OFFICE FOR HARMONIZATION
IN THE INTERNAL MARKET
(TRADE MARKS AND DESIGNS)

Intellectual property rights and firm performance in Europe:
an economic analysis

Firm-Level Analysis Report, June 2015

OFFICE FOR HARMONIZATION
IN THE INTERNAL MARKET
(TRADE MARKS AND DESIGNS)

Intellectual property rights and firm performance in Europe:
an economic analysis

Firm-Level Analysis Report, June 2015

01 / Foreword

The importance of intellectual property rights (IPR) to society and the economy in Europe has become increasingly clear in recent years.

The study on the contribution made by IPR-intensive industries to the EU economy carried out in 2013, in partnership with the European Patent Office, demonstrated the importance of those industries. It showed they support directly or indirectly 35% of jobs, almost 39% of the EU's GDP and 90% of external trade.

OHIM, through the European Observatory on Infringements of Intellectual Property Rights, has now carried out a follow-up study delving deeper into the influence of these rights at the firm or company level. This study, based on official public financial data from more than 2.3 million EU firms, covers companies which own patents, trade marks and designs at both national and at EU level.

The study shows that large companies are four times more likely to own IP rights than smaller companies - 40% of larger firms have registered rights, compared with 9% of SMEs. It also shows that companies that own IP rights perform better than those that do not. This is a particularly significant finding for the 1.8 million SMEs that have registered IP rights, since they represent such an important part of the EU economy.

The results demonstrate that businesses that own Intellectual Property Rights generate more revenue per employee than those that do not, have more employees and pay higher salaries to their workers and that this relationship is particularly strong for SMEs.

This is in our view a very important message for Europe's businesses and policymakers, highlighting the virtuous cycle between IP and economic performance. While it should not be interpreted as establishing a causal link between the ownership of Intellectual Property Rights and higher revenue per employee, there is nevertheless an indication of a relationship between the two.

This report will feed in to a number of Office projects including the upcoming SME Scoreboard. This Scoreboard is designed to examine in greater detail the use that SMEs make of IP rights and will be drawn up by OHIM, through the Observatory, in partnership with the European Commission.

The Office is confident that the present report will make a valuable contribution to a wider understanding of the role of creativity and innovation in EU society and the economy and will help to bring home the important message that Intellectual Property Rights are for everyone.

António Campinos
President, OHIM

Acknowledgements

In carrying out this study, valuable input was received from Member States; from the European Commission; from the European Patent Office; and from Europe Economics, which carried out the technical part of the analysis.

The authors are also grateful for comments on the draft report from Carsten Fink (WIPO), Kamil Kiljanski (European Commission), Alan Marco and Asrat Tesfayesus (USPTO), Philipp Schautschick (TU Munich) and Mariagrazia Squicciarini (OECD).

Project Team

Nathan Wajsman, Chief Economist

Michał Kazimierczak, Economist
Carolina Arias Burgos, Economist

02 / Executive summary

One of the mandates of the European Observatory on Infringements of Intellectual Property Rights ("the Observatory") is to provide evidence-based data on the impact, role and public perception of intellectual property in the economy of the European Union (EU). In order to meet that objective, the Observatory is undertaking a programme of socio-economic studies.

In September 2013, a study which provided an assessment of the combined contribution of industries that make intensive use of the various types of intellectual property right (IPR) to the economies of the EU as a whole and to the individual Member States.

The present report is a follow-up study that delves deeper into the role of IPRs by analysing a large representative sample of over 130 000 European firms[1] in order to compare the economic performance of firms that own IPRs with those that do not.

The IPRs included in the study are **patents, trade marks** and **designs** (and any combination of the three). Because of their nature, copyright and geographical indications, which were part of the 2013 study, were not included here.[2] On the other hand, the present study includes both European and national IPRs, an important enhancement to the data, and provides a complete view of each company's IPRs portfolio—both European and national rights.

The data on each company's IPR portfolio was matched with information contained in the commercial database ORBIS. This database provides financial and other information on millions of European companies, collected from the filings and accounting reports made by the companies in the commercial registers of all EU Member States. The matching of the IPR databases and the ORBIS database was done on the basis of IPR ownership. The study uses financial and other information about companies that are registered as formal owners of patents, trademarks and/or designs. Some companies that are part of a larger group structure may not be the formal owners of IPRs (their headquarters may have the formal ownership), but still use IPRs in their commercial activities.

There are various ways to measure the economic performance of a company. Because of data constraints and the need for like-for-like comparisons (eliminating the effect of firm size on the statistical results), **"revenue per employee"** was chosen as **the main indicator of firm performance**.

1 Some of the descriptive statistics in Chapter 5 are based on an even larger sample of more than 2.3 million firms.

2 The main reason is that copyright is not always registered, while geographical indications are not registered by individual firms. Hence, data on the ownership of those IPRs on the firm level simply does not exist.

The dataset was constructed in such a way that of the companies examined, about half, or 63 288, have at least one patent, trade mark or design in their portfolio. This allows a comparison of the performance of companies that own these IPRs with companies that do not. It also enables a detailed examination of the relationship between a company's performance and the size of the company's stock of IPRs. To our knowledge, the coverage of the dataset is significantly larger than that of any other data source of this type currently available, ensuring a sample sufficiently large to draw robust and representative conclusions.

The study makes no policy recommendations, as this is not within its scope. Instead, it provides evidence that can be used by policymakers in their work, and serves as a basis for raising awareness of IP among Europe's citizens.

2.1 Methodology

The data was analysed using three types of methodology:

First, **descriptive statistics** were compiled to illustrate the differences between owners and non-owners of IPRs in terms of economic characteristics of the firm. Differences were tested for statistical significance. Chapter 5 presents the results of this analysis.

Chapter 6 reports the findings of the **econometric analysis** of the data. It allows for an in-depth examination of the relationship between firms' ownership of IPRs and their economic performance. This is in contrast to the 2013 study of IPR-intensive industries which described the structure of the economy in terms of IPR use at sector level but did not attempt to draw any analytical conclusions. The results of the analysis strongly suggest that there is a systematic, positive relationship between the ownership of IPRs and economic performance at individual company level. The present study provides an indication of this relationship, based on statistical analysis of a very large sample of individual firms.

Whilst causality cannot be proven in the strict sense of the word, given the available data, econometric analysis allows the researcher to control for several additional factors that affect economic performance and to "isolate" the relationship between IP ownership and firm performance. There are various economic theories suggesting a causal link between IP ownership and firm performance. These will be discussed in this report.

Finally, a **cluster analysis** was conducted on the data. This analysis aims at identifying groups of firms ("clusters") that are similar in terms of their ownership of IPRs. These clusters are then analysed to see whether there are systematic differences among them in respect of the variables of interest, such as revenue per employee or average employment per firm. These results are reported in Annex 8.4.

2.2 Main findings

Table 1 shows the key financial and company variables for the firms in the sample for the year 2010.

Table 1: Average values of selected variables by IPR ownership

		Number of employees	Revenue per employee (EUR/year)	Wages per employee (EUR/year)
Non-owners of IPR		93.6	225 540	37 996
IPR owners	**All IPRs**	547.3	290 106	45 520
	% difference compared to non-owners	484.6%	28.6%	19.8%
	Patents	1 537.6	283 567	53 424
	% difference compared to non-owners	1 542.6%	25.7%	40.6%
	Trade marks	569.9	292 011	45 139
	% difference compared to non-owners	508.8%	29.5%	18.8%
	Designs	2 103.1	296 316	46 747
	% difference compared to non-owners	2 146.7%	31.4%	23.0%

Note: Based on available observations of 132 277 firms. All differences are statistically significant at the 1 per cent level. The group of 'All IPR owners' is defined as firms that owned at least one patent, trade mark or design, or any combination thereof. The groups of 'Patent owners, 'Trade mark owners' and 'Design owners' are defined as firms that owned at least one of the particular IPRs. Since many firms owned combinations of the three IPRs, the owners of the various IPRs overlap.

As Table 1 shows, firms that own IPRs tend to be larger than firms that do not, as measured by the number of employees (547 vs. 94 employees on average). For this reason, economic performance metrics such as revenue, profits or wages are expressed on a per-employee basis.

Thus, firms that own IPRs have on average **29 per cent** higher revenue per employee than firms that do not. This can be regarded as one of the central results of this study. In terms of individual IPRs, the average performance premium experienced by IPR-owning firms is 26 per cent for patents, 29 per cent for trade marks and 31 per cent for designs.

Table 1 also indicates that firms that own IPRs pay on average **20 per cent higher wages** than firms that do not. Here, the strongest effect is associated with owning patents (41 per cent), followed by design (23 per cent) and trade marks (19 per cent). Although in terms of revenue per employee, patents, compared with trade marks and designs, seem to be less associated with "extra" performance, they are the IPR type that on average generates the highest rewards for employees. This is also consistent with the results of the previous study which looked into the

contribution of IPR-intensive industries to the EU economy, in terms of gross domestic product, employment, wages and international trade.[3]

The econometric analysis in Chapter 6, the results of which are summarised in Table 2 below, confirms the positive association between IPR ownership and economic performance, with revenue per employee 28 per cent higher for IPR owners than for non-owners.

In addition, the analysis shows that this relationship is particularly pronounced for **small and medium-sized enterprises (SME)**.[4] This report uses the definition based on the number of employees and turnover. SMEs that own IPRs have almost **32 per cent** higher revenue per employee than SMEs that do not own IPRs at all. Thus, while the majority of SMEs in Europe do not own IPRs, those that do own IPRs have significantly higher revenue per employee. In the case of **large companies**, revenue per employee is **4 per cent** higher for IP owners than for non-owners. Here the analysis shows that 4 out of 10 large companies in Europe own IPRs, but the association with higher revenue per employee is less pronounced than in the case of SMEs. It is important to note that these findings are obtained while controlling for other factors that could influence a firm's performance, such as the country in which it is located or the sector in which it operates.

Table 2: IPR ownership and revenue per employee by firm size

	Difference in revenue per employee of IPR owners compared with non-owners of IPR
Large companies	+ 4.0%
SMEs	+ 31.7%
Total	+ 28.0%

Note: Based on observations of a total of 130 555 firms. Differences are statistically significant at the 1 per cent confidence level

The econometric analysis in Chapter 6 further shows that increases in firm performance depend on type and combination of IPRs. The highest revenue-per-employee increases are linked to trade mark-only and combined trade mark-and-design owners: 30 per cent and 39 per cent, respectively. Patent-only owners have 15 per cent higher revenue per employee, design-only owners 15 per cent, patent-and-trade mark owners 17 per cent, patent-and-design owners 15 per cent and owners of all three IPRs 16 per cent.

