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A taxonomy of firm-level IPR application practices to inform policy debates

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Abstract

Current debates on the social returns of Intellectual Property Right (IPR) systems deal with the presumed negative effects of two practices: IPR bundling and the strong concentration of IPRs in certain firms and industries. These debates are hampered by the lack of empirical evidence on IPR application practices. This study presents unique and comprehensive data about firm-level IPR application practices in the Netherlands. We develop a taxonomy based on the firm-level variety and intensity of IPR applications. We identify five archetypes of IPR applicants: patent rookies, trademark rookies, IPR strategists, IPR specialists and IPR generalists. Our findings show that a few large firms in high-tech industries combine high IPR application variety and high IPR application intensity. However, high variety is also associated with low intensity and low variety

with high intensity. For a large majority of the firms, IPR application is equivalent to single trademark application or the ad hoc application of another IPR. We discuss the implications of our findings for current IPR debates and for further research.

Keywords: intellectual property rights; taxonomy; policy

JEL codes: O34, 039

1. Introduction

Intellectual Property Right (IPR) systems are designed to ensure that market failures related specifically to the characteristics of intellectual property are solved, or at least mitigated, for the benefit of society as a whole. Whether these beneficial effects materialize, crucially depends on the actual practices for which IPRs are used (Dosi *et al.*, 2006). Certain practices may endanger dynamic competition, with consequences for the social returns of IPRs (Greenhalgh and Rogers, 2012). Two such practices have triggered the most recent debates on the 'bundling' of different IPRs to optimize appropriation strategies on the one hand, and the concentration of specific types of IPR in some firms and sectors on the other.

With respect to the bundling of different types of IPR, the first reason for concern is that bundling practices can cause long, complicated and costly infringement battles (Czarnitzki and Van Criekingen, 2018). For example, the Apple versus Samsung battle involved the alleged infringement of eight utility patents, seven design patents, and six trade dress rights (Carani, 2012). These legal battles, spread across several international courts, have cost hundreds of millions of dollars and resulted in several rulings and appeals (CNN, 2018). The second concern is the expansion of what can be protected by specific IPRs, creating significant overlaps between the application scope of different IPRs in a certain system (Moffat, 2004; Derclaye and Leistner, 2011). For example, trademarks covering the

trade dress of a product, including its shape (O'Connor, 2014), may overlap with other IPRs that protect product aesthetics, such as design rights and utility models. Overlapping rights may have unintended consequences for society when they foster overprotection (Beckerman-Rodau, 2010) and possibly endanger the specific goals of each IPR system (Derclaye and Leistner, 2011).

With respect to the issue of the high concentration of IPRs, various studies have addressed the rush on patent applications by firms in specific industries. This rush has been caused by the expansion of what can be patented, but also relates to practices of strategic patenting, which may lead to patent thickets (Shapiro, 2000; von Graevenitz *et al.*, 2011). One main concern is that dense patent positions held by incumbents may cause excessive barriers to market entry. There is evidence that these barriers restrict access to new scientific and technological discoveries for potential entrants (Jaffe, 2000; Cohen, 2004; Louwaars *et al.*, 2009) because a dense web of IPRs may impede further innovation in cumulative technologies by other firms. Moreover, Lanjouw and Shankerman (2004) found that the litigation risk is much higher for patents owned by individuals and firms with relatively small patent portfolios, while Beebe and Hemphill (2017) found a similar result in a study of trademarks. This might be a consequence of a lack of resources to enforce IPRs, which in turn may reinforce practices of under-protection, where SMEs in particular will apply less frequently for IPRs than expected by the IPR system objectives. Filitz *et al.* (2015) discussed similar concerns with respect to the case of design rights, while Louwaars *et al.* (2009) reported a decrease in the number of breeders' rights applicants and a higher share of application numbers for the top-five applicants in plant varieties at the CPVO (Community Plant Variety Office, EU) in some crop groups. In summary, this may indicate that a skewed distribution of IPRs in an industry has consequences for the appropriation regimes that SMEs must deal with. Firms may experience limitations in protecting their IP or may even consider

market entry to be inhibited because of the barriers imposed by strong IPR positions of the established firms in an industry.

Despite these important debates, we still have a rather unclear picture of actual IPR application practices. The legal literature tends to focus on specific cases based on court evidence and often turns to moral arguments. At the same time, economists have produced several large-scale empirical studies on the use and implications of IPRs (see Candelin-Palmqvist *et al.*, 2012; and Hall *et al.*, 2014, for two recent reviews). Nevertheless, existing studies still provide a fragmented picture of IPR application practices. The extent to which firms combine IPRs, as well as the levels of concentration of IPRs, both remain unclear. This is predominantly due to a lack of integrated databases containing all IPR types and all firms applying for IPRs. As our literature review will show, existing empirical evidence is limited to specific sectors, specific firm types (only large firms or only start-ups) and specific IPRs (predominantly patents). Consequently, a comprehensive empirical assessment of IPR application practices is lacking.

The aim of the current study is to inform the two IPR debates by exploiting a unique dataset of a national population of corporate IPR applicants. This dataset allowed us to build the very first taxonomy of firm-level IPR application practices, revealing five main archetypes. To link to the policy debates on IPR bundling and concentration, we focused on two firm-level measures: IPR variety and IPR intensity. Firm-level IPR variety is defined here as the number of IPR types a firm has applied for in a given timeframe, while a firm's IPR intensity is defined as the frequency of applications for a specific IPR type in the same timeframe.

The structure of the remainder of this paper is as follows: Section 2 will review the literature on firm-level IPR application practices, while Section 3 will explain the data collection and data matching. Section 4 will present the descriptive statistics, and Section 5

will present our taxonomy, revealing five archetypes of firms, each following different IPR application practices. In the final section, we will discuss the implications of our findings for the policy debates around IPRs and outline an agenda for future research into the economics of IPRs.

2. Literature review of firm-level studies into IPR application practices

Since the late 1970s, a large number of studies have been conducted to gain an understanding of the role and importance of IPRs in innovation processes in different industries (see the review in Hall *et al.*, 2014). However, most studies have not considered the aspect of variety in the use of IPRs, and predominantly focus on the role of patents, tending to ignore other IPRs (Candelin-Palmqvist *et al.*, 2012). Several economics scholars, however, have emphasized the importance of looking beyond patents. For example, Graham (2008, p. 159) pointed to the need to look at the combination of IPRs in innovation research:

> In reality, in today's world, the innovation process has many layers, and often involves complex technologies, with potentially thousands of individual 'inventions' embodied in a single product … . If we abstract away from the single 'invention,' to the innovation process or the complex product, it becomes apparent that different types of IP may serve in a complementary manner. Accordingly, these different mechanisms may bring benefits to the entrepreneur simply through their coincident use.

The focus of our review will be those empirical studies that have covered more than one IPR. Table 1 lists these studies, including the data source used and their coverage, in terms of

geography, IPR variety and firms, together with the key results. Basically, the data used originated from two data sources: (i) innovation surveys, including the CIS series and (ii) IPR registers.

TABLE 1 about here

The initial studies were based on the distribution of innovation surveys. They revealed the variety in both formal and informal appropriation measures but were constrained by the well-known limitations of survey studies: they sampled firms, the information was self-reported, and it did not include IPR intensities. Several widely distributed national surveys, such as the French, German, Canadian and Spanish innovation panels, are included in Table 1 (Mairesse and Mohnen, 2004; Licht and Zoz, 1998; Rammer, 2007; Thomä and Bizer, 2013; Amara *et al.*, 2008; Hanel, 2008; Brem *et al.*, 2017). Moreover, the use of IPRs in instruments such as the Community Innovation Surveys (CIS) (Blind *et al.*, 2003; Livesey and Moultrie, 2008; Peneder, 2010) was always self-reported using a simple dichotomy (y/n). Revilla and Fernandez (2012) used the number of years during which a firm declared it had filed a certain type of IPR as a proxy for application intensity.

Another limitation of these survey-based studies was the underrepresentation of SMEs and small firms particularly. This also applies to most studies in the middle rows of Table 1, where survey data were combined with firm-level IPR data from various IPR registers (Cohen *et al.*, 2000; Gallié and Legros, 2012; Neuhäusler, 2012). Most of these survey studies, which include data from IPR registers, only considered patent and trademark applications. Yet another concern was the lack of depth on IPRs, as the main focus of most surveys was to study

innovation and not IPRs as such. Therefore, the number and scope of the questions devoted to IPRs was typically very limited.

Survey-based innovation studies, nevertheless, have provided some important insights into IPR variety in innovative sectors (Amara *et al.*, 2008; Blind *et al.*, 2003; Mairesse and Mohnen, 2004; Hanel, 2008; Livesey and Moultrie, 2008; Gallié and Legros, 2012; Neuhäusler, 2012) and for different firm sizes (Kitching and Blackburn, 1998; Leiponen and Byma, 2009; Munari and Santoni, 2009; Thomä and Bizer, 2013). The general contribution of all of these studies has been to draw attention to the fact that firms can use a combination of IPRs to appropriate rents from innovation, but with significant differences across firm sector and size.

