed that λ_{it} not only depends on observable variables X_{it} but also on unobserved firm-specific effects. These firm-specific effects are

[15] Company figures published in currencies other than the EUR have been converted with average yearly crossrates obtained from Compustat. Inflation adjustments have not been made.

assumed to be time-invariant and might be interpreted as differences in the 'outsourcing propensity' between firms due to the possession of different capabilities or other reasons. In the following, these effects are denoted as μ_i and introduced in a multiplicative way Hausman et al. (1984), Cameron & Trivedi (1998). The model can then be reformulated as

$$out_{it}|\lambda_{it}, \mu_i \sim Poisson(\lambda_{it}) \tag{2}$$

with

$$\lambda_{it} = E(out_{it}|X_{it}, \mu_i) = \exp(X_{it}\beta + \mu_i). \tag{3}$$

Note that given the exponential form for λ_{it}, the multiplicative effect of the firm-specific μ_i can be interpreted as a shift in the intercept as in standard panel regression models. A reformulation of equation (4.3) yields the more familiar log-linear form with

$$\log(\lambda_{it}) = \log(E(out_{it}|X_{it}, \mu_i)) = X_{it}\beta + \mu_i. \tag{4}$$

Additional to the inclusion of firm-specific effects the empirical model has to consider a further firm-specific information which is the upper bound for the number of outsourced patent applications out_{it}. This upper bound is naturally given by the total number of applications PA_{it} filed in year t by firm i. If the average number of outsourced applications (per single application) is given by $\widetilde{\lambda}_{it}$ then the total number of outsourced applications for a total number of PA_{it} files should equal $\widetilde{\lambda}_{it} \cdot PA_{it}$. Given the specification in (4.3) this reasoning yields

$$\widetilde{\lambda}_{it} \cdot PA_{it}^{\gamma} = \widetilde{\lambda}_{it} \cdot \exp(\gamma \log PA_{it}) = \exp(X_{it}\beta + \mu_i + \gamma \log PA_{it}). \tag{5}$$

In (4.5) γ is introduced as the coefficient of the number of patent applications to be estimated. If the estimated value of γ does not equal one, the share of outsourced applications is not proportional to the yearly number of patent applications. According to (4.5) the regression coefficients for the independent variables X_{it} can now be estimated conditional on differing numbers of yearly filings by including $\gamma \log PA_{it}$.

Depending on the assumptions on the firm-specific effects μ_i fixed and random effects models (and numerous variations in each of these classes) can be distinguished. Cameron & Trivedi (1998) and Winkelmann (2000) contain a comprehensive overview of different approaches covering both fixed and random effects models. In the following it is assumed that firm specific effects are random[16] and that

[16]Hausman tests conducted with different sets of exogenous variables can not reject the Nullhypothesis that coefficients from random and fixed effects specification are different on a 5% level. Therefore the choice of a random effects model seems appropriate (Hausman 1978).

$$\frac{1}{1+\mu_i} \sim BETA(r,s). \tag{6}$$

Hausman et al. (1984) show that under these assumptions out_{it} is distributed following a negative binomial distribution with mean

$$E(out_{it}|X_{it},\mu_i) = \exp(X_{it}\beta + \mu_i + \gamma \log PA_{it}) \tag{7}$$

and variance

$$V(out_{it}|X_{it},\mu_i) = \exp(X_{it}\beta + \mu_i + \gamma \log PA_{it}) \cdot (1 + \exp(-\mu_i)). \tag{8}$$

Therefore, this specification allows for overdispersion in the data without any further assumptions. Using random effects is appropriate for the data at hand as a likelihood-ratio test (following Cameron & Trivedi 1998) rejects the nullhypothesis of equidispersion on the 1%-level for different sets of exogenous variables. A further advantage of this model specification is that it also solves numerical problems arising from firms with an observed count of outsourced applications equalling zero for all t. Estimation within this framework is carried using standard Maximum Likelihood methods as implemented in most contemporary statistical software packages.[17]

5.2 Results

Table 6 contains estimation results from negative binomial panel regressions of the number of outsourced patent applications on three different sets of exogenous variables. Presented figures are estimates of the unknown parameters β and γ which have the following interpretation (Cameron & Trivedi 1998). A unit change in a variable x_k leads to a leads to a change in the conditional mean by the amount $E(out_{it}|X_{it},\mu_{it}) \times \beta_k$ and therefore to a proportionate change in $E(out_{it}|X_{it},\mu_{it})$ by β_k. Since the number of yearly patent applications is included in logarithmic form γ has to be interpreted as elasticity of out_{it}. Including the yearly number of patent applications taken to the logarithm ensures that the results can be interpreted as determinants of the share of outsourced patent applications.