The figures above reflect binary comparisons. In other words, firms that do not own a particular IPR are compared with firms that do own it. Using econometric analysis, it is also possible to calculate the effect of *increasing* the number of IPRs owned by a firm. This type of analysis shows that a 10 per cent increase in the stock of European trade marks of a firm is associated with a 2.8 per cent increase in revenue per employee, a 10 per cent increase in the stock of national trade marks is associated with a 5.2 per cent increase, while for patents a 10 per cent increase in the stock of

3 Intellectual property rights intensive industries: contribution to economic performance and employment in the European Union, EPO/OHIM, September 2013.

4 An SME is defined in Article 2 of the annex to the Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises (2003/361/EC) as a company with fewer than 250 employees and turnover not exceeding EUR 50 million and/or an annual balance sheet total not exceeding EUR 43 million.

European patents leads to a 1.8 per cent increase and a 10 per cent increase in the stock of national patents to a 4.6 per cent increase. For national designs the analysis suggests that a 10 per cent increase in stock is associated with a 0.7 per cent increase in performance. For the other IPRs the econometric analysis could not establish a statistically significant relationship, which means that it is not possible to state with more than 90 per cent confidence that there is a positive relationship between increases in a company's stock of the relevant IPRs and its economic performance.

2.3 Limitations of the study and directions for future research

The analysis presented in this study confirms that there is a strong positive relationship between the ownership of different types of IPR and the performance of firms, as measured by revenue per employee and average wages paid.

However, as with every statistical analysis, these results must be interpreted with care. They do not constitute conclusive proof that encouraging firms to make greater use of IPRs will cause their performance to increase. The study shows a positive relationship between firms that own IPRs and their performance (as measured by revenue per employee). Indeed, there may be several mechanisms through which the link between the ownership of IPRs and firm performance may work. However, given the available data, it is not possible to disentangle these in the analysis.

The methodology used in the study allows for identification of owners of IP rights by company name, as it appears in the IP registers, and matches this name to the ORBIS database. ORBIS is the most extensive source of demographic and financial information of European firms available to researchers. However, there is not sufficient information in ORBIS to identify all beneficiaries/users of IP rights beyond their immediate owners.

Although the ORBIS database contains information on the economic links between companies (Domestic Ultimate Owner and Global Ultimate Owner) this information is not complete. In other words, there appear to be companies in ORBIS that are part of larger economic groups but for which ORBIS does not report ownership links.

Ownership links were taken into account as much as possible in the randomised sample that was used for all econometric models that form the core of this study (Chapter 6). This smaller sample was cleaned as much as possible, so that companies that are part of a larger group structure are considered as one entity. Thus, in the econometric analysis companies that could benefit from the IP rights owned by other entities in their group were not treated as the non-owners of IP rights. This cleaning process, however, could be done only partially for reasons explained above, and it is not feasible to carry it out on the larger sample of 2.3 million companies that is used for the descriptive statistics.

Although lack of sufficient information about the potential beneficiaries of IP rights affects both large companies and SMEs, the impact on the results for large companies is larger. Large companies are more likely than SMEs to set up branches in many European countries and group IP ownership in one entity that manages the whole IP portfolio. Although registered as an ownership of only one firm, this IP portfolio brings benefits to all the firms that are part of the economic group.

Economic analysis of the benefits accrued to all the IP users (owners, users and licensees) would potentially be more informative. However, there is no publicly available repository containing sufficient information on IP licensing. Therefore all economic studies similar to the present study, that are based on large samples of firms, are necessarily limited to the benefits of IP *ownership* rather than *use*.

While this study has helped to improve our understanding of the relationships between the firms' performance and their ownership of IPRs, much scope remains for further research using the dataset compiled for this study. For example, further analysis can be conducted on separate sub-samples of manufacturing and service firms to analyse in greater depth how the impact of IPRs on company performance varies across sectors.

Another option for future research would be to analyse the impact of IPRs on SMEs and young firms in more detail. The dataset allows companies to be broken down into micro, small and medium-sized companies,[5] and given the estimated significant relationship between IPR stocks and performance for SMEs, it would be worthwhile to analyse this dimension in more detail.

Finally, the analysis in this study is based on *counts* of IPRs held by each firm in the sample. A more challenging further development of the analysis would be to assess the extent to which the "quality" of a patent, trade mark or design affects this relationship. Higher-quality IPRs are likely to have a greater impact on performance than lower-quality ones. Hence, the results presented in this study are an 'average' of these effects.

5 The SME category is commonly broken down further into sub-categories based on the number of employees: 1-10 (referred to as micro enterprises), 11-50 (small) and 51-250 (medium-sized).

Contents

List of tables

Tables

03 / Introduction

What types of company own more IPRs in Europe, SMEs or large companies? What proportion of large companies and SMEs owns IPRs? Do firms that own IPRs exhibit better performance than firms that do not? Do companies register patents, trade marks or designs as single IPRs or rather as bundles? How do changes in a firm's stock of IPRs affect its performance?

This report presents the findings of an empirical economic analysis into the relationship between intellectual property rights and the performance of firms in Europe.

In September 2013, OHIM published a joint study on the contribution of IPR-intensive industries to the EU economy, in terms of gross domestic product, employment, wages and international trade. While that study focused on industries, this follow-up report is aimed at the firm level. Moreover, the current study quantifies the ownership of IPRs in terms of firm performance indicators, while the first study quantified the impact of IPR-intensive industries on main macro-economic variables. The 2013 study was of a purely *descriptive* nature: it examined the structure of the EU economy to identify sectors that use IPRs intensively, and quantified their "weight" in the overall economy. In contrast, the current study is *analytical* in nature: the unit of analysis is the individual firm, and a very large sample of more than 130 000 companies is analysed using statistical techniques to discern whether IPR ownership is associated with economic performance.[6] Whilst both studies lead to the conclusion that IPRs are important in a modern economy, the analysis in the current study provides a much stronger indication of this importance, especially for SMEs.

6 For some parts of the analysis an even larger database of more than 2.3 million European companies was used.

Table 3 provides an overview of the key differences between the previous and current studies.

Table 3: IPR contribution studies, Phase I and Phase II

Phase I: IPR-intensive industries: contribution to economic performance and employment in the European Union	Phase II: Intellectual property rights and firm performance in Europe: an economic analysis
Objective: assess macroeconomic evidence of importance of industries that make relatively intensive use of IPRs for the EU economy: employment, GDP, wages and international trade	**Objective:** assess microeconomic evidence of importance of IPRs for the performance of firms
IPRs: patents, trade marks, designs, copyright and geographical indications at European level	**IPRs:** patents, trade marks and designs at both European and national level
Countries: 27 EU Member States	**Countries:** 12 EU Member States
Methodology: descriptive statistics	**Methodology:** descriptive statistics and econometric analysis
Level & data: 615 industries	**Level & data:** 2 364 063 firms for the descriptive part of the analysis and 130 555 firms for the econometric part

3.1 Setting the scene: the increasing importance of intellectual property rights for firms

Judging by the strong growth in usage, during recent decades IPRs have become increasingly important for firms. IPRs are no longer perceived merely as tools that reward creativity and inventiveness, deter imitation and secure the reputation of a company's products and services. Beyond their traditional function, IPRs provide companies with new opportunities to reap the benefits of their original works and adequately monetise their intellectual property. IPRs have become flexible instruments that provide firms with an array of strategic options. Firms can for example decide to open up IPRs for use by others through licensing programmes or through research & development joint ventures, thus creating valuable economic activity.

Patent portfolios, technology licensing programmes, brand equity and goodwill determine much of the value of many modern companies, and have become central to their financial performance. Indeed, the corporate value of many large firms in advanced economies is now mostly accounted for by intangible rather than tangible assets.[7] Ideas and creativity are often the most valuable source of inputs, replacing the more traditional factors of production such as land, labour and capital.

Within this changing environment, businesses are adapting their models accordingly and seek to appropriate returns on their investments by exploiting their intangible assets. A range of options from formal to informal tools of protection of their intellectual assets is at their disposal. The choice of specific tools depends on a number of factors, including the size of a firm and the sector in which it operates.

7 See Malackowski et al. (2007).

Additionally, instead of focusing on one IPR at a time, companies increasingly look at their intellectual assets collectively and take the combination and interaction of various IPRs into account in their decisions. In fact the usage of IPRs as a bundle displays significant potential for companies to strengthen their competitive position in the market, and research is pointing out that IPRs can be used in a complementary way in order to generate additional streams of revenue and to improve the financial performance of the company.[8]

Box 1: Patents, trade marks and designs

The methods of protecting intellectual property can be divided into two broad categories: informal methods of intellectual property protection (e.g. speed to market and trade secrecy) and formal IPRs. Formal IPRs include patents, trade marks, designs, copyright, geographical indications and plant variety rights. This study focuses on patents, trade marks and designs because no firm-level data for the other formal IPRs was available. Box 1 summarises the main aspects of each of these three IPRs.

	Patent	Trade mark	Design
Subject matter	Industrially applicable invention, new and involves an inventive step	Distinctive signs that distinguish a company's goods or services from others	Ornamental and non-functional features of an article or product
Conferred rights	Exclusive right to make, use, and sell the patented invention	Exclusive right to use the trade mark in trade and prevent its use by others for similar or identical goods or services	Exclusive right to use the design and prevent its use by others
Benefits of rights protection	Incentive for innovation; protection of knowledge; full technical disclosure of invention	Promotes quality and competition between brands; provides the public with brand information and use in commerce	Ornamental and non-functional features of an article or product; provides a means for product differentiation and promotes competition between brands
Duration	Typically maximum 20 years from filing	Commonly 10 years from filing, but can be renewed indefinitely for successive periods	The usual maximum term is 25 years

8 The **OECD Science, Technology and Industry Scoreboard** (2013) calls for the need to look at intellectual property bundles and the joint use of European patents, trade marks and industrial designs by firms to protect their inventions.

3.2 Contribution of the study

Several attempts have been made in the academic and management literature to show how the use of IPRs is linked to the economic and financial performance of firms. While most of these studies focus on patents and only some deal with trade marks or designs, empirical evidence of a direct link for European firms is scarce.[9] The methodological approaches used in these studies are largely dictated by the nature of the available data.