In the past two decades, the number of studies using data from IPR registers has risen substantially (see also the review by Candelin-Palmqvist *et al.*, 2012). Researchers have put considerable effort into the matching of patents and/or trademarks with firm-level economic data. Matching IPRs has proven to be doable for specific industry-focused and technology studies, but not yet in studies with a broad approach to industries or technologies . A detailed account of the matching efforts is provided by Thoma *et al.* (2010) and Munari (2013). A few focused studies matched more than one type of IPR at the firm level, usually patents and trademarks. These studies are listed at the bottom of Table 1. Some of these studies covered a limited number of firms, which were predominantly large (Daizadeh, 2009; Sandner and Block, 2011). Most of them, like our own study, aimed to achieve a broad coverage of firms across all sectors and sizes by matching IPR and firm data either at the firm level (Greenhalgh and Rogers, 2006; Millot, 2012; Filitz and Tether, 2015a) or by comparing aggregated IPR and firm data at the sector level (USPTO, 2012; EUIPO/EPO, 2016).

In terms of variety, a handful of studies investigated patent-trademark combinations, either in specific sectors (Amara *et al.*, 2008), in large firms (Daizadeh, 2009; Sandner and Block, 2011) or in a limited number of SMEs (Munari and Santoni, 2009). Studies by

Greenhalgh and Rogers (2006) and Millot (2012) covered a broad range and found higher rates of firms applying for both patents and trademarks, and especially by large firms in high-tech manufacturing sectors and knowledge-intensive services. Amara *et al.* (2008) also studied the use of design rights and showed that firms in Knowledge-Intensive Business Services (KIBS) relied simultaneously on patents, design rights and trademarks.

In terms of intensity, studies that included information on application volumes revealed that both the propensity to innovate and the use of IPRs increased strongly with firm size (Jensen and Webster, 2006) and also varied strongly between firms in different sectors (Greenhalgh and Rogers, 2006; Millot, 2012). Studies focusing on both patent and trademark intensities (Greenhalgh and Rogers, 2006; Daizadeh, 2009; Sandner and Block, 2011) found a strong correlation with R&D spending at firm level. Filitz and Tether (2015a) found differences in application intensity levels between similar firms (same sector and size class) in Germany and the UK for three types of IPR.

To conclude, we can identify two gaps in the literature. Firstly, most contributions only provided a fragmented picture of IPR application practices because they only considered a specific group of firms, sectors, or only two types of IPR. The combination of patents and trademarks was researched quite extensively. However, little is known about other combinations, such as patents and design rights, or trademarks and design rights. Secondly, several contributions analysed variety or intensity, but always separately, as the relationship between variety and intensity could not be considered due to limitations of the data. Therefore, this paper aims to provide a full account of the firm-level variety and intensity of IPR applications and their relationship, across all sectors and sizes in a single country, and covering all types of IPR filed at official registers. Below, we introduce our database and the empirical analysis that will allow us to develop a taxonomy of IPR application practices based on the measurement of both variety and intensity.

3. Data collection and data matching

3.1 Data collection

The Netherlands Patent Office (OCNL), in cooperation with the BOIP (Benelux Office for Intellectual Property) and Panteia Business Research, linked all patent, design rights and trademark applications by Dutch firms between 2006 and 2010 – made to the EPO (European Patent Office, patents), the WIPO (World Intellectual Property Organization, patents), the OCNL (patents), the EUIPO (European Intellectual Property Office, trademarks and design rights) and the BOIP (trademarks and design rights) – to business register data (the REACH database[1] of the Bureau van Dijk and the Dutch LISA employment register,[2] both based on the register of the Dutch Chamber of Commerce). IPR applications by Dutch firms that were filed directly at other national offices (such as the patent and trademark offices of the US, Japan or Germany) were not taken into account. Only firms registered at the Dutch Chamber of Commerce were considered. Therefore, IPR applications by foreign firms (not registered at the Dutch Chamber of Commerce) at Dutch national IPR offices were also excluded.

The goal of the matching procedure was to maximize the matching percentage, which is the share of firm applicants matched to firms in the firm register and reach a level higher than 80% to obtain an unbiased picture of the distribution and use of different forms of IP protection among firms. We started by matching the applicant name and address data for patent, trademark and design rights applicants to firm register data. Because of the importance of horticulture for the Dutch economy, breeders' rights applications by Dutch firms were also added. NACE codes and size classes were taken from the LISA Employment register, based on the register of the

[1] www.bvdinfo.com/reach
[2] www.lisa.nl

Dutch Chamber of Commerce. We would have preferred to relate the number of applications to firm size but only firm-size classes were available. Ideally, we also would have liked to include copyright, but we were limited to the types of IPR with active registration.

The final database covers a five-year period. This might be seen as a limitation, since the entire cycle of applying for a patent until actual use of it in the market is often longer than five years. In addition, the economic cycle may have an impact on IPR applications, and a five-year period does not cover an entire economic cycle. The five-year period considered also included a period of economic crisis. However, while our data show a reduction of applications in 2009 for all four types of IPR that we considered, in 2010, the numbers began to rise again. Moreover, the long-term patent statistics show little change in the patent distribution across sectors and firm sizes (Statline CBS, 2013). Overall, the main strength of our database is the exhaustive coverage of firm applicants and IPRs within one country.

3.2 Data matching

To link the IPR data to firm data, we used both firm and applicant names and harmonized address data obtained from the administrative databases of the EPO, EUIPO, BOIP, OCNL, CPVO and the Dutch Board for Plant Varieties. Thoma *et al.* (2010) provided an overview of the most widely used databases as well as the matching methods that are useful in matching assignee names. Some of these methods have also been used in some of the following steps (those which involve the matching of applicant names) taken to maximize the matching rate:

1. Labelling of all applicants on the basis of their names: as firms, private persons, universities, non-profit organizations, etc.
2. Removal of common Dutch company acronyms such as B.V. and N.V.
3. Separation of IPR applicant address data into street name and number, postcode and town/city name.

4. Matching of all IPR applicants to firms in the firm database by linking the combination of postcode and street number in each database.

5. Validation of the matched postcode-street number pairs: if the harmonized names of the IPR assignee equals firm name then the link is considered to be valid. If not, then the linked results must be checked and validated manually.

6. Matching of the remaining IPR applicants by linking the harmonized applicant and firm names. Subsequently, we validated each of the newly matched pairs to maximize the results of the process (only for patent, design and breeders' rights applications).

7. Final manual check of the matched pairs for all firms with more than 100 IPR applications.

The final two steps included a manual check of the matched pairs for IPR applicants with more than 100 applications, and large firms (more than 100 employees), to verify if a link was made to the correct legal entity within the legal structure of a firm (i.e. the legal entity that represented the core business of a firm where most employees are active). In the case of large firms, many IPRs were found to be registered by entities within the legal structure of the firm that represented the holding activities rather than the main activities of the firm. In the case of such a 'mismatch', or in the case of multiple possible matches, the legal entity that represented the activities of a majority of its employees was manually selected. The final results of the matching process, which involved both automatic and manual name and address matching, are shown in Table 2. On average, more than 80% of firms applying for an IPR were linked to firms in the business register. Due to the large number of trademark applicants, the sixth step, which also involved applicant name matching and manual validation of the remaining unmatched applicant names, was only done for the patent, design and breeders' rights applicants. As a consequence, the final matching rate was lower for the trademark applicants than for the other types of IPR.

TABLE 2 about here

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4. Descriptive results

4.1 IPR variety

Figure 1 shows a proportioned Venn diagram with the frequencies of applicants for the four different types of IPR covered in this study. Most firms with IPR applications in the period 2006-2010 used only one type of IPR – predominantly trademarks. The number of trademark applicants was 5.6 times higher than the number of patent applicants. This is in line with evidence from the US, where the number of trademark applicants was 7.7 times higher than the number of patent applicants in the same period (Dinlersoz *et al.*, 2018). This also confirms that trademarks are used across more sectors and also by more firms of all sizes than other IPRs (Mendonça *et al.*, 2004).

A minority of the firms exhibited variety in their IPR applications. About 25% of the firms with patent applications also applied for one or more trademarks. Millot (2012) found similar numbers for French and German firms that had made patent and/or trademark applications at national and international IPR offices. For the firms with design rights applications, this percentage is higher, with about 40% also filing one or more trademarks and 20% also filing one or more patents. These results confirm figures presented by Filitz *et al.* (2015).

Our data show that many firms with design rights applications also use patents. However, the firms with plant breeders' rights applications are a special group. Few of these firms combine plant breeders' rights with other types of IPR. Those firms that did exhibit variety included a few large agrochemical firms specializing in seed production, who also

applied for patents and trademarks and who are also responsible for the majority of all breeders' rights registrations; and firms with seed trading as their main economic activity, who thus combine breeders' rights with trademarks.