INSERT TABLE 6 ABOUT HERE

[17] Bayesian estimations of semiparametric specifications do not contain indications for significant non-linearities in the explanatory variables and do not improve the explanatory power of the estimations. For reasons of brevity these results are not reported here. They are available upon request.

Column (1) of Table 6 contains results from a simple specification which includes solely firm-specific information on patenting characteristics controlling for firm-size as well as R&D-intensity. The effect of the number of yearly patent applications γ is of the expected magnitude and highly significant. Since the variable has been taken to logarithm the coefficient has to be interpreted as elasticity. A coefficient being smaller than 1 indicates that an increase in the number of patent application does not lead to an proportionate increase in the number of outsourced applications and hence decreases the share of outsourced patent applications. Here, higher demand for patent related services (i.e. patent applications) within a firm leads to a lower share of outsourced patent applications. This result is in line with $H1$ derived above and confirms findings contained in previous studies of TCE (David & Han 2004). Further, increasing volatility of the number of yearly applications leads to an increase in the share of outsourced applications. This result is highly significant, too, and confirms $H2$. Again this finding is in line with recent studies who apply TCE to the make-or-buy decision with regard to business services (Abraham & Taylor 1996, Houseman 2001). Previous results from Anderson & Schmittlein (1984) who did not find significant impact of the frequency of the underlying transaction are not supported by my results.

Regarding the control variables, increasing firm-size in terms of employees reduces the share of outsourced applications. Unsurprisingly, larger firms are more likely to have their own IP-department and hence more likely to process a higher share of the workload internally. The R&D-expenses per employee have also a positive effect on outsourcing and are significant on the 5% level. This result seems to be counterintuitive since one might suspect that firms characterized by a high research intensity are more likely to have own IP-departments and therefore rely less on external attorneys. However, this result might be induced by differences among industrial sectors since this basic specification does not contain industry dummies. Further, neither the technical breadth of the stream of applications nor the R&D-expenses per patent application have significant explanatory power. It should be noted, that the indicator of missing R&D-data is insignificant indicating that there is no systematic lack of data in this variable.

Departing from this basic specification, the model is gradually expanded by including dummy variables for the firms' home countries (Column 2). The magnitudes of the effects estimated in the basic specification slightly decrease but are stable considering their signs and significance. The country effects show that German applicants (reference group) have the least tendency to purchase patent services from external attorneys, while applicants from Great Britain, France and the remaining European countries (in increasing order) have higher outsourcing levels. With the exception of Great Britain these effects are highly significant.

As it is hard to control for the importance of patents for firms directly, industry dummies are included in the regression in order to test the hypothesis derived from the RBV (see Column 3). As discussed previously in Subsection 4.1, there is reliable survey evidence distinguishing industries in which patents are of major importance from industries in which patents play only a minor role in appropriating returns from innovations. Having these previous findings in mind, the industry effects which are all significant are highly informative (see Column 3, reference group used: Electr./ Telco.). Chemical and pharmaceutical firms have the least outsourcing rates. Engineering firms as well as car manufacturers and Biotech/ Medtech-firms have higher outsourcing rates than firms from Electr./ Telecommunications which are the reference group and have second least outsourcing rates. Firms from other industrial areas ('Miscellaneous', e.g. trade companies) display highest outsourcing rates. The ranking of the industrial sectors in terms of the observed effects on the make-or-buy decision of patent related services coincides with the importance of patents in these industries. While patents have been found to be most important to chemical firms they are less important to engineering firms and least important to trade companies (Levin et al. 1987, Cohen et al. 2000, Gottschalk et al. 2001). Given the results of these previous studies the estimated industry effects clearly support $H3$: The importance of patents in an industrial sector is a determinant of the make-or-buy decision concerning patent related services. Fields in which patents are more important are significantly characterized by lower outsourcing rates.