The main contribution of the current study lies in the construction and analysis of a unique and large dataset with financial variables and IPR data at firm level for European companies. The study employed a unique merged dataset containing company-level information for multiple years on patents, trade marks and designs (both at national and European level) together with data on the financial performance and structural data of firms for the years 2002-2010.

The process of obtaining data on national IPR filings from each country and incorporating it into the merged database is labour-intensive and time-consuming. Because of time constraints, it was not possible to include firms from all 28 EU Member States in the sample. In order to allow for completion of the analytical work by Europe Economics within the time frame provided for in the contract, the collection of data and the matching exercise had to be "frozen" in March 2014. Thus, the analysis in this study is based on data from a representative sample of more than 130 000 firms drawn from 12 EU Member States: Austria, Belgium, Germany, Denmark, Spain, France, UK, Hungary, Italy, Lithuania, Netherlands and Portugal. Data from the remaining Member States is being collected so that future studies of this type can be carried out using data for all EU Member States.

From a statistical point of view, this limitation is not decisive. The 12 Member States in the sample include the five largest EU economies, and provide a geographically balanced representation of the EU as a whole. It should also be noted that the countries included in this analysis accounted for approximately 85 per cent of EU GDP in 2013. Finally, inclusion of additional countries would be unlikely to have a significant impact on results because the focus of the study is on the characteristics of firms, not on country characteristics.

The in-depth analysis of this dataset resulted in finding clear (statistically significant) and positive relationships between the ownership of IPRs and firm performance as measured by revenue per employee. Moreover, this relationship is more important for SMEs than for large firms.

Caution is needed in interpreting the findings of this study. First, the nature of the statistical analysis used does not allow conclusions about the causal links between IPRs and firm performance. Causal links can potentially work in two different directions: the ownership of IPRs can lead to better financial performance of firms, or it can be the case that firms own more IPRs because they are performing better.

9 For a recent overview of existing empirical literature see F. Munari (2012) and Schautschick and Greenhalgh (2013).

Economic theory on IPRs sets out various possible ways in which IPRs can lead to superior economic performance by firms. IPRs create incentives for firms to engage in innovative activity that allows them to reduce costs (mainly process innovation) or/and raise profitability and sales (mainly product innovation). Therefore the ownership of IPRs is likely to be a proxy for a firm's general ability to generate intangible assets. The positive relationship between IPR ownership and economic performance might partially be due to the positive influence that intangible assets can have on a firm's productivity.

Also, licensing activity enabled by IPRs brings additional revenue to innovative firms without the necessity to engage directly in the corresponding production activity.

Finally, the right to exclude competitors that patents, trade marks, or designs guarantee, leads directly to reduced competitive pressure on their holders, and thus to higher profits.

Conversely, strong economic performance can also impact a firm's decisions to apply for formal IPRs.[10] Companies that have already been able to generate high financial returns in the past might turn to using tradable and enforceable IPRs to protect their revenue streams in the future. Finally, there is a risk that any statistical association found between IPRs and performance is spurious and driven primarily by firm-specific features (e.g. management practices, quality of management). However, the available data allowed to reduce this risk considerably.

3.3 Outline of the report

The structure of this report is as follows:

- Chapter 4 describes the data sources, the data-matching methodology applied, the resulting dataset and the types of analysis carried out in this study;
- Chapter 5 provides a first look at the evidence, in the form of descriptive statistics of the dataset;
- Chapter 6 sets out the main findings of the econometric analysis;
- Chapter 7 summarises the findings of the study;
- The Annex contains supplementary information and analyses.

10 See for example O'Mahony and Vecchi(2009) or Marrocu et al. (2011).

04 / The foundations: data and methodology

4.1 Introduction

The purpose of this study is to examine the relationship between companies' ownership of IPRs (patents, trade marks and designs) and their economic performance, as measured by revenue per employee. The methodological approach used to establish links between IPRs and performance is dictated to a large extent by the nature of the data available, which is discussed in greater detail later in this chapter.

The overall approach taken in this study is summarised in Table 4. It also specifies the types of IPR included in the research, the level at which the analysis has been conducted, the IPR metrics employed and the performance measures employed.

Table 4: Key characteristics of methodological approach

Characteristics of the analysis	
Type of IPR	- National patents - European patents[11] - National trade marks - European trade marks - National designs - European designs
Level of analysis	Firm level
IPR metrics	- Whether or not a firm owns IPRs - Stocks of IPR per employee
Performance metrics	Revenue per employee
Methodological approach	- Descriptive statistics - Econometric panel analysis - Cluster analysis

11 The term "European patent" refers to a patent granted by the EPO and is in fact a bundle of national patents. "European trade mark" and "European design" refer to the Community Trade Mark and Registered Community Design, respectively.

With regard to the methods of IP protection considered, the analysis is based on three main categories of IPR: patents; trade marks; and designs. A distinction is made between IPRs granted/registered at the European level and those granted/registered at the national level because the characteristics of such rights are different and it would be incorrect to treat a single national right and a European right (a bundle of national rights in the case of patents) equally. The IPR data was obtained from the EPO's PATSTAT database, OHIM's trade marks and designs register, and from the databases of national IP offices. A description of these databases is provided in Section 4.2.1 below.

The economic impact of IPRs is assessed in this study at the firm level. Information on the financial performance and basic characteristics of firms was obtained from the ORBIS database and was matched with the IPR data described above. A more detailed discussion of these issues is provided in Section 4.2.2.

The analysis employs two main definitions of IPR ownership: **binary indicators** that identify whether or not a firm owns any IPRs, and several indicators for a specific type or combination of IPRs, and the **stock per employee** of patents, trade marks and designs. The main performance measure is revenue per employee.

This study employs three methodological approaches to identify links between IPRs and performance: descriptive statistics, econometric analysis and cluster analysis.

These methodological approaches are complementary in the following sense. The descriptive statistics and the cluster analysis provide a basic overview of the characteristics of firms included in the dataset and identify the extent to which the level of IPR ownership differs between firms with different characteristics (e.g. sector, country, size, etc.). The econometric analysis moves beyond pure description and seeks to identify the relationship between IPRs and the performance of a firm, controlling for other factors that affect performance. The detailed approaches and the results of the analysis are described in the following chapters:

- ➔ Chapter 5: A first look at the evidence: descriptive statistics;
- ➔ Chapter 6: IPRs and firm performance: econometric analysis.

The cluster analysis is discussed in Annex 8.4.

4.2 Data

The results presented in this report are based on a newly produced dataset, which consists of a panel of nine years (2002-2010) that includes information on more than 130 000 companies from 12 EU Member States.

The dataset used for this study combines financial information reported by a large number of European firms (ORBIS database, see below) and details about intellectual property rights obtained by the firms from national and European IP offices (see the following section for a description of the data sources). To the best of our knowledge, the coverage of the dataset is significantly larger than that of any other data source of this type currently available, ensuring a sufficiently large sample to draw robust and representative conclusions.

4.2.1 IPR data

The data sources for the IPR data used in this study are the following:

- **PATSTAT** — the EPO's Worldwide Patent Statistical Database. It contains all records of published patents filed at the EPO and the vast majority of national patent offices around the world. It includes information such as filing and grant dates, legal events, citations and industry classification of patents. The dataset used in this report was based on PATSTAT April 2013.
- **OHIM Register** — this database contains filing, registration and expiration dates for Community Trade Marks and Registered Community Designs granted by OHIM.
- **National IPR registers** — for most of the Member States in the sample, trade mark and design information was obtained directly from the national IP offices, supplemented by data from TMview and DesignView[12] where necessary.

The approach used to construct the IPR dataset for the subsequent analysis involved three basic steps:

1. Standardising the data structure on individual intellectual property rights from various sources, in particular the dates of filing, grant/registration and expiration.
2. Merging the IPR-level data. This is a many-to-many merge, as IPR owners can have more than one IPR and the same IPR can be owned by different firms.
3. Consolidating the IPR-level data into firm-level data. This was achieved typically by counting the number of IPRs of each type (trade mark, design or patent at national or European level) associated with each firm in each of the years of the panel (2002-2011). However, if the same IPR was registered to multiple owners, then each owner would be assigned the appropriate fraction of the right.

12 TMview is an online database (free of charge) which allows users to search the trade marks of all participating official trade mark offices. It gives access to trade mark applications and registrations of the participating offices in a single place. DesignView is a centralised access point to view the registered design information held by any of the participating offices, in a unique presentation format, independently of which office the data is coming from. The design search tool is based on the data of the registers of the participating offices, WIPO and OHIM.

Part of the statistical and econometric analysis in this study relies on the construction of stocks of IPRs. Hence, it is necessary to account for the number of IPRs (of each type) that are valid at any point in time during the period covered in the panel. In general, all the data sources are reasonably complete in terms of information on filing and grant/registration. However, the exact year in which an IPR stops being valid is sometimes missing. To address this issue, various approaches were followed:

- **European patents.** These patents are granted by the EPO but are typically validated in multiple Member States. Each of the national patent offices reports back to the EPO when a patent is no longer valid. For the purposes of this study, it has been assumed that an EPO patent is "alive" as long as it has not lapsed or expired in at least one of the national offices where it was validated. In calculating the stocks of European patents held by the firm, each European patent was treated as a single patent, even if it was validated in multiple countries.[13]

- **National patents.** Expiry, lapse and other events are also recorded in the legal events table of PATSTAT. However, national patent offices typically use several different codes to record various events.[14] The different practices among patent offices complicate the task of using a uniform criterion for defining the date when a patent is no longer alive. For patents with no relevant termination event available due to misreporting by national patent offices, the average national patent life was used to calculate the expiration date.[15]

- **European trade marks and designs.** The OHIM database contains complete information on filing, grant and expiration dates. No further assumptions were required.

- **National trade marks and designs.** The data obtained from TMview, DesignView and the national offices contained much missing data on lapse/expiration. In those cases, it was assumed that the average life for trade marks and designs is ten and five years respectively. These estimates correspond to the initial term, without taking potential renewals into account.

In the case of national trade marks and designs, the registration date was used as the grant date. This might be inaccurate in jurisdictions where the registration is awarded with significant delays after filing while firms in practice enjoy the benefits of the property right from the time of filing. However, it is not possible to produce a more accurate estimate for these countries using the data available.