FIGURE 1 about here

To study cross-sectoral differences in IPR variety, we relied on an innovation-based taxonomy for both the manufacturing and the services sectors proposed by Castellacci (2009) and followed Castaldi (2009) in its implementation. The taxonomy integrated the one proposed by Pavitt (1984) for sectors in manufacturing, including supplier-dominated (SD), scale-intensive (SI), specialized suppliers (SS) and science-based (SB) sectors, and the extension by Miozzo and Soete (2001) to cover services, such as supplier-dominated services (SDS), physical networks (PN), information networks (IN), knowledge-intensive business services (KIBS) and non-market services.

The extent of IPR variety depends strongly on both sector and firm size. Figure 2 shows the share of firms with variety in IPR practices compared to all firms applying for an IPR across different sectors and size classes. The share of firms with high variety is higher in the manufacturing (SD, SI, SS and SB) than in the services sectors. In all sectors, IPR variety increases with firm size. For most sectors other than manufacturing, other types of IPR are also relevant. This includes the physical networks sector (PN), where many firms in wholesale and retail can be found. Most of these firms trade goods produced elsewhere, or their IPRs refer to marketing activities for existing goods. One example is a small firm (0-1 employee) which had developed a new design for a tent. Its design is protected by a European design right (EUIPO design right application number 000912266). One of its features is that it can easily be connected to similar tents, and a trademark filed by the firm refers to this feature (EUIPO

trademark application number 006119036). Figure 2 also shows that large firms tend to combine different types of IPR more often than small firms, especially in the manufacturing sectors. In the low-tech services sectors (SDS and IN), variety does not increase with firm size. In these sectors, trademarks are generally used, irrespective of a firm's size.

FIGURE 2 about here

Differences in variety were also examined at the NACE two-digit sector level of economic activity. This level was chosen because very few firms are diversified across two-digit classes (Leiponen and Drejer, 2007) and because there were still a sufficient number of firms within each sector to obtain a reliable picture of the IPR practices within each sector. At this level, in most sectors there were at least 50 IPR applicants. The two sectors with the highest share of firms that exhibit IPR variety (i.e. applying for more than one type of IPR) are those in the manufacture of pharmaceutical products (39.3% of all IPR applicants) and those in the manufacture of computer, electronic and optical products (38.9% of all IPR applicants), both innovation-intensive sectors in science-based (SB) manufacturing.

4.2 IPR Intensity

Figure 3 shows the distribution of IPR intensity across firms for different types of IPR. This distribution is highly skewed for all IPR types, implying that for most types of IPR a few firms are responsible for a large share of all applications. Most firms have only one application over a five-year time period. In the case of patents and trademarks, these one-time applicants account for more than 50% of all of the applicants. The increased skewness of the patent ownership distribution was studied a few decades ago by Watson and Holman (1970) for US patent

ownership between 1921 and 1962. In accordance with their study, we also found that the distribution of the number of IPR applications by applicants has a Pareto or power law distribution (Newman, 2006). Moreover, this applied to all four types of IPR considered. In the case of discrete variables, the normalized distribution obeys the following equation (Newman, 2006):

$$p(k) = (\alpha - 1)B(k, \alpha) \quad (1)$$

where k is the measured value (in our case, the number of applications by a firm for a certain type of IPR) and B(k, α) is the Legendre Beta function with exponent α, which determines the slope of the distribution. Using the least squares method, we fitted power laws to the distribution of the four IPRs considered. We found the slope of the distribution to be steeper for trademarks (α=2.286) and patents (α=2.068) than for design and breeders' rights (α=1.707 and α=1.536, respectively). This suggests that more specialized types of IPR, which are used to protect specific types of innovation such as design and plant breeders' rights, are employed more frequently by the few firms for whom they are intended, while more general IPRs, such as patents and trademarks, are mainly used by 'one-time-only' applicants.

FIGURE 3 about here

The skewness of the intensity distribution of IPR application practices was also analysed at a NACE two-digit sector level of economic activity (see Table 3). For each sector, we calculated the following parameters capturing concentration: i) the share of patent applications within a sector by the top 5% of applicants with the most patent applications within a sector, ii) the share of trademark applications within a sector by the top 5% of applicants with the most trademark applications within a sector, and iii) the share of design rights applications within a

sector by the top 5% of applicants with the most design rights applications within a sector. Breeders' rights were not included in this analysis because most applications originated from firms in the same sector, which was horticulture.

We calculated these shares for sectors at NACE two-digit level with at least 20 applicants for the types of IPR considered. Table 3 shows that there is considerable overlap in the sectors for each of the top-five lists. Sectors with a high concentration of one type of IPR also had a high concentration of other types of IPR. The correlation results, based on more than 50 sectors at NACE two-digit level, revealed a significant correlation ($p < 0.05$) between the three concentration parameters.

TABLE 3 about here

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5. A taxonomy of IPR application practices

The previous sections provided a descriptive account of the variety and intensity of new IPR applications for different sectors and firm sizes independently. In this section, we examine variety and intensity simultaneously, with the ultimate goal of developing a taxonomy of IPR application practices. We applied a two-step cluster analysis that included all firms in our database that had filed at least one IPR in the period 2006-2010, and for which both the sector and firm-size class were known. Ideally, we would have preferred to relate the number of applications to actual firm size, but we only had firm-size classes. We controlled for this by including the firm-size class in the cluster analysis. Only firms in sectors (NACE 2-digit) covered by the innovation taxonomy were considered. More than 22,000 out of almost 27,000 matched firms were included in the analysis.

We opted for a two-step cluster analysis method since hierarchical and k-means clustering do not scale efficiently in the case of large datasets (Garson, 2009; Norušis, 2012). In addition, the method is based on a distance measure, which allows for the use of both categorical and continuous variables. In the first step, individual cases are pre-clustered. The decision whether the observation should be added to an already formed cluster or whether a new cluster should be formed is made on the basis of the distance criteria using a log-likelihood distance measure. In the second step, the pre-clusters are grouped using the standard agglomerative clustering algorithm (Ward, 1963). Running the cluster analysis without a predetermined number of clusters resulted in a two-cluster solution and an average silhouette of cohesion and separation of 0.7 for cluster quality, indicating good separation of the two clusters.

Differences between the clusters were found mainly in IPR variety, IPR intensity and the types of IPR used. The largest cluster contained all firms that only filed trademarks. The smaller cluster consisted of firms applying for other types of IPR or firms that attempted to benefit from a variety of IPRs. To reveal archetypes among these firms we carried out a second cluster analysis for all firms in the smaller cluster, which amounted to 4,970 firms in this second stage of the cluster analysis. This resulted in a four-cluster solution and an average silhouette of 0.3 for cluster quality, indicating fair separation of the different clusters. Table 4 shows the variables that were part of the analysis and their importance for each of the two stages of the cluster analysis.

TABLE 4 about here

The combined results for the five clusters from the two-step cluster analysis are shown in Table 5.

TABLE 5 about here

Once the cluster solution was performed, χ2-tests were conducted for the categorical variables, and independent sample *t*-tests were done on the continuous and ordinal variables for all the different cluster pairs to examine the importance of individual variables in a cluster (Norušis, 2012). The results confirmed that the clusters varied significantly (95% confidence interval) for all of the different variables which made up the clusters, with the exception of some specific variables that had a similar distribution for some cluster pairs. For example, Clusters 2 and 3 were not significantly separated for the IPR size class (intensity) variable (18% significance when equal variances were assumed; 23% significance when equal variances were not assumed); many firms in these clusters had made 2-4 IPR applications.

The two-step cluster analysis separated firms with one patent application from the ones with multiple patent applications. In addition, firms combining patents with other types of IPR were included in the latter cluster. For design and breeders' rights, the cluster analysis did not separate firms that only applied for one IPR from those that applied for multiple IPR types. The distribution of the number of patent applications for each firm was skewed to the left and exceeded the skewness of the firm-level design or breeders' rights distribution (see Section 4.2). This might explain the differences in cluster formation for the different types of IPR. The root cause may be the high costs of patent application, which may mean that firms with limited financial resources cannot afford them. The latter types of IPR (design and breeders' rights) are cheaper and can be obtained more easily, also by small firms.

Overall, the cluster analyses resulted in five groups of IPR applicants covering all of the combinations of high and low IPR variety and intensity. When plotted in a stylized diagram, where the x-axis represents IPR variety and the y-axis IPR intensity (Figure 4), our taxonomy reveals five archetypes, which were labelled in accordance with Alkaersig *et al.* (2015), who proposed a taxonomy of IPR applicants based on qualitative research:

- **Trademark rookies (n = 17,776):** low IPR variety and low intensity. This was the largest cluster in the first cluster analysis, and it consisted solely of trademark applicants. More than 60% of the firms in this cluster had only one trademark application. A very small number of firms (2.6%) exhibited some variety in their IPR applications. The firms in this cluster are typically small and found in the low-tech service sectors (IN, PN and SDS). However, many small firms in the trade sector, who apply for trademarks to protect the products they market with private labels, can also be found here.
- **Patent rookies (n = 1,776):** low IPR intensity and variety. All of the firms in this cluster had only one patent application. Applicants are typically small firms from services sectors such as Information Networks (IN) and KIBS. It is reasonable to assume that there are many high-tech start-ups in this cluster.
- **IPR specialists (n = 1,265):** low IPR variety but high intensity. The applicants in this cluster are typically supplier-dominated firms using IPRs that serve specific sector needs, such as plant breeders' rights and design rights. The cluster predominantly contains plant breeders with up to five employees, mainly applying for plant breeders' rights. About 8% also used other types of IPR, which were mainly trademarks that secured brand protection of new plant varieties. Cluster 4 also contained the majority of design rights applicants. IPR variety was also low for the majority of them.