It should be noted that the full specification (Column 3) contains measures related to both TCE and RBV. The inclusion of these measures allows to test hypotheses related to TCE and RBV simultaneously and clearly shows that these approaches have significant explanatory power with regard to the make-or-buy decision of patent related services. Therefore, the results from the negative binomial panel regression support previous literature arguing for an integration of TCE and RBV to a comprehensive theoretical framework explaining the boundary decision of firms (Mahoney & Pandian 1992, Poppo & Zenger 1998).

6 Conclusions and Future Research

The analysis of the degree to which firms outsource knowledge-intensive and human capital driven tasks is important in order to completely understand firms' make-or-buy decisions. In this paper, the outsourcing behavior of firms has been studied focusing on the processing of patent applications which can be done either in-house by an own IP-department or by external lawyers. Previous work showed that make-or-buy decisions can be explained by different theoretical frameworks. In this paper, I derived

hypotheses both from TCE and RBV and tested them simultaneously using panel data covering 107 firms over eight years. The results from a negative binomial regression showed that the demand for patent applications and its fluctuation over time are major determinants of the degree of outsourcing. These results confirm previous evidence that firms outsource business services primarily to smooth workload fluctuations. At the same time, my analysis contains – at least indirectly – evidence that the importance of patents for the individual firm also influences the degree of outsourcing significantly. I interpret this as clear indication that the RBV is complementary to TCE in explaining make-or-buy decisions. My findings imply that the efforts to completely understand firms' make-or-buy decisions must embody different strands of explanations in order to constitute a comprehensive theoretical framework for the explanation of the boundary of the firm. In particular, my findings support previous literature arguing for an integration of TCE and RBV by providing empirical evidence for their joint explanatory power.

This analysis was primarily concerned with testing the explanatory power of different theories on make-or-buy decisions using data from IP-related outsourcing decisions. Future research can expand on this analysis linking observed organizational structures in the field of IP-management to some observable measures of performance in order to derive implications with regard to efficient organization. Even if it might be hard to measure performance in the case of patent management, it is not impossible. For instance, performance could be measured in terms of legal validity of granted patents once they are challenged by others or also by a firm's success in attacking other patents. Linking organizational structures to measures of performance is clearly of primary interest for IP- as well as R&D-managers which can gain important insights for the organization of their firms. However, from a broader perspective, this link could also deliver important insights in the success of outsourcing of knowledge-intensive business services in general. The analysis of what determines the degree of outsourcing in this field provides a first point of departure for this research.

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External	- Licensing and Litigation - Patent Information - Product Clearing	**- Proactive:** Licensing, Learning, Trend-/ Technologyscouting **- Reactive:** Litigation/ Opposition
Internal	- Drafting and Filing of Patent Applications - Renewal of Patents - Management of Interfaces between R&D- and IP-Department	- Decision, whether formal IPRs should be obtained - Patent by Demand
	Operative	**Strategic**

Table 1: Schematic systematization of the tasks of a patent department according to their market relation and their strategic orientation according to Pitkethly (2001).

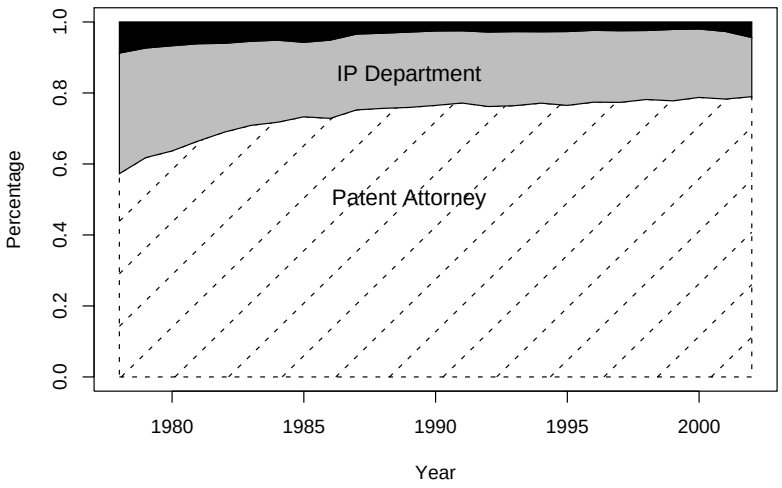

Figure 1: Share of patent applications filed by patent attorneys, IP departments and individual applicants at the European Patent Office between 1978 and 2002. (Black area represents the share of applications filed by individual applicants without representative.)