13 The number of countries in which a patent was validated is one element of the patent quality index that will be introduced in Annex 8.5.2.2.

14 Annex 8.2 provides details of the codes used to obtain the expiration or lapse dates for national patents.

15 For Italy and Lithuania, no data was available for any patents and so the average life of national patents in all the other countries in the sample was used to estimate the expiration dates for those two countries.

4.2.2 Firm data

The most reliable financial and demographic data on companies as gathered by statistical offices or tax authorities is not available for research purposes due to data protection concerns. Given those constraints, many firm-level analyses are based on data collected by commercial providers, who gather information from publicly available business registers. The ORBIS dataset,[16] provided by Bureau van Dijk, is one of the sources most commonly used by researchers and contains financial information on millions of listed and unlisted companies worldwide, including more than 20 million firms in Europe. The data was extracted for the years 2002-2011. ORBIS includes a variety of key financial variables that are crucial for firm-level analysis.

Matching IPR and firm data

In order to create a combined IPR and firm dataset for the analysis, the IPR data was matched with ORBIS data so that, for each company in the sample, its portfolio of IPRs and its financial and economic characteristics could be correlated. Although there are known problems with the representativeness of the ORBIS data and with the availability of some of its key variables,[17] all companies available in ORBIS have been used for matching purposes. Potential problems that could have distorted subsequent analyses have been tackled during the construction of the research samples and by employing relevant control variables such as country, industry and firm size dummies during the econometric analysis. Further details of the matching process are explained in Annex 8.1.

4.2.3 Samples

Reduced sample

The financial data provided in ORBIS has a very large proportion of missing values. This is observed in a large number of firms that no longer exist, sparse data for the last year in the panel (2011, which was dropped from the analytical datasets for that reason) and variables that are only rarely reported, such as R&D expenditure and revenue from exports. To tackle this problem, only firms that have **three consecutive years** of data in three key variables - revenue, profits (measured by P/L before tax) and number of employees[18] - were kept in the dataset. This constitutes a minimal condition that needs to be met in order to apply panel econometrics techniques (see Chapter 6). The dataset which contains only firms with three consecutive years of financial data is called the 'reduced' sample.

16 For this study, the April 2012 version of ORBIS was used.

17 For a detailed discussion of the representativeness and potential weaknesses of the ORBIS dataset, see Squicciarini and Dernis (2013).

18 ORBIS contains several measures of profits. This report uses the variable "P/L before tax", as it abstracts from differences across countries such as different tax regimes. In principle, EBITDA could have been used as a measure of profits but data is not available for all the Member States in the sample and so it was not pursued.

Randomised sample

In the resulting dataset, Spain, France, Italy and Portugal have many more firms with financial data than other countries. This is in itself not a problem given that the focus of this study is on firms rather than countries. However, close examination of the data revealed that the proportion between SMEs and large companies is skewed for some countries, possibly due to different accounting and reporting requirements across Member States.[19]

In order to correct for this issue, a random sample from the reduced dataset was generated, subject to two constraints:

1. The fraction of firms from each country should be the same as for the economy as a whole. Data was obtained from Eurostat on the total number of companies in each Member State, and the proportion of the total accounted for by each Member State was calculated. The sampling strategy then ensured that the proportion of companies from each country in the 'randomised' dataset would be equal to the proportions evident in Eurostat data and that the proportion of SMEs in the sample would be similar to that of the EU economy. Since the ownership of IPRs by SMEs was a particular focus of this study, this was an important consideration.
2. Within each country, the fraction of firms that are owners of intellectual property rights should be equal to one half, wherever possible. This would ensure that the dataset contained a sufficient number of IPR owners to allow the econometric models to measure the association between IPR ownership and performance.

Using these constraints for the 'reduced' sample, the selection of firms from each country was random. Table 5 presents the number of firms in the full sample of data, the 'reduced' sample of firms for which three consecutive years of data were available, and the 'randomised' sample of firms that was the basis of the subsequent analysis. Eurostat data on the number of firms in each Member State is presented as well, since the distribution of firms by Member State as reported by Eurostat was the reference point for construction of the randomised sample.

This had the effect of reducing the sample to approximately 140 000 companies. Following inspection of this dataset a further refinement was made: the highest and lowest 2.5 per cent of observations, as for the revenue per employee, were dropped from the sample to avoid the results being driven by outliers. This type of adjustment is standard practice in econometric analysis and is designed to account for situations where a small proportion of firms in the sample has extreme values of the key variables due to errors in the data (for example, in some cases, due to coding errors either revenue or the number of employees might be off by an order of magnitude, leading to very high or very low revenue-per-employee figures).

---

19 Because ORBIS is essentially an aggregation of data filed by companies with authorities in Member States (e.g. Companies House in the UK, Handelsregister in Germany, Kamer van Koophandel in the Netherlands etc.), the quality and coverage of the data in ORBIS depend on the filing requirements in each Member State and the degree to which companies comply with those filing requirements. In some Member States, reporting requirements are less stringent for SMEs in order to lessen the administrative burden on business. This limitation in the data stems from the primary sources and hence cannot be easily resolved. For the countries with a significantly lower-than-expected number of companies, it is clear that the missing companies are predominantly SMEs. For example, while according to Eurostat data, 99.5 per cent of German companies are SMEs, in the sample only 50.5 per cent of German companies fall into that category. Conversely, for the countries with a large number of companies in the sample, the proportion of SMEs is close to that reported by Eurostat (for example, for Spain, 98.7 per cent of companies in the sample are SMEs, compared with 99.9 per cent according to Eurostat).

Table 5: Composition of firms in all samples by Member State

Member State	Eurostat (2011)		Full ORBIS sample (2002-2011)		Reduced ORBIS sample (2002-2010)			Randomised ORBIS sample (2002-2010)	
	Firms	%	Firms	%	Firms	%	% of full sample	Firms	%
AT	304 242	1.9	651 296	2.9	3 985	0.2	0.6	1 968	1.5
BE	550 785	3.5	2 231 856	9.9	51 945	2.2	2.3	4 646	3.5
DE	2 158 095	13.7	2 310 961	10.2	25 891	1.1	1.1	17 638	13.3
DK	213 398	1.4	422 812	1.9	17 088	0.7	4.0	1 712	1.3
ES	2 087 371	13.3	3 059 104	13.6	654 039	27.6	21.4	18 376	13.9
FR	2 567 437	16.3	1 768 729	7.8	1 012 882	42.7	57.3	22 213	16.8
GB	1 696 589	10.8	5 754 415	25.5	85 087	3.6	1.5	13 436	10.2
HU	550 259	3.5	770 297	3.4	15 329	0.6	2.0	4 656	3.5
IT	3 843 455	24.4	1 465 910	6.5	249 129	10.5	17.0	33 391	25.2
LT	127 517	0.8	124 474	0.6	8 229	0.3	6.6	1 027	0.8
NL	803 873	5.1	3 526 967	15.6	7 203	0.3	0.2	6 120	4.6
PT	831 655	5.3	486 364	2.2	242 613	10.2	49.9	7 094	5.4
Total	**15 734 676**	**100.0**	**22 573 185**	**100.0**	**2 373 420**	**100.0**	**10.5**	**132 277**	**100.0**

Note: This table shows that, in some cases, the number of firms in ORBIS exceeds that in Eurostat while in other cases the reverse is true. As ORBIS contains only a subset of companies in the economy, it may seem that the number in ORBIS should be lower than the number in Eurostat. However, this is not the case since the Eurostat data includes only firms operating in 2011 while the ORBIS data contains firms for the period 2002-2011. In addition, it might be possible that companies that ceased to operate even before 2002 have not been deleted from ORBIS. Another point to note is that SMEs appear to be underrepresented in the case of AT, DE, NL and GB, hence the smaller number of firms in the full ORBIS sample.

Due to the elimination of outliers, there are slight differences in percentages of firms for each Member State when comparing the randomised sample and the data from Eurostat. An additional reason is that the percentages in Eurostat are for 2011, whilst the percentages in the randomised ORBIS sample cover the period 2002 to 2010.

The randomised sample in the last column, comprising **132 277 firms**, is used in the analysis presented in subsequent chapters. In particular, all the econometric analyses in Chapter 6 are based on the randomised sample.[20] The descriptive statistics presented in Chapter 5 are based on either the reduced sample or the randomised sample, whichever is more appropriate in each case. For example, when analysing IPR ownership by firm size in Table 8, the reduced sample is used, since using the randomised sample (which by construction has roughly equal numbers of owners and non-owners) would have given incorrect results in this case.

Variables included in the sample

Box 2 shows a summary of the variables that are included in the dataset. A distinction is made between company variables, financial data and IPR data.

20 As a robustness check several independently drawn random samples were used to ensure that the econometric results do not depend on the sub-sample drawn and that the estimation precision does not suffer from the reduced sample size.

Box 2: Variables in the dataset

Company variables (time-independent):

- ORBIS ID (identity) number;
- Member State where company is located;
- ID number of domestic owning company;
- Year of incorporation;
  - This was used to construct a variable reporting the firm's age
- NACE Rev. 2 code: four-digit and broad categories, as defined by Eurostat;[21]
- Size: Micro, Small, Medium or Large according to the definition of the European Commission.[22]
  - The key indicator used in the analysis is a binary indicator of whether the firm is an SME or a large company.

Financial data (time-dependent)

- Revenue;
- Number of employees;
  - This was used to construct various per-employee variables (e.g. revenue per employee)
- Wages (costs of employees);

IPR data (time-independent)

- IPR owners: several variables were constructed to capture the type of ownership of IPRs by each firm:
  - binary (owner/non-owner). A firm is defined as an owner of IPR if it was granted a right (patent, trade mark or design) at any level (national or European) at any point in the period covered in the panel;
  - by type of right (e.g. owner/non-owner of designs);
  - by type of right and national/European level (e.g. owner/non-owner of European designs); and
  - combination of the types of right owned (e.g. owner of patents and trade marks). Since three types of IPR are considered, there are eight possible ownership combinations.
- Year in which each IPR is filed, granted or expired. The dates of grant and expiration were used to construct, for each company in each of the years covered in the panel:
  - European patent stock;
  - national patent stock;
  - European trade mark stock;
  - national trade mark stock;
  - European design stock; and
  - national design stock.