- **IPR generalists (n = 449):** high IPR variety and moderate intensity. Typically, this cluster contained small firms in service industries – mostly in the trade sector – which combine different types of IPR to safeguard protection of their offers. In this cluster, almost 55% of the firms combine trademarks with design rights. Nevertheless, IPR intensity is moderate; almost half of the firms in this cluster applied for fewer than five IPR applications between 2006-2010.
- **IPR strategists (n = 1,480):** both low and high IPR variety but high intensity. This cluster included firms who frequently use patents or different types of IPR to maximize the protection of their intellectual property; in other words, the most frequent IPR users. About 40% of the firms combined different types of IPR, mainly patents and trademarks. More than 50% of the firms that combined different types of IPR had ten or more IPR applications, which were predominantly patent applications. These serial IPR applicants are mainly medium-sized and large firms in high-tech sectors such as KIBS, scale-intensive and science-based manufacturing.

FIGURE 4 about here

A robustness check with additional sector-level variables measuring the skewness of the patent and trademark distribution supported these findings. Although the sector of the applicant firm gained more importance in this check, when additional sector-dependent variables were added to the analysis, the taxonomy predominantly remained unchanged, except for the IPR generalists, which were split into two and added to either the IPR strategists or the patent rookies.

6. Discussion and a research agenda

This study identified five archetypes of IPR application practices. In this section, we will first reflect on how insights from our taxonomy may contribute to the debates on the functioning of IPR systems. We will subsequently outline a research agenda inspired by our findings. Finally, we will offer some concluding remarks.

6.1 Implications for current IPR debates

The first finding is that the bundling of different types of IPR (high IPR variety) and high concentrations of IPR applications (high IPR intensity) are found predominantly within the same group of firms. In our taxonomy, these firms fall under the archetype of 'IPR strategists'. They are predominantly large firms in high-tech sectors such as science-based (electronics, pharmaceutics), scale-intensive manufacturing (chemistry) and knowledge-intensive business services (R&D services). This is in line with and extends the findings of other studies based solely on patent data, which showed that the presence of thickets was limited to a number of industries and technologies (von Graevenitz *et al.*, 2013; Gatkowski *et al.*, 2018). Our results further reveal that these large high-tech firms not only resort to the bundling of *different* types of IPR but also have a high application intensity for all types of IPR. The Apple versus Samsung battle has already demonstrated that in these sectors trademarks and design rights are the subject of legal battles as much as are patents. Our study looked beyond these highly visible cases and found that there is systematic adoption of these practices in the group of IPR strategists. This implies that the debate on the strategic use of patents that centres around concepts such as 'patent thickets' (Shapiro, 2000; Egan and Teece, 2015) should also consider other IPRs, since the application intensity of these firms and the concentration of rights is also high with respect to the other IPRs available. The term 'IPR thicket' would therefore be

more appropriate and could refocus attention on both intensity and variety in the use of IPRs by IPR strategist firms.

The second finding concerns the two groups of firms labelled patent and trademark rookies. The majority of these firms showed very low application variety and intensity, with most firms only applying for one type of IPR on a very ad hoc basis. The skewness of the distribution of the different types of IPR indicates that the tendency towards high IPR intensity is extremely low, and very few firms become repeat or regular applicants. The group of patent rookies consists almost entirely of applicants who used the patent system once.

The implication of this finding is that although firms with high IPR variety and intensity are very interesting to study and are a big part of IPR-related debates, the large group of firms who only marginally use IPRs should also be considered. With respect to these firms, one important question is whether their limited use of the IPR system corresponds with actual limited benefits from the IPR system and, if so, why? Is this due to weak appropriation regimes, or perhaps a lack of complementary assets? Our findings indicate that IPR rookies are predominantly SMEs. Other studies have found that these firms tend to be in a weak position when it comes to IPR (Lanjouw and Shankerman, 2004; Leiponen and Byma, 2009; Brem *et al.*, 2017). Spithoven *et al.* (2013), for example, found that SMEs experience a higher threshold in patent applications because of a lack of resources.

The third finding concerns firms labelled as IPR specialists. Our study shows that SMEs, in general, have low application intensity, with the exception of some 'IPR specialists' who apply for design or breeders' rights that meet their specific needs. Plant breeders' rights were introduced to accommodate the special needs of plant breeders (Louwaars *et al.*, 2009). This might explain the popularity of these rights among SMEs as well. In the case of plant breeders' rights, SMEs especially value what is known as the 'breeders' exemption', which allows the use of protected plant varieties for further breeding and, therefore, stimulates the innovation

necessary for SMEs to survive in this sector (Louwaars *et al.*, 2009).Similar arguments apply to design rights, although they are more broadly applicable IPRs. Firms in some low-tech manufacturing sectors acknowledge that design rights are the only IPR which meets the needs of their sector (Filitz *et al.*, 2015). Our results point to these IPRs being accessed by firms of all sizes, which could be taken as an indication of efficiency. We found that the distribution of both design and breeders' rights across firms was less skewed compared to patents and trademarks. Some legal scholars (e.g. Carroll, 2009) have voiced support for more tailored IPRs which meet the specific needs of firms, rather than enlarging the scope of what can be protected by more general types of IPR such as patents and trademarks.

Finally, our findings showed that high variety might also be combined with low intensity, and low variety with high intensity. The firms that fall into these categories have thus far received less attention than the IPR strategists and the rookies. The most commonly used high variety/low intensity IPR combination concerns trademarks combined with design rights (55% of all IPR generalists). This combination is especially used by SMEs with trade as their main economic activity. Possible explanations for the frequent use of this combination are: i) they are combined to protect different elements of the firm IP, ii) they are combined frequently because in the Netherlands they are handled by the same IPR office and the application procedures are also similar, and iii) what is covered by the two IPRs significantly overlaps (Carboni, 2006).

The legal literature and the policy debate on overlapping rights (Derclaye and Leistner, 2011) mainly concern the third explanation. Earlier debates have sometimes led to amendments to the IPR system (Gangjee, 2017), such as in the case of plant patents (Dutfield, 2018), which overlapped with the use of plant breeders' rights. Apart from the legal literature, to date the combination of trademarks and design rights by SMEs has not been investigated. Economists mainly focus on the patent-trademark combination, while there has been no evidence gathered

on the determinants and effects of a design right-trademark combination. Further research could attempt to assess which explanation is most realistic, as the sheer fact of their combination does not necessarily generate policy concerns.

6.2 Implications for further research

Our taxonomy and related results have several implications for further efforts within the field of economic research on IPRs.

The first research avenue could tackle the question of how IPR application practices relate to the properties of underlying innovation processes. One of the reasons to expect more IPR variety is a changing focus from technological innovation to broader types of innovation. Manufacturers not only compete by creating new products (including their design) or processes, but also in service innovation and their distinctive business models. The latter implies the use of various types of IPR to protect the different elements of a new business model, from technology to new concepts and designs (Desyllas and Sako, 2013). At the same time, several service sectors have not only become more innovative, often thanks to IT, but have also professionalized and matured up to the point that appropriability considerations have become pressing (Miles, 1993). One key limitation of our study is that we can only observe the bundling of IPRs at the firm level and not at project level. Ongoing methodological efforts to match patent and trademark data at the project level (Thoma, 2015) will hopefully provide the opportunity to investigate the motives behind IPR variety in more detail and incorporate factors such as the complexity of a new project or its radical nature.

The second direction for further research could analyse the reasons why most firms focus on a preferred type of IPR and/or why they only rarely use the IPR system. There may be various reasons, such as a defensive strategy (Somaya, 2012), a lack of resources, business

failure, industry structure, the availability of non-statutory IPRs, the innovation mode they are pursuing, limited access because of bundling and a high concentration of IPRs, or a lack of familiarity (Kitching and Blackburn, 1998; Hanel, 2006). Rather than expecting limited benefits because of bundling and high concentration, firms in some sectors might actually be unaware of IPRs other than those typically used in their sector. Castaldi (2018), for example, found that the main reason that firms in the creative sectors do not consider trademarks is that these firms focus on copyright as the IPR specifically designed for their needs. Further research could focus on the motives behind the use, or not, of IPRs.