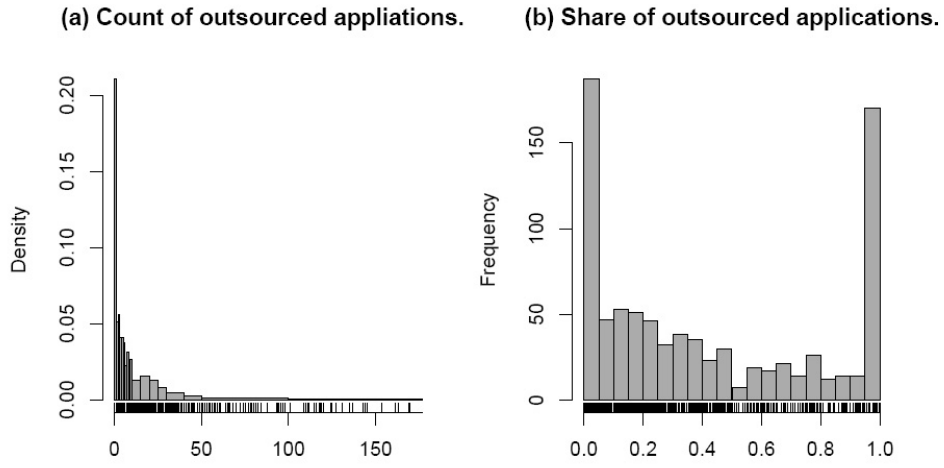

Figure 2: Histograms of the count and the share (relative to the total number of applications) of outsourced patent applications for the 107 firms and the 856 firm-years from 1993 to 2000.

Status of patent application	All Applications $n = 1,195,724$			EP First Filings $n = 93,199$		
	Filing Agent			Filing Agent		
	Attorney 75.6%	IP-Department 21.2%	None 3.17%	Attorney 71.8%	IP-Department 23.9%	None 4.35%
Pending	*210,922* . (.)	*47,319* . (.)	*3,970* . (.)	*16,986* . (.)	*5,698* . (.)	*391* . (.)
Granted	450,261 64.98% (4.54 Yrs.)	139,946 67.76% (4.14 Yrs.)	16,390 43.20% (3.95 Yrs.)	27,807 55.70% (4.75 Yrs.)	9,895 59.84% (4.49 Yrs.)	1,215 29.95% (4.24 Yrs.)
Refused	30,733 4.44% (4.76 Yrs.)	8,383 4.06% (4.48 Yrs.)	1,155 3.04% (4.22 Yrs.)	2,090 4.19% (4.03 Yrs.)	631 3.82% (4.69 Yrs.)	112 2.76% (4.09 Yrs.)
Withdrawn	211,043 30.46% (3.38 Yrs.)	57,734 27.96% (3.19 Yrs.)	16,351 43.09% (2.22 Yrs.)	19,993 40.05% (3.34 Yrs.)	5,997 36.27% (3.08 Yrs.)	2,334 57.53% (2.56 Yrs.)
Other loss	913 0.13% (2.45 Yrs.)	457 0.22% (2.46 Yrs.)	77 0.20% (2.29 Yrs.)	33 0.07% (2.94 Yrs.)	12 0.07% (2.94 Yrs.)	5 0.12% (2.28 Yrs.)
Total	**903,872**	**253,839**	**37,943**	**66,909**	**22,233**	**4,057**

Table 2: Filing agents for patent applications at the EPO between 1978 and 2000. The left part of the table refers to all applications filed at the EPO, the right part is limited to patents with priority filing at the EPO. The average duration for the application proceedings is reported in brackets.