21 For a description of the NACE classification, see: http://epp.eurostat.ec.europa.eu/portal/page/portal/product_details/publication?p_product_code=KS-RA-07-015

22 See http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/sme-definition/index_en.htm.

4.3 Methodology

The dataset constructed for this study was analysed starting with descriptive statistics, continuing with cluster analysis, and finally progressing to full econometric analysis. For each of these analyses, either the reduced sample or the randomised sample was used, whichever was most appropriate, as explained in section 4.2 above.

This sub-section contains a general technical description of the methodology used in each of these three analyses. Additional detail, in particular as regards the interpretation of the results and the definition of the variables, is provided in conjunction with the presentation of the results in order to facilitate the reader's understanding of those results.

4.3.1 Descriptive statistics

The overarching goal of the statistical analysis in this study is to answer the following questions:

- What is the proportion of IPR owners among large firms and SMEs? Do common patterns exist in the way IPRs are owned?
- Are there apparent links between IPR ownership and firms' characteristics?
- What are the links between the ownership of IPRs and companies' performance?

These questions have been addressed using both basic and more advanced descriptive statistical techniques. As a first step, a number of cross-tabulations are presented that identify key differences between the characteristics of IPR owners and non-owners, and illustrate links between IPR ownership and company performance. For this analysis, data from the most recent year for which there is reasonably complete information, 2010, is used. Both the reduced and the randomised samples are used in this section.

In addition, tests are carried out on the statistical significance of the differences between the group means in respect of the variables of interest (such as revenue per employee or average wages). These tests, known as t tests, are designed to determine the degree of confidence one can have that observed differences (for example, the fact that IPR owners have higher revenue per employee than non-owners) are not merely the result of chance.

The descriptive statistics are reported in Chapter 5.

4.3.2 Cluster analysis

As a next step beyond the basic descriptive statistics and cross-tabulations, cluster analysis was used to identify typical profiles of IPR usage.

Cluster analysis is an Analysis of Variance (ANOVA) method which aims to assign a set of objects (e.g. IPR indicators) into segments (clusters) so that the objects in the same cluster are more similar to each other than to those in other clusters. Applied to IPR indicators, the technique can be used to identify clusters of companies that share common and unique characteristics in terms of IPR ownership. Cluster analysis can, for example, be used to distinguish IPR owners that have a large IPR portfolio per employee and have IPR protection in multiple countries from those with a small IPR portfolio and having protection in few countries.

Cluster analysis can be performed using different computational algorithms, and the choice of algorithm would typically depend on the nature of the underlying data. It is important to stress that these statistical techniques require a significant degree of external judgment. For example, the initial number of groups/components in which the variable would be clustered must be decided before running the analysis. While statistical tests to support the researcher in this decision exist, it is common practice to report the results for different assumptions on the initial number of clusters/components. The preferred choice is then usually dictated by the ability to provide a clear and intuitive interpretation for the emerging profiles.

The cluster analysis conducted in this study is based on six variables: the stocks of patents, trade marks and designs both at the national and European levels. Analysis results obtained from the randomised sample are reported. The year 2010 was chosen as the base year, and the variables were normalised to account for differences in scale and variability.

Once the clusters have been identified, they are examined for systematic differences among them in terms of average number of employees per firm, age, proportion of SMEs in each cluster,[23] which sectors predominate, and whether the clusters differ according to average revenue per employee.

The results of the cluster analysis are reported in the Annex 8.4.

23 A recent study by Eurostat (2014) estimates the proportion of patents (EPO and PCT applications and USPTO patent grants) filed by European companies and accounted for by SMEs for different fields of technology. The study finds that 79 percent of all patents can be attributed to large firms and 17 percent to SMEs. The firm size remained unclear for 4 per cent of corporate applicants.

4.3.3 Econometric analysis

In the last step of the analysis, an econometric analysis to further investigate the relationship between firm performance and IPR ownership was conducted. Revenue per employee, which serves as the measure of firm performance, constitutes the dependent variable. Independent variables are variables which indicate whether a firm owns IPRs or particular types of IPR at all and variables which specify the number of patents, designs or trade marks held by a firm. Therefore, the first set of regressions analyses the relationship between firm performance and the general ownership of IPRs. The second set examines the relationship between firm performance and stocks of IPRs.

The data allows for use of panel data econometric techniques which exploit variation in two dimensions. The first is the so-called cross-sectional dimension, which refers to observed differences between firms at one particular point in time. The second is the so-called time-series dimension and refers to observed changes for one particular firm over time. Using panel data techniques such as the "fixed-effects" and "random-effects" models, one can control for unobserved heterogeneity among firms stemming from differences in terms of the industry sector, country, firm type or age. Moreover, unobserved heterogeneity[24] can also be taken into account by such methods, minimising the risk of obtaining spurious or biased results driven primarily by firms' characteristics. All econometrics are performed using only the randomised sample, in order to ensure sufficient representation of owners and non-owners in the analysis.

24 Unobserved heterogeneity refers to the possibility that relevant differences among firms (e.g. differences in revenue per employee) stem from underlying „invisible" factors such as the quality of a firm's management team.

4.4 Summary and limitations

The present study is built on the foundations of a carefully constructed dataset. To the best of the authors' knowledge, the coverage of the dataset is significantly larger than any other data source of this type currently available, ensuring a sufficiently large sample to draw robust and representative conclusions. The analysis in the subsequent chapters confirms that there is a strong positive relationship between the ownership of different types of IPR and the performance of firms.

Nevertheless, there are limitations as regards both the data and the methodology that must be noted. Some of these limitations are inherent in the methodology or the data, while others can hopefully be overcome in future studies.

One of the limitations of this study that makes it difficult to establish a causal link between IPR ownership and firm performance is the lack of data on intangible assets (some of which can be protected by IPRs, as investment in R&D and in design and marketing activities) and the quality of those assets. The dataset at hand contains no information on a firm's investments in intangible assets, and it is therefore impossible to control for this characteristic in the analysis. If, for example, firms that have many IPRs are also those that invest more in intangible assets in general, then the apparent relationship between IPR ownership and economic performance found in this study could be explained by the higher investment in intangibles. Without data on intangible investments, this hypothesis cannot be ruled out, nor can its potential impact on the results be assessed.

The IPR data used for the analysis includes trade marks and designs registered in the company's own country or with OHIM (i.e. CTMs and RCDs), but not national trade marks and designs registered in other countries (as explained in Annex 8.1). It is in principle possible to include such national IPRs held in other countries, but the resulting matching exercise would place enormous demands on time and resources, by orders of magnitude.

The quality of the economic and financial data in ORBIS largely depends on the different reporting requirements in the Member States, and on the degree to which companies comply with these requirements. As explained in Section 4.2.3, significant efforts were made in this study to correct for this problem. Nevertheless, the fact remains that to the extent the data is not supplied by firms to the relevant national authorities, there is no alternative source of such data—it simply does not exist in an accessible form.

The econometric analysis was conducted in a manner so as to correct for potential problems in the data, such as heteroskedasticity[25] and unobserved heterogeneity (see Annex 8.5). However, the fact remains that the observed relationships in the data could be a result of some underlying factors not captured by the analysis. This is an inherent potential risk in every econometric analysis.

25 One of the key assumptions in regression analysis, the main econometric technique used in this study, is that the residuals (or error terms) have a constant variance. If this is not the case (for example, if the variance increases as the value of the dependent variable increases), then the error terms are said to be heteroskedastic. If this heteroskedasticity is not corrected for, then the statistical results may not be valid.

05 / A first look at the evidence: descriptive statistics

5.1 Introduction

This section presents descriptive statistics which explore patterns of IPR ownership by firms in Europe. In particular, it first focuses on whether IPR-owning firms exhibit significant differences compared to firms that do not own IPR, in terms of key financial and company variables, including revenue and number of employees. Next, it investigates how IPR ownership depends on firms' characteristics. The analysis relies on cross-tabulations to study how IPR ownership varies across large firms and SMEs, firms in different sectors, and younger and older firms. In addition, this section will also analyse the average stocks of IPRs and compare them across firm types.

As explained in Chapter 4, the statistics reported in this section are based either on the reduced sample or on the randomised sample for the year 2010, whichever is more appropriate depending on the context. More specifically, the reduced sample is used when it is important to stress the distribution between owners and non-owners of IPRs. The randomised sample is not suitable for this purpose because, by construction, it contains roughly equal proportions of owners and non-owners.

On the other hand, since the reduced sample may be biased towards particular countries in which the number of SMEs is likely to be under-reported, when reporting on characteristics of IPR owners only, the descriptive statistics are based on the randomised sample (which accounts for this potential bias).

Furthermore, the number of firms may vary throughout the tables since not all variables are available for all firms.

5.2 Key financial and company variables

Table 6 summarises the key financial and company variables of the randomised sample (revenue per employee, number of employees, wages and age), broken down by owners and non-owners of IPRs and also by type of IPR. Significance tests were conducted to determine whether the mean values of interest between the group of owners and the group of non-owners were significantly different for each type of IPR. The results of these statistical tests show that:

- revenue per employee is significantly greater for owners than for non-owners of IPRs; when considering all IPRs, revenue per employee is 28.6 per cent higher for IPR owners than for non-owners.[26] The premium in the case of patents, trade marks and designs is 25.7 per cent, 29.5 per cent and 31.4 per cent, respectively;[27]
- owners of patents, trade marks and/or designs have a greater number of employees than non-owners do (employing at least 5.8 times the number of people compared to non-owners);
- employees of companies that own patents, trade marks and/or designs earn higher wages than those that work for companies that do not own these types of IPR (by 19.8 per cent on average). Here, the strongest effect is associated with owning patents (40.6 per cent), followed by designs (23 per cent) and trade marks (18.8 per cent); and
- owners of patents, trade marks and designs are older than non-owners, with an average age of 26.9 years compared to 20.9 years for non-owners.

26 The revenue-per-employee premium for all IPR owners was calculated as follows: Premium = ((290.1-225.5)/225.5)* 100 = 28.6 per cent. Premiums for other variables and individual IPRs were calculated in a similar manner.

27 Note that the difference in revenue per employee premium between IPR owners and IPR non-owners is not equal to a weighted average of the premiums for trade marks, patents and designs. The reason is that the owner and non-owner groups are different for each IPR or combination of IPRs.