Finally, by focusing on one country we were not able to tackle the role of institutional differences in IPR systems. The external validity of our taxonomy can only be assessed if more comprehensive studies based on full accounts of IPRs in different countries are conducted. Ideally, it would be of value to compare countries with different IPR systems, or those which also include other types of IPR. For example, some countries have IPR systems that include utility models (abolished in the Netherlands in 2008), which are similar to patents but more suited to protect 'incremental' innovations. Such utility models are still popular in several countries, especially in developing countries (Lakshmikumaran and Bhattacharya, 2004). Another useful comparison would be with countries where the application of IPRs is organized in a different manner. Many countries have one organization for granting patents, trademarks, design rights and sometimes other IPRs such as breeders' rights (e.g. the USPTO). The Netherlands has separate offices for national patents and breeders' rights, while there is a third office for trademarks and design rights, whose jurisdiction covers not only the Netherlands but also Belgium and Luxembourg. This is similar to the organization of European applications generally, with the European Patent Office administering patents and the European Office for Intellectual Property administering trademarks and design rights, while the CPVO administers breeders' rights. Such country differences may also help to explain differences in IPR filing

practices. This, in turn, can help governments to implement policies to optimize their IPR system.

6.3 Conclusions

This study provided new empirical evidence that can inform two pressing debates concerning IPR application practices by firms. While previous studies into these practices were limited in terms of the firms chosen or IPRs which they covered, we used a unique dataset providing a complete overview of all officially registered IPR applications within one country in a five-year period. We suggest that the debate on strategic patenting be broadened by including other strategic combinations of IPRs. Of all these combinations, often used by smaller firms as well, we found that trademarks and design rights are commonly combined but have received little attention in research to date.

Our results also offered a reminder that most firms make very occasional use of IPRs. These IPR rookies were mostly SMEs, and this result confirmed the importance of questioning the benefits of IPRs for all firms. Nevertheless, we also found that several SMEs are IPR specialists who focus on design and breeders' rights, forming an exception to the rule of SMEs usually being trademark rookies. Although this study has shown that IPR application practices depend on firm properties such as innovation mode and size, it also showed that there is a lot of variety between firms, which can be explained by other firm IPR positions. This underlines the value of using more encompassing databases of registered IPRs to identify IPR concentration and bundling, and the relationship of these practices to innovation and, ultimately, both private and social returns.

References

Alkaersig, L., Beukel, K., Reichstein, T. (2015). *Intellectual Property Rights Management: Rookies, Dealers and Strategists*. Springer.

Amara, N., Landry, R., & Traoré, N. (2008). Managing the protection of innovations in knowledge-intensive business services. *Research Policy*, *37*(9), 1530-1547.

Beckerman-Rodau, A. (2010). The Problem with Intellectual Property Rights: Subject Matter Expansion. *Yale JL & Tech.*, *13*, 35.

Beebe, B., & Hemphill, C. S. (2017). The Scope of Strong Marks: Should Trademark Law Protect the Strong More than the Weak. *NYUL Rev.*, *92*, 1339.

Blind, K., Edler, J., Schmoch, U., Andersen, B., Howells, J., Miles, I., Roberts, J., Green, L., Evangelista, R., Hipp, C., Herstatt, C. (2003) Patents in the service industries, final report prepared for the European Commission, Fraunhofer ISI, Karlsruhe, EUR 20815.

Brem, A., Nylund, P. A., & Hitchen, E. L. (2017). Open innovation and intellectual property rights: How do SMEs benefit from patents, industrial designs, trademarks and copyrights?. *Management Decision*, *55*(6), 1285-1306.

Candelin-Palmqvist, H., Sandberg, B., & Mylly, U. M. (2012). Intellectual property rights in innovation management research: a review. *Technovation*, *32*(9-10), 502-512.

Carani, C. V. (2012). Apple v. Samsung-Design Patents Take Center Stage. *Landslide*, *5*, 25.

Carboni, A. (2006). The overlap between registered Community designs and Community trade marks. *Journal of Intellectual Property Law & Practice*, *1*(4), 256-265.

Carroll, M. W. (2009). One Size Does Not Fit All: A Framework for Tailoring Intellectual Property Rights. *Ohio St. LJ*, *70*, 1361.

Castaldi, C. (2009). The relative weight of manufacturing and services in Europe: An innovation perspective. *Technological Forecasting and Social Change*, *76*(6), 709-722.

Castaldi, C. (2018). To trademark or not to trademark: The case of the creative and cultural industries. *Research Policy, 47(3),* 606-616.

Castellacci, F. (2009). The interactions between national systems and sectoral patterns of innovation. *Journal of Evolutionary Economics*, *19*(3), 321-347.

CNN (2018). Apple and Samsung settle their epic patent infringement battle. Available at: *http://money.cnn.com/2018/06/27/technology/apple-samsung-patent-infringement-settlement/index.html*

Cohen, W. M. (2004). Patents and appropriation: Concerns and evidence. *The Journal of Technology Transfer*, *30*(1-2), 57-71.

Cohen, W. M., Nelson, R. R., & Walsh, J. P. (2000). *Protecting their intellectual assets: Appropriability conditions and why US manufacturing firms patent (or not)* (No. w7552). National Bureau of Economic Research.

Czarnitzki, D., & Van Criekingen, K. (2018). New evidence on determinants of IP litigation: A market-based approach. *ZEW Discussion Paper No. 18-018*

Daizadeh, I. (2009). An intellectual property-based corporate strategy: An R&D spend, patent, trademark, media communication, and market price innovation agenda. *Scientometrics, 80*(3), 731-746.

Derclaye, E., & Leistner, M. (2011). *Intellectual property overlaps: a European perspective*. Bloomsbury Publishing.

Desyllas, P., & Sako, M. (2013). Profiting from business model innovation: Evidence from Pay-As-You-Drive auto insurance. *Research Policy, 42*(1), 101-116.

Dinlersoz, E., Goldschlag, N., Myers, A., & Zolas, N. (2018). An Anatomy of US Firms Seeking Trademark Registration. In *Measuring and Accounting for Innovation in the 21st Century*. University of Chicago Press.

Dosi, G., Marengo, L., & Pasquali, C. (2006). How much should society fuel the greed of innovators?: On the relations between appropriability, opportunities and rates of innovation. *Research Policy*, 35(8), 1110-1121.

Dutfield, G. (2018). Farmers, innovation and intellectual property: Current trends and their consequences for food security. In *The Commons, Plant Breeding and Agricultural Research* (pp. 21-38). Routledge.

Egan, E. J., & Teece, D. J. (2015). Untangling the patent thicket literature. *Working paper #7.* Tusher Center for Management of Intellectual Capital *http://businessinnovation.berkeley.edu/wp-content/uploads/businessinnovation-archive/documents/Tusher-Center-Working-Paper-7.pdf*

EUIPO, EPO, (2016). *Intellectual property rights intensive industries and economic performance in the European Union. Industry-Level Analysis Report.*

Filitz, R., Henkel, J., & Tether, B. S. (2015). Protecting aesthetic innovations? An exploration of the use of registered community designs. *Research Policy*, *44*(6), 1192-1206.

Filitz, R., & Tether, B. (2015a). Single Market; Same Practices? The Use of Intellectual Property Rights in Germany and the UK. In *Academy of Management Proceedings* (Vol. 2015, No. 1, p. 16066).

Gallié, E. P., & Legros, D. (2012). French firms' strategies for protecting their intellectual property. *Research Policy, 41*(4), 780-794.

Gangjee, D.S. (2017), Trade Marks and Allied Rights. In *Rochelle C Dreyfuss & Justine Pila (eds), The Oxford Handbook of Intellectual Property Law (OUP, 2017) [Forthcoming]*. Available at SSRN: https://ssrn.com/abstract=2923890

Garson, D. 2009: *Cluster analysis from Statnotes: Topics in Multivariate analysis* retrieved from http://faculty.chass.ncsu.edu/garson/pa765/statnote.htm

Gątkowski, M., Dietl, M., Skrok, L., Whalen, R., & Rockett, K. (2018). Patent Thickets Identification.

Graham, S. (2008). Beyond Patents: The Role of Copyrights, Trademarks, and Trade Secrets in Technology Commercialization, in G. Libecap and M. Thursby, eds, *Advances in the Study of Entrepreneurship, Innovation & Economic Growth*, Elsevier.

Graevenitz, G. von, Wagner, S., & Harhoff, D. (2011). How to measure patent thickets—A novel approach. *Economics Letters*, *111*(1), 6-9.

Graevenitz, G. von, Wagner, S., & Harhoff, D. (2013). Incidence and growth of patent thickets: The impact of technological opportunities and complexity. *The Journal of Industrial Economics, 61*(3), 521-563.

Greenhalgh, C., & Rogers, M. (2006). The value of innovation: The interaction of competition, R&D and IP. *Research Policy*, *35*(4), 562-580.

Greenhalgh, C., & Rogers, M. (2012). Trade marks and performance in services and manufacturing firms: evidence of Schumpeterian competition through innovation. *Australian Economic Review*, *45*(1), 50-76.

Hall, B., Helmers, C., Rogers, M., & Sena, V. (2014). The choice between formal and informal intellectual property: a review. *Journal of Economic Literature*, *52*(2), 375-423.

Hanel, P. (2008). The use of intellectual property rights and innovation by manufacturing firms in Canada. *Econ. Innov. New Techn.*, *17*(4), 285-309.