	All Applications* $n = 1,152,730$			**EP First Filings*** $n = 87,837$		
	Origin of Applicant			Origin of Applicant		
Share of all applications	Europe 50.45%	US 29.04%	JP 16.92%	Europe 62.32%	US 22.52%	JP 9.40%
Attorney	380,543 63.09% (3.71 Yrs.)	283,351 81.59% (4.52 Yrs.)	201,392 99.56% (4.76 Yrs.)	38,197 65.76% (3.86 Yrs.)	14,916 71.05% (4.70 Yrs.)	8,736 99.71% (4.77 Yrs.)
IP-Department	189,752 31.46% (3.75 Yrs.)	60,339 17.38% (4.06 Yrs.)	823 0.41% (3.82 Yrs.)	16,645 28.66% (3.87 Yrs.)	5,424 25.84% (4.31 Yrs.)	19 0.22% (4.09 Yrs.)
No Repr.	32,888 5.45% (3.35 Yrs.)	3,578 1.03% (1.86 Yrs.)	64 0.03% (3.83 Yrs.)	3,241 5.58% (3.39 Yrs.)	653 3.11% (2.23 Yrs.)	6 0.07% (4.40 Yrs.)
Total	**603,183**	**347,268**	**202,279**	**58,083**	**20,993**	**8,761**

Table 3: Filing agents for patent applications at the EPO between 1978 and 2000 by origin of patent applicant. The left part of the table refers to all applications filed at the EPO, the right part is limited to patents with priority filing at the EPO. The average duration for the application proceedings is reported in brackets.

* Figures for applications not originating from Europe, the U.S. or Japan are not reported in this table.

	Technical Area associated with IPC	Filing Agent: Attorney Freq.	Attorney Pct.	IP-Department Freq.	IP-Department Pct.	None Freq.	None Pct.	Total
1	Electric/Energy	25,029	62.51%	13,193	32.95%	1,815	4.53%	40,037
2	Audiovisual	8,476	64.23%	4,257	32.26%	463	3.51%	13,196
3	Telecom	17,609	52.64%	15,121	45.21%	719	2.15%	33,449
4	IT	8,659	64.92%	4,237	31.77%	441	3.31%	13,337
5	Semiconductors	4,871	62.88%	2,707	34.95%	168	2.17%	7,746
6	Optical	6,916	49.19%	6,653	47.32%	491	3.49%	14,060
7	Analysis/ Measurement/ Control Technology	26,948	64.27%	12,489	29.79%	2,491	5.94%	41,928
8	Medical Technology	17,863	80.92%	2,991	13.55%	1,222	5.54%	22,076
9	Nuclear Technology	2,194	69.32%	818	25.85%	153	4.83%	3,165
10	Organic Chemistry	13,959	33.78%	25,629	62.02%	1,738	4.21%	41,326
11	Polymers	7,618	34.74%	13,360	60.92%	952	4.34%	21,930
12	Pharmaceuticals/ Cosmetics	10,045	60.51%	5,686	34.25%	870	5.24%	16,601
13	Biotechnology	7,771	65.82%	3,623	30.69%	412	3.49%	11,806
14	Agriculture/ Foods	4,298	71.54%	1,467	24.42%	243	4.04%	6,008
15	Petrol/ Materials Chemistry	5,509	34.42%	9,875	61.69%	623	3.89%	16,007
16	Surface Technology	5,472	59.04%	3,295	35.55%	501	5.41%	9,268
17	Materials	9,593	59.80%	5,536	34.51%	912	5.69%	16,041
18	Chem. Engineering	12,503	68.80%	4,657	25.63%	1,012	5.57%	18,172
19	Material Processing/ Textiles/ Paper	19,407	67.97%	7,483	26.21%	1,663	5.82%	28,553
20	Handling/ Printing	27,144	74.98%	7,000	19.34%	2,057	5.68%	36,201
21	Agricultural/Food Processing-Machines	8,187	75.04%	1,685	15.44%	1,038	9.51%	10,910
22	Environment	5,461	65.42%	2,357	28.24%	529	6.34%	8,347
23	Machine Tools	15,526	79.18%	2,709	13.82%	1,374	7.01%	19,609
24	Motors	8,397	52.88%	6,390	40.24%	1,091	6.87%	15,878
25	Thermal Processes	8,640	73.34%	2,295	19.48%	845	7.17%	11,780
26	Mechanical Elements	17,944	69.88%	5,927	23.08%	1,808	7.04%	25,679
27	Transportation	20,885	62.25%	10,386	30.96%	2,277	6.79%	33,548
28	SpaceTech/Weapons	2,718	61.74%	1,307	29.69%	377	8.56%	4,402
29	Consumer Goods	25,760	80.18%	3,927	12.22%	2,440	7.59%	32,127
30	Construction Technology	25,128	83.81%	2,691	8.98%	2,163	7.21%	29,982
	Total	**380,530**	**63.09%**	**189,751**	**31.46%**	**32,888**	**5.45%**	**603,169**