Table 6: Average values of selected variables by IPR ownership (randomised sample)

		Number of employees	Revenue per employee (EUR/year)	Wages per employee (EUR/year)	Age (years)
Non-owners of IPR		93.6	225 540	37 996	20.9
IPR owners	**All IPRs**	547.3	290 106	45 520	26.9
	% difference compared to non-owners	484.6%***	28.6%***	19.8%***	28.6%***
	Patents	1 537.6	283 567	53 424	34.0
	% difference compared to non-owners	1 542.6%***	25.7%***	40.6%***	62.5%***
	Trade marks	569.9	292 011	45 139	26.8
	% difference compared to non-owners	508.8%***	29.5%***	18.8%***	28.4%***
	Designs	2 103.1	296 316	46 747	33.9
	% difference compared to non-owners	2 146.7%***	31.4%***	23.0%***	62.2%***

Note: Age is defined at 2013 according to the date of incorporation reported by ORBIS. The asterisks denote that the null hypothesis that the group means are equal is rejected at the 10 per cent (*), 5 per cent (**) or 1 per cent (***) significance level.[28] The group of 'All IPRs owners' is defined as firms that owned at least one patent, trade mark or design, or any combination thereof. The groups of ‚Patent owners', 'Trade mark owners' and 'Design owners' are defined as firms that owned at least one of the particular IPRs. Since many firms owned combinations of the three IPRs, the various groups of IPR owners overlap.

28 Significance tests are used to calculate the probability that the observed difference could have come about merely by chance (and therefore does not reflect a real difference between owners and non-owners). If the calculated probability is less than 1 per cent, then the result (that is, the observed difference) is said to be significant at the 1 per cent level. If the probability is between 1 per cent and 5 per cent, then the result is significant at the 5 per cent level, and if it is between 5 per cent and 10 per cent, then the result is significant at the 10 per cent level.

The results presented above are based on the randomised sample. Annex 8.3 shows the results for the reduced sample (which is larger but biased in respect of SMEs). The revenue per employee of all types of IPR owners is greater in the reduced sample, while there is relatively little difference in the case of non-owners. By contrast, the number of employees is lower for owners in the reduced sample, while wages are higher.

Nonetheless, there is significant consistency between the two samples in terms of the results of significance tests on the difference between owners and non-owners. Indeed, each of the differences that were found to be significant in the randomised sample is also significant in the reduced sample, with the exception of differences for wages in the case of design owners.

5.3 IPR ownership by firm characteristic

5.3.1 IPR ownership by sector (NACE category)

Table 7 presents differences in the ownership of IPRs depending on the main activity of firms, as defined by NACE section classification.

Table 7: IPR ownership by NACE category (randomised sample)

NACE section	Non-owner (%)	Patent owner (%)	Trade mark owner (%)	Design owner (%)
C: Manufacturing	**17.2**	**66.8**	**32.6**	**58.8**
D: Electricity, gas, steam and air-conditioning supply	0.6	0.5	0.7	0.2
E: Water supply; sewerage, waste management and remediation activities	0.7	0.6	0.6	0.2
F: Construction	**13.1**	**3.6**	**4.6**	**2.8**
G: Wholesale and retail trade; repair of motor vehicles and motorcycles	**23.6**	**10.5**	**23.2**	**21.5**
H: Transportation and storage	5.0	0.8	2.3	0.8
I: Accommodation and food service activities	4.6	0.2	2.8	0.8
J: Information and communication	4.2	2.6	7.7	2.6
K: Financial and insurance activities	6.0	1.2	4.2	2.0
L: Real-estate activities	4.8	0.8	2.5	0.8
M: Professional, scientific and technical activities	**8.5**	**9.3**	**9.1**	**5.7**
N: Administrative and support service activities	4.8	1.7	4.7	1.9
O: Public administration and defence; compulsory social security	0.1	0.1	0.1	0.0
P: Education	0.8	0.1	0.8	0.1
Q: Human health and social work activities	2.8	0.4	1.4	0.3
R: Arts, entertainment and recreation	1.1	0.3	1.4	0.9
S: Other service activities	1.9	0.5	1.3	0.5
Total	**100.0**	**100.0**	**100.0**	**100.0**

Number of firms = 132 277.

The four largest sectors in the sample are manufacturing, construction, wholesale and retail and professional, scientific and technical services. The results show that manufacturing firms represent only one-third of firms that own trade marks but almost two-thirds of the firms that own patents. Construction represents a (relatively) small fraction of owners for all three IPRs (between 2.8 and 4.6 per cent of owners in each group). Compared to other sectors, the wholesale and retail trade sector owns relatively many trade marks and designs (23.2 and 21.5 per cent of trade mark owners and design owners, respectively), but owns less patents (10.5 per cent of patent owners). Similarly, professional services firms ("professional, scientific and technical activities") own trade marks and patents (9.1 and 9.3 per cent), but represent a smaller fraction of design owners (5.7 per cent).

5.3.2 IPR ownership by firm size

In addition to understanding differences in IPR ownership between firms with varying revenue, it is also important to understand whether there are differences between SMEs and large firms, in terms of:

- ➔ the extent to which IPRs are owned;
- ➔ the types of IPR that are typically owned; and
- ➔ the extent to which European rather than national rights are used.

Table 8: IPR ownership by firm size (reduced sample)

		Large (%)	SME (%)	Overall (%)
IPR non-owner		59.7	90.9	89.9
IPR owner		40.3	9.1	10.1
		100.0	100.0	100.0
Patent	Patent non-owner	89.6	99.2	98.9
	NAT only*	3.2	0.5	0.5
	EUR only	1.9	0.1	0.2
	NAT & EUR	5.3	0.2	0.3
		100.0	100.0	100.0
Trade mark	Trade mark non-owner	61.9	91.4	90.5
	NAT only	21.0	7.3	7.7
	EUR only	2.1	0.3	0.4
	NAT & EUR	15.0	1.0	1.4
		100.0	100.0	100.0
Design	Design non-owner	93.6	99.3	99.2
	NAT only	3.0	0.5	0.6
	EUR only	1.6	0.1	0.2
	NAT & EUR	1.8	0.1	0.1
		100.0	100.0	100.0

Number of firms = 2 364 063.

* 'NAT only' indicates that the firm owns national patents and not European patents. It can nonetheless own other types of IPR, such as trade marks or designs.

Table 8 shows a number of interesting results:

- a considerable number of firms (89.9 per cent) do not own any of the three IPRs;
- a greater proportion of SMEs are non-owners of all three IPRs than are large firms (90.9 per cent of SMEs versus 59.7 per cent of large companies);
- in other words, only 9 per cent of SMEs own any kind of IPR.

Looking at the ownership of individual IPRs, one can see that 38.1 per cent of all large companies and 8.6 per cent of all SMEs own trade marks. Moreover, only 0.8 per cent of SMEs are relying on patents and 0.7 per cent on design rights, whereas 6.4 percent of large companies own designs and 10.4 per cent own patent rights. It should again be stressed that companies that are not the formal owners of IPRs can still use IPRs. For example, a company that is part of a company group may not be the entity within the group that formally owns the IPRs, but still actually use them.

In Table 9, the randomised sample is used to compare IPR owners across SMEs and large companies.

Table 9: IPR ownership by firm size, IPR owners only (randomised sample, 2010)

Type of IPR	Use by geography	Large (%)	SME (%)	Overall (%)
Patent	NAT only*	33.4	61.0	48.5
	EUR only	16.2	17.0	16.6
	NAT & EUR	50.4	22.1	34.9
		100.0	100.0	100.0
Trade mark	NAT only	51.3	79.9	73.2
	EUR only	6.5	5.7	5.9
	NAT & EUR	42.1	14.5	20.9
		100.0	100.0	100.0
Design	NAT only	25.8	55.3	44.1
	EUR only	55.0	37.0	43.8
	NAT & EUR	19.2	7.8	12.1
		100.0	100.0	100.0

Number of firms = 63 338.

* 'NAT only' indicates that the firm owns national patents and not European patents. It can nonetheless own other types of IPR, such as trade marks or designs.

First, note that of all the firms that own patents, SMEs own national rights more frequently than large companies. For example, whereas 61 per cent of patent-owning SMEs own exclusively national patents, only 33.4 per cent of large patent-owning companies do so (alone or possibly in combination with trade marks and/or designs). It is also noteworthy that, in their respective groups, the share of large firms owning combinations of national and European IPRs is larger than the share of SMEs. For example, in the case of trade marks 42.1 per cent of large trade mark-owning companies own national and European trade marks, whereas only 14.5 per cent of SMEs do so. In the case of patents, 50.4 per cent of large companies own European and national patents, compared to 22.1 per cent of SMEs. In the case of designs, 19.2 per cent of large firms own both European and national designs, versus 7.8 per cent of SMEs.

Yet another characteristic of IPR ownership by firm size is shown in Table 10. This table is based on the randomised sample and presents the types of IPR that are owned by large companies and SMEs, and whether these IPRs are owned in isolation or in combination with other IPRs.

Table 10: IPR ownership by type of IPR, IPR owners only (randomised sample)

Type of IPR	Large (%)	SME (%)	Overall (%)
Patent only	5.1	4.8	4.8
Trade mark only	62.1	81.5	77.2
Design only	0.5	1.8	1.5
Patent and trade mark	16.4	6.0	8.3
Patent and design	0.5	0.4	0.4
Trade mark and design	5.8	3.7	4.2
Patent, design and trade mark	9.5	1.9	3.6
	100.0	100.0	100.0

Number of firms = 63 338.

Note that amongst IPR owners, firms make most use of trade marks as stand-alone rights (81.5 per cent of all SME IPR owners and 62.1 per cent of all large firms that own IPR). Another interesting fact is that large companies own different IPR types more often in combination than SMEs. For example, 16.4 per cent of large companies that own IPRs own a combination of patents and trade marks, and 9.5 per cent own a combination of patents, designs and trade marks. Overall, only 16.6 per cent of all firms rely on a combination of different types of IPR: 32.3 per cent of large firms and only 12.0 per cent of SMEs.

5.3.3 IPR ownership by revenue per employee

Table 11 distinguishes groups of firms in five equally-sized categories, from low (1) to high (5) according to their revenue per employee.