Helmers, C., Rogers, M., & Schautschick, P. (2011). *Intellectual property at the firm-level in the UK: The Oxford firm-level intellectual property database*. Department of Economics, University of Oxford. *http://www.economics.ox.ac.uk/materials/working_papers/paper546.pdf*

Jaffe, A. B. (2000). The US patent system in transition: policy innovation and the innovation process. *Research policy*, *29*(4-5), 531-557.

Jensen, P. H., & Webster, E. (2006). Firm Size and the Use of Intellectual Property Rights. *Economic Record*, *82*(256), 44-55.

Kitching, J., & Blackburn, R. (1998). Intellectual property management in the small and medium enterprise (SME). *Journal of small business and enterprise development*, *5*(4), 327-335.

Lakshmikumaran, M., & Bhattacharya, S. (2004). Utility models: Protection for small innovations. *Journal of the Indian Law Institute*, *46*(2), 322-332.

Lanjouw, J. O., & Schankerman, M. (2004). Protecting intellectual property rights: are small firms handicapped?. *The Journal of Law and Economics*, *47*(1), 45-74.

Leiponen, A., & Byma, J. (2009). If you cannot block, you better run: Small firms, cooperative innovation, and appropriation strategies. *Research Policy*, *38*(9), 1478-1488.

Leiponen, A., & Drejer, I. (2007). What exactly are technological regimes?: Intra-industry heterogeneity in the organization of innovation activities. *Research Policy*, *36*(8), 1221-1238.

Licht G. and K. Zoz (1998), Patents and R&D - An econometric investigation using applications for German, European and US patents by German companies, *Annales d'Economie et de Statistique, No. 49/50*, p. 329-360.

Livesey, F., & Moultrie, J. (2008, May). Do trademarks and design registrations provide a better perspective on national innovation activity. In *DIME Conference on the Creative Industries and Intellectual Property. London*.

Louwaars, N., Dons, H., Van Overwalle, G., Raven, H., Arundel, A., Eaton, D., & Nelis, A. (2009). Breeding business. The future of plant breeding in the light of developments in patent rights and plant breeder's rights. *CGN-report, 2009-14 http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1720088*

Mairesse, J., & Mohnen, P. (2004). Intellectual property in services: what do we learn from innovation surveys?. *Patents, Innovation, and Economic Performance*, 227-245.

Mendonça, S., Pereira, T. S., & Godinho, M. M. (2004). Trademarks as an indicator of innovation and industrial change. *Research Policy*, *33*(9), 1385-1404.

Miles, I. (1993). Services in the new industrial economy. *Futures*, *25*(6), 653-672.

Millot, V. (2012). *Trade mark strategies and innovative activities* (Doctoral dissertation, Strasbourg).

Miozzo, M., & Soete, L. (2001). Internationalization of services: a technological perspective. *Technological Forecasting and Social Change*, *67*(2), 159-185.

Moffat, V. R. (2004). Mutant copyrights and backdoor patents: the problem of overlapping intellectual property protection. *Berkeley Tech. LJ*, *19*, 1473.

Munari, F., & Santoni, S. (2009, September). Exploiting complementarities in IPR mechanisms: the joint use of patents, trademarks and designs by SMEs. In *4th Annual Conference of the EPIP Association–24-25 September*.

Munari, F.(2013). Review of Literature on the Use and Impact of IPRs at the Firm Level: Patents, Trademarks and Designs. *Study prepared for the European Observatory on Infringements of Intellectual Property Rights*

Neuhäusler, P. (2012). The use of patents and informal appropriation mechanisms—Differences between sectors and among companies. *Technovation*, *32*(12), 681-693.

Newman, M. J. E. (2006). Power laws, Pareto distributions and Zipf's law. arXiv: cond. *arXiv preprint math/0412004*.

Norušis, M. J. (2012). *IBM SPSS statistics 19 statistical procedures companion*. Prentice Hall.

O'Connor, T. S. (2014). Trade dress: The increasing importance of an ancient yet new form of intellectual property protection. *Journal of Business Research*, *67*(3), 303-306.

Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. *Research Policy*, *13*(6), 343-373.

Peneder, M. (2010). Technological regimes and the variety of innovation behaviour: Creating integrated taxonomies of firms and sectors. *Research Policy*, *39*(3), 323-334.

Rammer, C. (2007). Innovationsverhalten der Unternehmen in Deutschland 2005-Aktuelle Entwicklungen–öffentliche Förderung–Innovationskooperationen–Schutzmaßnahmen für geistiges Eigentum. *Studien zum deutschen Innovationssystem*, (13-2007).

Revilla, A. J., & Fernández, Z. (2012). The relation between firm size and R&D productivity in different technological regimes. *Technovation*, *32*(11), 609-623.

Sandner, P. G., & Block, J. (2011). The market value of R&D, patents, and trademarks. *Research Policy*, *40*(7), 969-985.

Shapiro, C. (2000). Navigating the patent thicket: Cross licenses, patent pools, and standard setting. *Innovation Policy and the Economy*, *1*, 119-150.

Somaya, D. (2012). Patent strategy and management: An integrative review and research agenda. *Journal of Management*, *38*(4), 1084-1114.

Spithoven, A., Vanhaverbeke, W., & Roijakkers, N. (2013). Open innovation practices in SMEs and large enterprises. *Small Business Economics*, *41*(3), 537-562.

Statline, CBS (2013). Statistics Netherlands. Patentaanvragers en -aanvragen; bedrijfstakken/branches (SBI'93) 2000-2008 *http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=80826ned&D1=0-*

3&D2=a&D3=a&VW=T ondernemingsgrootte aanvrager, 2000-2010 *http://statline.cbs.nl/StatWeb/publication/?VW=T&DM=SLNL&PA=80813NED*

Thoma, G. (2015), The Value of Patent and Trademark Pairs, Academy of Management Proceedings 2015 (1), 12373

Thoma, G., Torrisi, S., Gambardella, A., Guellec, D., Hall, B. H., & Harhoff, D. (2010). *Harmonizing and combining large datasets-An application to firm-level patent and accounting data* (No. w15851). National Bureau of Economic Research.

Thomä, J., & Bizer, K. (2013). To protect or not to protect? Modes of appropriability in the small enterprise sector. *Research Policy*, *42*(1), 35-49.

USPTO (2012). Intellectual Property and the U.S. Economy: Industries in Focus.: https://www.uspto.gov/sites/default/files/news/publications/IP_Report_March_2012.pdf

Ward Jr, J. H. (1963). Hierarchical grouping to optimize an objective function. *Journal of the American statistical association*, *58*(301), 236-244.

Watson, D. S., & Holman, M. A. (1970). The concentration of patent ownership in corporations. *The Journal of Industrial Economics*, 112-117.