Table 4: Share of patent applications filed by IP-departments, patent attorneys or individuals for European patent applicants at the EPO between 1978 and 2000. Note that for 14 patents information on their IPC classification had not been available.

Variable	**n**	**Mean**	**S.D.**	**Min**	**Max**
Yearly Patent Applications	856	97.80	198.46	0	2,053
Share Outsourced	856	0.427	0.375	0	1
Techn. Breadth of Portfolio	856	0.641	0.190	0.067	0.923
Volatility of applications	856	0.356	0.275	0	2
Employees (000s)	856	50.01	77.87	0.072	466.9
R&D-Expenses (Mio. EUR)	595	524.3	942.1	0.227	6,337
R&D-Intensity (000's EUR/ Employee)	595	11.24	18.96	0.020	215.7
R&D per Patent (Mio. EUR/ Patent)	595	8.79	28.61	0.038	465.3
Germany	856	0.355	.	0	1
France	856	0.159	.	0	1
United Kingdom	856	0.150	.	0	1
Other Countries	856	0.336	.	0	1
Chemistry/ Pharma	856	0.168	.	0	1
Electr./ Telco	856	0.196	.	0	1
Engineering	856	0.131	.	0	1
Car Manuf./ Subcontr.	856	0.103	.	0	1
Medtech./ Biotech.	856	0.103	.	0	1
Miscellaneous	856	0.299	.	0	1

Table 5: Descriptive statistics for the pooled data on 107 European firms and 856 firm years. R&D-data has not been available for 261 firm years.

Variable	(1) Coefficient (Std. Error)	(2) Coefficient (Std. Error)	(3) Coefficient (Std. Error)
Yearly Applications	0.7651**	0.8271**	0.9303**
(in logs)	(0.0376)	(0.0323)	(0.0311)
Volatility	0.2911**	0.2456**	0.2675**
	(0.0962)	(0.0935)	(0.0916)
Breadth	-0.1113	-0.0747	-0.0425
	(0.1994)	(0.1779)	(0.1634)
Employees	-0.0022**	-0.0016**	-0.0017**
(in 000's)	(0.0006)	(0.0006)	(0.0005)
R&D per Appl.	-0.0007	0.0022	0.0039†
(in MIO Eur.)	(0.0026)	(0.0023)	(0.0021)
R&D per Empl.	0.0033*	0.0037*	0.0028†
(in MIO Eur.)	(0.0016)	(0.0015)	(0.0015)
R&D Missing$^+$	-0.0227	0.0662	-0.0052
	(0.0636)	(0.0641)	(0.0535)
FRA$^+$		0.9507**	0.6347**
		(0.2389)	(0.2775)
GBR$^+$		0.4474	0.2416
		(0.2756)	(0.3013)
OTH$^+$		1.6596**	1.2222**
		(0.2308)	(0.2570)
Chem./ Pharma$^+$			-1.1328**
			(0.2821)
Engineering$^+$			0.7537†
			(0.3959)
Car Manu./ Subcontractor$^+$			0.6059†
			(0.3662)
Biotech/ Medtech$^+$			0.7657†
			(0.4352)
Miscellaneous$^+$			1.4862**
			(0.3083)
Intercept	-0.6514**	-1.5396**	-1.7983**
	(0.2071)	(0.2270)	(0.3083)
Log likelihood	-2742.97	-2710.68	-2656.61
LR χ^2	556.02	825.66	1230.32

Significance levels: †: 10% ∗: 5% ∗∗ : 1%

Table 6: Estimation results from negative binomial random effects panel-regressions of the number of outsourced patent applications regressed on different sets of explanatory variables. ($^+$ Discrete Variables.)