Table 11: Ownership of IPR by revenue per employee (reduced sample)

		Category of firm according to revenue per employee					
		1 (lowest) (0-20%) (%)	2 (20-40%) (%)	3 (40-60%) (%)	4 (60-80%) (%)	5 (highest) (80-100%) (%)	Overall (%)
IPR non-owner		92.9	90.5	89.1	85.9	82.4	88.2
IPR owner		7.1	9.5	10.9	14.1	17.6	11.8
		100.0	100.0	100.0	100.0	100.0	100.0
Patent	Patent non-owner	99.7	99.6	98.9	97.8	97.7	98.7
	NAT only*	0.2	0.3	0.6	1.0	1.0	0.6
	EUR only	0.1	0.0	0.1	0.4	0.5	0.2
	NAT & EUR	0.1	0.1	0.3	0.8	0.9	0.4
		100.0	100.0	100.0	100.0	100.0	100.0
Trade mark	Trade mark non-owner	93.1	90.9	89.7	86.7	83.3	88.7
	NAT only	6.4	8.2	8.6	9.9	11.9	9.0
	EUR only	0.2	0.2	0.4	0.7	0.9	0.5
	NAT & EUR	0.4	0.7	1.4	2.7	3.9	1.8
		100.0	100.0	100.0	100.0	100.0	100.0
Design	Design non-owner	99.7	99.5	99.1	98.4	98.2	99.0
	NAT only	0.2	0.4	0.7	0.9	1.0	0.7
	EUR only	0.0	0.1	0.1	0.3	0.5	0.2
	NAT & EUR	0.0	0.0	0.1	0.3	0.3	0.2
		100.0	100.0	100.0	100.0	100.0	100.0

Number of firms = 1 456 125.

* 'NAT only' indicates that the firm owns national patents and not European patents. It can nonetheless own other types of IPR, such as trade marks or designs.

The percentage of companies owning IPRs increases as revenue per employee increases. There are 17.6 per cent IPR owners in the highest quintile of revenue per employee and only 7.1 per cent in the lowest one. This pattern emerges in the case of patents, trade marks, or designs. It is also observed for national rights only, European rights only, or a combination of both. Thus, in the case of trade marks, in the highest revenue/employee category, 16.7 per cent of firms are owners, compared to 6.9 per cent in the lowest category; for patents, the respective percentages are 2.3 and 0.3; and for designs, 1.8 and 0.3.

Table 12 shows the same information as Table 11, but for IPR owners only.

Table 12: Ownership of IPR by revenue per employee, IPR owners only (randomised sample)

		Category of firm according to revenue per employee					
Type of IPR		**1 (lowest) (0-20%)** (%)	**2 (20-40%)** (%)	**3 (40-60%)** (%)	**4 (60-80%)** (%)	**5 (highest) (80-100%)** (%)	**Overall** (%)
Patent	NAT only*	64.6	57.8	48.1	44.1	41.4	47.3
	EUR only	17.9	15.9	15.4	16.4	19.9	16.9
	NAT & EUR	17.5	26.3	36.5	39.4	38.6	35.8
		100.0	100.0	100.0	100.0	100.0	100.0
Trade mark	NAT only	88.5	79.2	67.8	63.9	66.1	71.4
	EUR only	3.1	5.1	6.3	6.9	6.8	5.9
	NAT & EUR	8.3	15.6	25.9	29.1	27.1	22.7
		100.0	100.0	100.0	100.0	100.0	100.0
Design	NAT only	69.4	54.1	40.5	32.9	35.8	41.0
	EUR only	25.5	33.3	44.9	53.6	51.9	46.1
	NAT & EUR	5.1	12.6	14.6	13.6	12.3	12.9
		100.0	100.0	100.0	100.0	100.0	100.0

Number of firms with patents = 6 202, with trade marks = 38 336 and with designs = 3 257.
*'NAT only' indicates that the firm owns national patents and not European patents. It can nonetheless own other types of IPR, such as designs or trade marks.

Firms in the higher quintiles of IPR owners tend to rely less on national IPRs only and more on European only or a mix of European and national IPRs. For example, 88.5 per cent of trade mark-owning firms in the lowest quintile own national trade marks only, 3.1 per cent own European trade marks only, and 8.3 per cent own European and national trade marks in combination. In contrast, 66.1 per cent of trade mark-owning firms in the highest quintile own national trade marks, 6.8 per cent own European trade marks and as many as 27.1 per cent own a combination of both.

Although this is not shown in the table, another finding is that firms with higher revenue per employee are less likely to own stand-alone patents, trade marks or designs than firms with lower revenue per employee, and more likely to own combinations of the three IPRs.

5.3.4 IPR ownership by firm age

As far as age of firms is concerned, four categories are distinguished: between 2 and 5 years, between 5 and 10 years, between 10 and 20 years, and older than 20 years.

Table 13 shows IPR ownership by firm age for the randomised sample. Two interesting facts can be seen in the table. First, younger firms own trade marks more than older firms. Furthermore, they are more likely to own trade marks as stand-alone rights (87.1 per cent of firms aged between 2 and 5 years that own IPRs own only trade marks; this is only 72.0 per cent for firms older than 20 years). Second, in their respective groups, the share of older firms owning combinations of various IPRs is higher than of younger ones (8.8 per cent of IPR-owning firms aged between 2 and 5 years and 21.1 per cent for firms older than 20 years owned combinations of IPR).[29]

Table 13: IPR ownership by age, IPR owners only (randomised sample)

Type of IPR	Between 2 and 5 years old (%)	Between 5 and 10 years old (%)	Between 10 and 20 years old (%)	More than 20 years old (%)	Overall (%)
Patent only	2.5	3.7	4.4	5.4	4.8
Trade mark only	87.1	85.6	81.4	72.0	77.2
Design only	1.6	1.5	1.6	1.4	1.5
Patent and trade mark	4.1	4.4	6.6	10.5	8.3
Patent and design	0.2	0.2	0.3	0.5	0.4
Trade mark and design	2.2	2.9	3.4	5.1	4.2
Patent, design and trade mark	2.3	1.6	2.2	5.0	3.6
	100.0	100.0	100.0	100.0	100.0

Number of firms = 63 330

Another interesting finding which is not shown in Table 13, is that, in the case of trade marks and designs, a larger proportion of older firms own national and European IPRs in combination compared with younger firms. In the case of patents this is reversed: younger firms tend to own national and European patents more in combination.

29 Looking at the reduced sample (not shown here), it can be observed that younger firms generally own IPRs less frequently than older firms: 6.1 per cent of firms aged between 2 and 5 years are owning IPRs, whereas 15.2 per cent of firms of 20 years and older own IPRs.

5.3.5 Average stock by firm size

Finally, Table 14 presents the average stock (counts) for each group of IPRs held by SMEs and large companies across Europe as a whole.

Table 14: Average stock (counts) by firm size, IPR owners only (randomised sample)

	EUR trade mark	NAT trade mark	EUR design	NAT design	EUR patent	NAT patent
Large	8.2	16.6	26.8	22.6	22.0	22.3
SME	2.5	3.4	9.2	13.2	2.9	3.8
Overall	4.9	6.5	18.0	16.0	14.1	12.2

Note: Number of firms: EUR trade mark = 14 272, NAT trade mark = 50 215, EUR design = 2 420, NAT design = 2 435, EUR patent = 4 318, NAT patent = 6 990.
The mean values have been calculated for the group of owners of the respective IPR. All non-owners of that IPR have been excluded from the calculation. For some countries particular types of IPR were not owned by the firms in the sample. For example, there was no Lithuanian firm which owned a European patent in 2010.

Overall, the stock of rights is largest in the case of design owners (on average 18.0 European design rights and 16.0 national design rights), followed by patent and trade mark owners. Interesting to note is that, on average, large companies own more rights than SMEs throughout all types of IPR and independently of geographical coverage. Overall, firms tend to have larger stocks of national than European IPRs, the only exception being large design-owning firms. The average stock of European-design-owning firms exceeds that of national-design-owning firms.

5.4 Summary

This section presents a first look at a newly constructed dataset, which is significantly larger than any other data source of this type currently available. The following descriptive statistics are most noteworthy:

- The revenue per employee of owners of IPRs (patents, trade marks and/or designs, national and/or European) is 28.6 per cent higher than of non-owners of IPRs. This IPR "revenue premium" is largest for design owners at 31.4 per cent, followed by trade mark and patent owners at 29.5 per cent and 25.7 per cent, respectively. All the differences found are statistically significant, meaning that they are very unlikely to have occurred purely by chance.

- IPR owners on average employ almost six times as many workers as non-owners. Also, wages paid by IPR owners are almost 20 per cent higher than by firms that do not own IPRs. In this case, the "wage premium" is highest for patents at 40.6 per cent, followed by designs at 23 per cent and trade marks at 18.8 per cent. Again, these differences are statistically significant.

- A considerable number of firms (89.9 per cent) do not own any of the three IPRs. Moreover, a greater proportion of SMEs are non-owners than are large firms (90.9 per cent of SMEs versus 59.7 per cent of large companies). In other words, only 9.1 per cent of SMEs own any of the three IPRs included in this study. Not owning IPRs does not necessarily mean that these firms do not use IPRs. They may use IPRs in their commercial activities, but formal ownership may be with other entities within the same company group structure.

- IPRs are mostly owned by manufacturing firms, although there are differences between IPRs. About one-third of trade mark owners are manufacturing firms, whilst manufacturing firms represent almost two-thirds of all patent owners. Next to manufacturing firms, firms in wholesale and retail trade constitute the largest group of trade mark and design owners.

- Firms in the top quintile (20 per cent) in terms of revenue per employee are more likely to own IPRs than firms in the lowest 20 per cent: 17.6 per cent versus 7.1 per cent. Among the IPR owners, firms in the top category of revenue per employee tend to rely more on European rights (often combined with national rights), while firms in the lowest category tend to own national rights.

- There are noticeable differences among IPR-owning firms in terms of ownership of particular IPRs, in terms of SMEs versus large companies owning IPRs and in terms of average stock (counts) of IPRs. On average, large companies own more IPRs of all three types than SMEs, independently of geographic coverage.

06 / IPRs and firm performance: econometric analysis

6.1 Introduction

This chapter further examines the link between IPRs and firm performance. In particular, econometric modelling is applied to estimate the relationship between firms' performance and their ownership of IPRs overall, but also the ownership of patents, trade marks and registered designs separately. Furthermore, the chapter explores the link between stocks of different types of IPR and the performance of the firms.

Applying econometric techniques to the dataset makes it possible to control for external influences on firms' performance to the greatest extent possible. Compared to previous studies, the data used in this study offers not only a wide geographical scope but also information on several registered IPR types and on the performance of a large number of firms over several years.

The focus in this chapter is on the results of the econometric analysis. Methodology is discussed only to the extent that it is necessary to understand the results. A deeper description of the methodology is contained in Annex 8.5.