Tables and Figures

Table 1: Review of studies into IPR variety and intensity

Data source type	Source	Citation	Countries	IP rights covered	Firm coverage	Key results
Survey	CIS + interviews with 50 large service companies + Patstat (not matched)	Blind *et al.* (2003)	International	Formal types of IPR especially patents	Service industries	Patent intensity: propensity to patent and patent intensity is lower in the services sector than in the manufacturing sector
Survey	French CIS3 survey	Mairesse and Mohnen (2004)	France	Formal and informal	All sectors and firm sizes	IPR variety and intensity: innovating firms use all protection mechanisms more intensively than non-innovating firms
Survey	German Innovation Panel	Licht and Zoz (1998); Rammer (2007)	Germany	Formal and informal	All sectors and firm sizes	IPR variety and intensity: patent intensity increases with R&D expenditure; complementary use of patents and trademarks (IPR variety) in case of continuous R&D
Survey	SCIS (Statistics Canada Innovation Survey)	Amara *et al.* (2008); Hanel (2008)	Canada	Formal and informal	KIBS (Amara *et al.*, 2008) or manufacturing (Hanel, 2008)	IPR variety: patents, registration of design rights, trademarks, secrecy and lead-time advantages are used jointly
Survey	ETLA survey	Leiponen and Byma (2009)	Finland	Formal and informal	504 SME's	SMEs prefer informal protection over formal protection
Survey	CIS	Peneder (2010)	International	Formal and informal	Survey including all sectors and firm sizes	IPR variety ("full arsenal") in case of high-tech sectors
Survey	Survey on Business Strategies (SBS)	Revilla and Fernández (2012)	Spain	Formal and informal	2000 manufacturing firms	IPR intensity: regimes stimulating IPR use associated with innovative activity in small firms
Survey	German Innovation Panel	Thoma and Bizer (2013)	Germany	Formal and informal	1257 SME's	IPR variety in case of SME's: SMEs combine trademarks with technical IPRs
Survey	CIS	Brem *et al.* (2017)	Spain	Formal and informal	2873 firms > 10 employees	IPR variety: high correlation between use of different IPR types
Survey/ firm data	Carnegie Mellon Survey with Compustat	Cohen et al.(2000)	USA	Formal and informal	Large firms, all sectors	IPR variety in sectors: most sectorsreport high effectiveness scores for two or more mechanisms (both formal and informal)
Survey/IPR registers/ firm data	MIBS survey, Australian IP databases, IBISWorld	Jensen and Webster (2009)	Australia	Patents, trademarks, design rights	1400 firms covering most sectors and sizes	IPR variety: SMEs have higher rates of patent, trademark and design usage once industry effects are controlled for
Survey/firm data	French CIS4 survey with additional official registers	Gallié and Legros (2012)	France	Patents, trademarks, design rights, copyright	3628 firms from various sectors	IPR variety: statutory and non-statutory means of protection are complementary within their own category
Survey/IPR registers/ firm data	Survey of German firms combined with IRP data	Neuhäusler (2012)	Germany	EPO patents (incl. intensity), domestic patents, utility models, design rights	534 manufacturing firms with at least 3 patent applications at EPO	IPR variety: different IPRs are used complementary, patent intensity and variety are correlated.
Linked IPR + firm data	OIPRC/OFLIP database (various firm and IP databases)	Greenhalgh and Rogers (2006); Helmers *et al.* (2011)	UK	Patents, trademarks	Broad coverage (exhaustive matching)	IPR intensity: median R&D intensity and patent intensity are higher in science-based and specialized suppliers sectors. Trademark intensity is more even across sectors.
Linked IPR + firm data	NSF, USPTO	Daizadeh (2009)	USA	Patents, trademarks	33 very large firms	IPR intensity: stronger correlation between R&D spent and trademark intensity than between R&D spent and patent intensity
Linked IPR + firm data	Compustat (firms), PATSTAT (patents), OHIM (trademarks)	Sandner and Block (2011)	International	Patents, trademarks	1216 very large firms	IPR variety and intensity: patent stock and trademark stock show strong correlation
Linked IPR + firm data	Orbis (firms), OHIM (trademarks), PATSTAT (patents)	Millot (2011)	France, Germany	Patents, trademarks	Broad coverage (exhaustive matching)	IPR variety and intensity : significant and positive correlation between trademarks and patents in high-tech manufacturing
Linked IPR + firm data	Orbis (firms), OHIM, DPMA, UKIPO (trademarks + designs), PATSTAT (patents, from EPO, WIPO, DPMA and UKIPO)	Filitz and Tether (2015a)	Germany, UK	Patents, trademarks, design rights	48.000 firms in both countries with annual revenues ≥10 million EUR	IPR intensity: in high-tech and medium high-tech sectors, German firms have considerably larger IPR portfolios than similar UK firms
Linked IPR + firm data	Compustat (firms), USPTO (patents, trademarks, copyright)	USPTO (2012)	USA	Patents, trademarks, copyright	Broad coverage of industries	IPR intensity: considerable overlap between patent intensive and trademark intensive industries
Linked IPR + firm data	ORBIS (firms), OHIM (trademarks, design rights), EPO (patents)	EUIPO/EPO (2016)	EU countries	Patents, trademarks, design rights, geographical indications	240.000 European firms	IPR intensity: many industries have intensive use of more than one of the IPRs
Linked IPR + firm data	Reach + Lisa (firms), EPO+WIPO+OCNL (patents), OHIM+BOIP (trademark, design rights), CPVO+RvP (breeding rights)	*This study*	Netherlands	Patents, trademarks, design rights, breeders' rights	More than 80% of Dutch firms applying for IP	IPR variety and intensity: full account based on exhaustive data on IPR variety, intensity, firm sector and size

Table 2: Matching results of IPR applicants to the Dutch business register

	Number of applicants			Number of applications		
	Firms matched (% of all firms)	Firms unknown (% of all firms)	Private persons	Firms matched (% of all firms)	Firms unknown (% of all firms)	Private persons
Trademarks	20833 (74%)	7493 (26%)	7025	53274 (80%)	13351 (20%)	15212
Patents	4904 (97%)	131 (3%)	2822	35661 (99%)	226 (1%)	3381
Design rights	1475 (82%)	333 (18%)	17	11217 (82%)	863 (18%)	54
Breeders' rights	518 (92%)	45 (8%)	59	9445 (98%)	245 (2%)	277

Table 3: Top-five sectors (NACE 2 digit) with highest skewness of patent, trademark and design right distribution

	Share of patent applications by top 5% patent applicants			Share of trademark applications by top 5% trademark applicants			Share of design right applications by top 5% design right applicants		
Top 5 sectors	NACE 2	Sector description	Share (%)	NACE 2	Sector description	Share (%)	NACE 2	Sector description	Share (%)
1	26	Manufacture of computer, electronic and optical products	96.0	26	Manufacture of computer, electronic and optical products	70.0	26	Manufacture of computer, electronic and optical products	95.4
2	20	Manufacture of chemicals and chemical products	88.8	20	Manufacture of chemicals and chemical products	67.6	10	Manufacture of food products	69.7
3	72	Scientific research and development	72.0	10	Manufacture of food products	60.8	46	Wholesale trade	61.1
4	10	Manufacture of food products	71.5	11	Manufacture of beverages	55.2	32	Other manufacturing	59.4
5	62	Computer programming, consultancy and related activities	66.3	30	Manufacture of other transport equipment	55.0	62	Computer programming, consultancy and related activities	58.4

Table 4: Input cluster analysis

	STAGE		STAGE A							STAGE B						
	Variable	type	N	%	Minimum	Maximum	Mean	Std. Deviation	Importance	N	%	Minimum	Maximum	Mean	Std. Deviation	Importance
Firm taxonomy	SD	Nominal	1238	5.4					1.0	578	11.6					1.0
	SI		1569	6.9						600	12.1					
	SS		545	2.4						339	6.8					
	SB		302	1.3						181	3.6					
	SDS		2345	10.3						234	4.7					
	PN		5916	26.0						1081	21.8					
	IN		6971	30.6						956	19.2					
	KIBS		2544	11.2						871	17.5					
	Non market services		1316	5.8						130	2.6					
Firm size class	0 emp.	Ordinal	1213	5.3	1	12	4.13	2.29	.77	715	14.4	1	12	3.98	2.57	1.0
	1 emp.		5661	24.9						1131	22.8					
	2-4 emp.		4569	20.1						848	17.1					
	5-9 emp.		2715	11.9						502	10.1					
	10-19 emp.		2405	10.6						422	8.5					
	20-49 emp.		2723	12.0						546	11.0					
	50-99 emp.		1418	6.2						272	5.5					
	100-199 emp.		922	4.1						240	4.8					
	200-499 emp.		650	2.9						138	2.8					
	500-799 emp.		170	.7						45	.9					
	800-999 emp.		42	.2						7	.1					
	1000 or more emp.		258	1.1						104	2.1					
IPR size class	1 application	Ordinal	13012	57.2	1	7	1.636	0.948	.71	2149	43.2	1	7	2.007	1.267	1.0
	2-4 applications		6868	30.2						1714	34.5					
	5-9 applications		1722	7.6						538	10.8					
	10-19 applications		655	2.9						251	5.1					
	20-49 applications		324	1.4						183	3.7					
	50-99 applications		105	.5						82	1.6					
	100 or more appl.		60	.3						53	1.1					
Other	Share of patent applications	%	22746		0	1	0.1495	0.3432	1.0	4970		0	1	0.6626	0.4409	1.0
	Share of trademark applications	%	22746		0	1	0.7903	0.3918	1.0	4970		0	0.9151	0.0673	0.1557	.55
	Share of design right applications	%	22746		0	1	0.0396	0.1813	1.0	4970		0	1	0.1756	0.3541	1.0
	Share of breeders' right applications	%	22746		0	1	0.0207	0.1411	1.0	4970		0	1	0.0945	0.2901	1.0

Table 5: A taxonomy of firm-level IPR applications: cluster analysis results

	A (first stage)	B (second stage)			
Cluster	1	2	3	4	5
Label	Trademark rookies	IPR specialists	IPR strategists	IPR specialists (63.8%) IPR generalists (36.2%)	Patent rookies
Number of firms	17776	474	1480	1240	1776
Largest sectors	IN: 33.8% PN: 27.2% SDS: 11.9%	SD: 70.9%	KIBS: 28.3% SI: 20.4%	IN:42.1% PN: 28.1%	IN:23.0% KIBS: 21.1%
Largest firm size classes	0-1 empl.: 28.3% 2-4 empl.: 20.9%	2-4 empl.: 29.5% 20-49 empl.: 16.2%	0-1 empl.: 23.9% 20-49 empl.: 12.6%	0-1 empl.: 43.2% 2-4 empl.: 17.1%	0-1 empl.: 47.3% 2-4 empl.: 18.9%
Largest IPR size classes	1 appl.: 61.1%	2-4 appl.: 34.4% 1 appl.: 26.6%	2-4 appl.: 63.7% 5-9 appl.: 15.1%	2-4 appl.: 44.9% 1 appl.: 20.6%	1 appl.: 97.1%
Share of patent applications (stand. dev.)	0.6% (4.7%)	0.1% (1.0%)	83.2% (26.0%)	23.0% (38.3%)	100.0% (0.0%)
Share of trademark applications (stand. dev.)	99.2% (5.1%)	1.5% (6.5%)	13.4% (20.3%)	10.4% (18.0%)	0.0% (0.0%)
Share of design right applications (stand. dev.)	0.2% (2.0%)	0.0% (0.1%)	3.3% (11.8%)	66.5% (40.7%)	0.0% (0.0%)
Share of breeders' right applications (stand. dev.)	0.0% (0.2%)	98.4% (6.9%)	0.2% (2.3%)	0.1% (1.9%)	0.0% (0.0%)
IPR variety (more than one type of IPR filed)	2.6%	8.4%	40.1%	36.2%	0.0%

Figures

Figure 1: IPR variety: Dutch firms applying for one or more types of IPR (2006-2010)

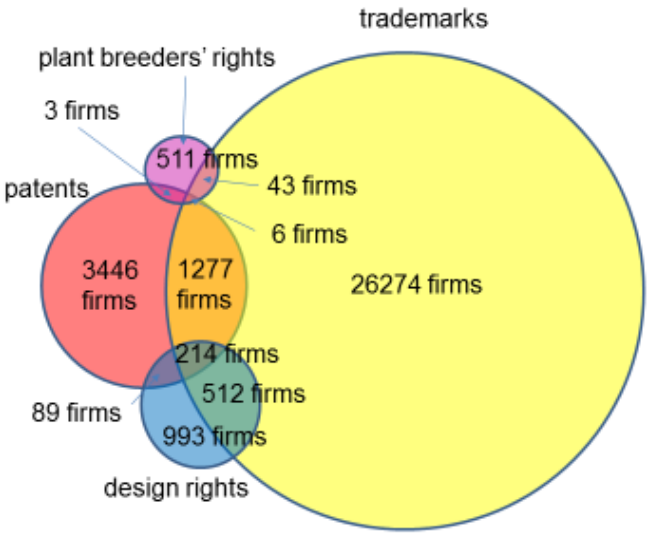
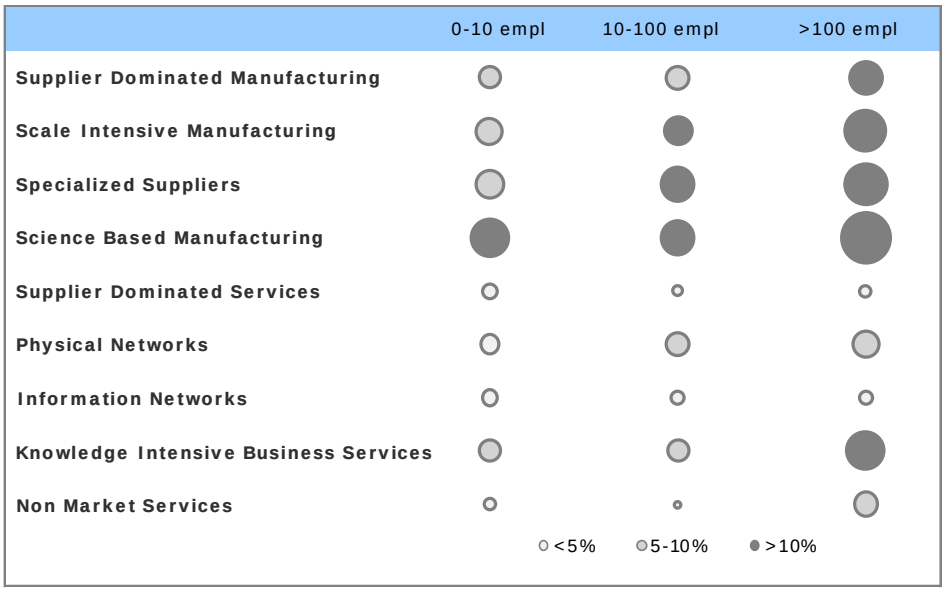


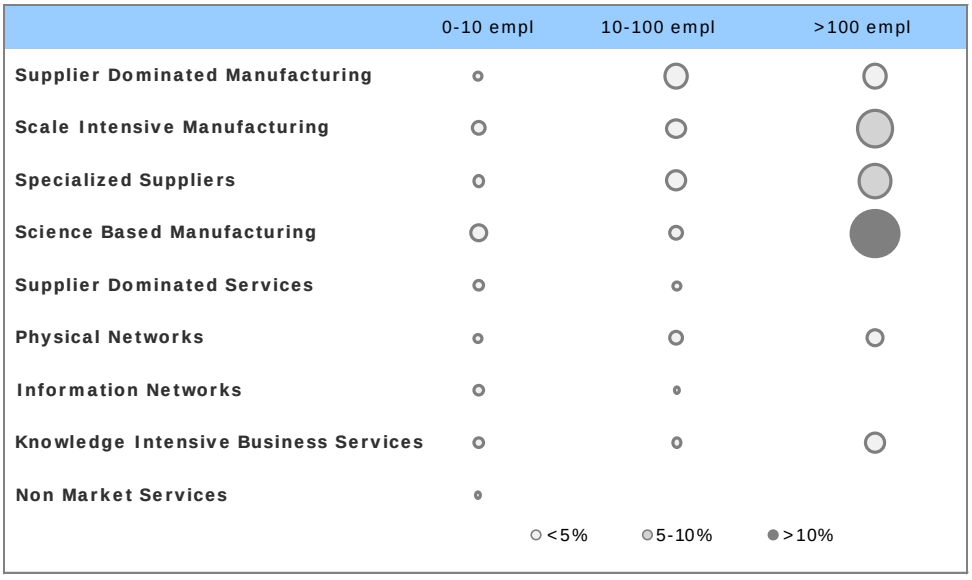
Figure 2: IPR variety across firm sizes and sectors

N=2 (two types of IPR)*



*** circle size represents the share of IPR applicants with two types of IPR among all firms with IPR applications**

N=3 (three types of IPR)*



*** circle size represents the share of IPR applicants with three types of IPR among all firms with IPR applications**

Figure 3: IPR intensity: distribution of number of applications for one type of IPR per firm (2006-2010)

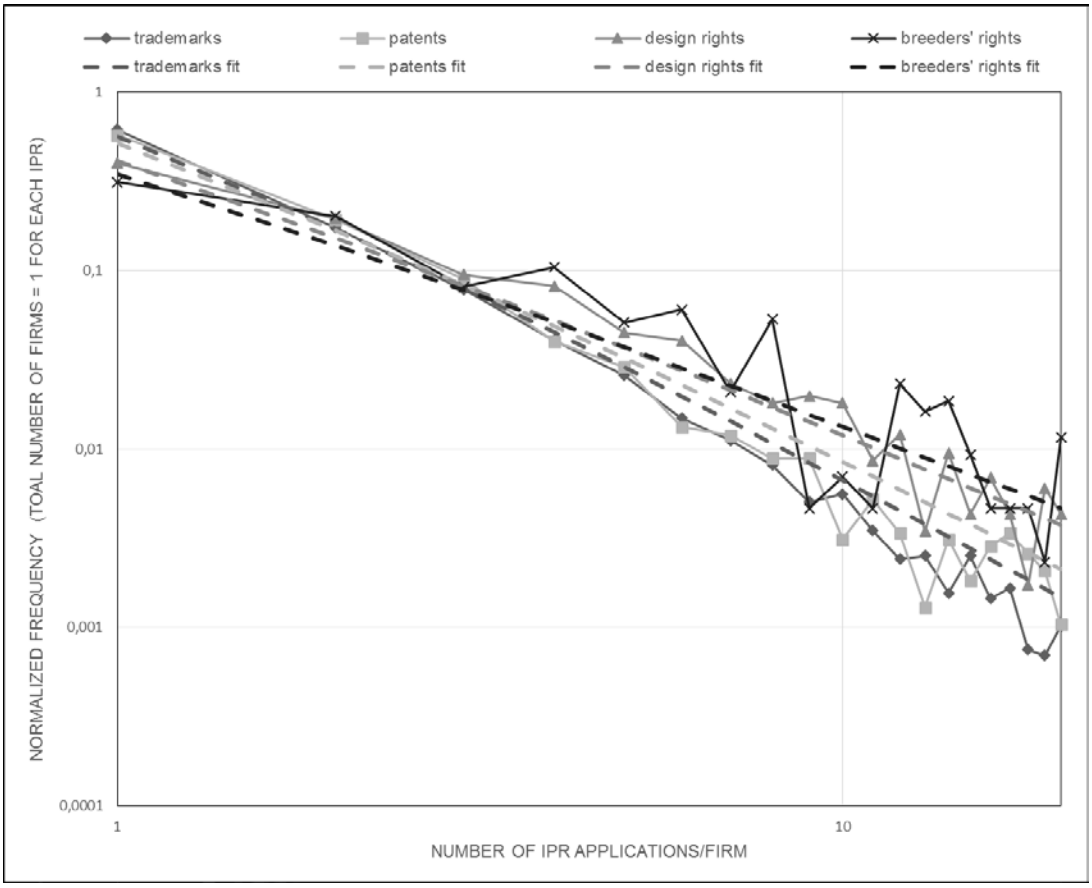


Figure 4: A taxonomy of IPR applicants: five archetypes