6.2 Selection of variables

Econometric analysis consists in examining, using statistical techniques, the relationship between a variable whose movements the researcher seeks to explain (called the dependent variable) using a set of explanatory or independent variables.

This section describes the selection of the dependent variable and the independent variables.[30] Moreover, it provides descriptive statistics for the main variables used.

30 See Annex 8.5.1.2 for a detailed description and definitions of the variables.

Dependent variable

The purpose of this study is to analyse the relationship between IPRs and the performance of firms. Therefore, the dependent variable of the models needs to be an indicator of company performance. The ORBIS database described in Chapter 4 contains several potential candidates, including various measures of revenue, sales and profit or loss. Given that this study relies on data from several EU Member States, it is important that the basis on which the dependent variable is constructed is identical between countries over time as this will minimise the risk that weaknesses in the data lead to biased results. For this reason, various measures of profitability, which are often affected by accounting and tax considerations, were discarded in favour of **revenue** as the basis of the performance measure in the models. Given the substantial variation in revenue between firms of different sizes, the decision was made to transform the performance measure by dividing it by the number of the firm's employees.

Thus, **revenue per employee** (operating revenue per employee in a given year) is the measure of performance in the econometric models.

Explanatory variables

The differences between firms in their performance, as represented by revenue per employee, are then sought to be explained by a set of explanatory variables, which fall into two main categories:

- ➔ binary or dummy variables that indicate whether the firm owns IPRs (or whether the firm owns a particular type of IPR);
- ➔ quantity of IPRs owned by the firm.

With regard to measures of IPR ownership, the following dummy variables were constructed from the raw data:[31]

- ➔ **IPR owner:** takes the value 1 if the firm owns any type of IPR in any of the years, and 0 otherwise
- ➔ a set of dummy variables which indicates whether or not a firm owns a specific **combination of IPRs** in any of the years and which divides the sample into eight corresponding groups:
  - Patents only: takes the value 1 if the firm owns patents but no other type of IPR, and 0 otherwise
  - Trade marks only: takes the value 1 if the firm owns trade marks but no other type of IPR, and 0 otherwise
  - Designs only: takes the value 1 if the firm owns design rights but no other type of IPR, and 0 otherwise
  - Patents and trade marks: takes the value 1 if the firm owns patents and trade marks but not designs, and 0 otherwise
  - Patents and designs: takes the value 1 if the firm owns patents and designs but not trade marks, and 0 otherwise

31 Dummy or binary variables are variables which take a value of either zero or one. For example, a dummy variable indicating whether or not the company is domiciled in Spain would take a value of one for all Spanish companies and zero for all other companies.

- Trade marks and designs: takes the value 1 if the firm owns trade marks and designs but not patents, and 0 otherwise
- Patents, trade marks and designs: takes the value 1 if the firm owns all three types of IPR, and 0 otherwise
- No IPRs: takes the value 1 if the firm does not own any type of IPR, and 0 otherwise

➔ Stock measures of a particular form of IPR were also used, distinguishing between stock measures for European and national IPRs. As with the dependent variable, these explanatory variables of interest were transformed by dividing by the number of employees:

- **EU patent stock per employee:** number of European patents owned by the firm divided by the number of employees in a given year.
- **NAT patent stock per employee:** number of national patents owned by the firm divided by the number of employees in a given year.
- **EU trade mark stock per employee:** number of European trade marks owned by the firm divided by the number of employees in a given year.
- **NAT trade mark stock per employee:** number of national trade marks owned by the firm divided by the number of employees in a given year.
- **EU design stock per employee:** number of European design rights owned by the firm divided by the number of employees in a given year.
- **NAT design stock per employee:** number of national design rights owned by the firm divided by the number of employees in a given year.

In addition, so-called *control variables* were also used. These are variables which indicate, or control for, non-IPR factors which might affect company performance and which therefore need to be taken into account when analysing the relationship between performance and IPR ownership:

➔ **Country dummies:** the country in which the company is domiciled.
➔ **Sector dummies:** the sector in which the company is active (NACE sections).
➔ **Year dummies:** the year (to control for the effects of the economic cycle).
➔ **SME:** a dummy variable which takes the value 1 if the company is an SME, and 0 if the company is large.[32]
➔ **Age of company:** a variable that indicates the age of the company in the year 2013.[33]

32 Firms are classified as SMEs only if they were an SME for the whole period included in the analysis. If a company was 'large' for at least one year, it was treated as 'large' in the analysis.

33 The variable was calculated by subtracting the year of incorporation reported in ORBIS from the year at the point of analysis - 2013. There are a small number of observations that are particularly old, including one company that has an age of 813 years. ORBIS reports its date of incorporation to be 1200. A few other companies have an age of 300-400 years.

Descriptive statistics for main variables

The basic descriptive statistics for the dependent and explanatory variables are shown in Table 24 in Annex 8.5.1.2.

The dataset used for the regression analysis consists of 130 555 firms.[34] For each firm revenue and employment information is available for 5.4 years on average, yielding a total of 705 929 data points. The majority of the companies had revenue per employee per year of less than EUR 250 000, although a small fraction reported numbers in excess of one million. The mean value in the whole sample was EUR 263 800. On average, firms own more national than European IPRs per employee. For example, the average national trade mark stock for all firms in the sample is 9.4 trade marks per 100 employees, whereas it only amounted to 0.9 for European trade marks.

For technical reasons, the relationship between revenue per employee and the IPR-related variables (other than dummy variables) is most appropriately modelled by transforming the variables logarithmically, a common technique in econometric analysis.

34 Compared to Section 4 the number of firms has reduced from 132 277 to 130 555. The reason is that for some firms several revenue-per-employee observations were missing, either because there was data only for revenue or for employees (but not both), or because the reported number of employees was zero.

6.2.3 Model specifications

Annex 8.5 contains a full technical description of the model specifications that have been used and a description of several econometric challenges that were faced. Throughout all models a limited number of obvious firm-specific control variables were included that one would *a priori* expect to have an effect on company performance: industrial sector, Member State, firm type and the age of the company.[35] Time-specific effects which affect all firms in the same way, e.g. economic cycles, were also taken into account by including a variable for each time period.[36]

Using these control variables, two different model specifications were applied, each designed to analyse a different relationship.

1. **The relationship between the ownership of IPRs and firm performance:** in this specification the (log of) the revenue per employee is the dependent variable and the ownership or not of IPRs overall or specific IPRs is the key explanatory variable.

2. **The relationship between IPR stock and firm performance:** for the second set of regressions, variables of patent, design and trade mark stocks were constructed from the raw dataset. The stock measures the number of a particular form of IPR that was held by a firm in a given year. Separate stock measures were defined for European designs, national designs, European trade marks, etc., such that a total of six stock variables were constructed. As was done for the dependent variable, these key explanatory variables of interest were transformed by dividing by the number of employees and taking logarithms.

35 Due to data limitations it was not possible to use additional explanatory variables. While the ORBIS database contains a considerable amount of information, there are missing observations for many firms in several years, for many of the financial variables. If these few gaps are summed together, they considerably reduce the amount of information available and so would lead to many observations being lost.

36 As a robustness check pairwise interactions between Member States, industrial sectors and time variables have been included in all regression models to allow the economic cycles to vary by country and industry sector, as well as to allow country effects to vary by industry sector. Since the results did not change significantly, for the sake of simplicity and clarity these are not included in the final report.

6.3 Results

In this section the key results of the econometric modelling are presented using summary results tables. Qualitative interpretation of the results is provided. The following sub-section contains a brief explanation of how the results should be interpreted.

6.3.1 Interpreting regression results

To interpret the regression results presented in the tables below, a little background knowledge of econometrics and statistics is required. In this section, the necessary knowledge to understand the discussion that follows is provided.

Understanding coefficients

The tables containing the regression results consist of the following columns:

Variable	Coef

The "Variable" column contains the explanatory variables of the regression model. Explanatory variables are those factors that are believed to have an impact on the performance of the firm.

The "Coef" column shows the impact of each explanatory variable on the performance of the firm. A positive value for the coefficient means that an increase in the value of the variable improves the performance of the firm, whilst a negative coefficient means that an increase in the value of the variable weakens the performance. The greater the magnitude of the coefficient (either positive or negative), the greater the impact on the performance of the firm.

In the vast majority of the models, both the dependent variable and the measures of IPR are measured in logs. In these cases, the coefficient measures the elasticity of firm performance (revenue per employee) with respect to IPR stocks. In other words, the coefficient identifies the percentage change in revenue per employee given a one per cent change in the stock of IPRs. For example, a coefficient of 0.2 on a variable measuring the stock of national designs means that a 1 per cent change in the stock of national designs leads to a 0.2 per cent increase in revenue per employee, all else being equal.

It is important to note that not all variables have a statistically significant influence on the dependent variable, however. Statisticians and econometricians use significance tests to determine whether or not a particular explanatory variable has a statistically significant relationship to the dependent variable. The significance level indicates the probability of a false rejection of the null hypothesis, for example that the coefficient is different from zero, in a statistical test. In other words, it indicates the probability that the coefficient appears to be non-zero solely as a result of chance. In the tables of results, a single asterisk next to an entry in the "Coef" column indicates that the coefficient is significantly different from zero at the 10 per cent confidence level, whilst a double asterisk indicates that it is significant at the five per cent level and a triple asterisk indicates that it is significant at the one per cent level.

One can have greater confidence that the independent variable truly has an impact on the dependent variable if it is significant at the one per cent level than if it is significant at the five or even ten per cent level.

Dummy variables

Some of the variables included in the regressions are 'dummy variables', which take a value of either zero or one. For example, some of the models include a dummy variable that takes a value of one if the company owns IPRs (or, in some models, a specific type of IPR) and zero otherwise. Dummy variables are indicated by a ~ symbol in the results tables below.

Interpreting the coefficients on dummy variables is slightly more complex than is the interpretation of the coefficients on standard logarithmic variables. The coefficient on a dummy variable indicates the change in the performance of the firm, given a change in the value of the dummy variable from zero to one. For example, a positive and significant coefficient on the "IPR owner" dummy variable in a regression examining whether IPR owners exhibit superior performance to non-owners should be interpreted as follows:

> *IPR owners have higher revenue per employee compared to non-owners of IPRs, all else being equal.*

An added complication arises where dummy variables are used to indicate whether or not an application has one given characteristic from several characteristic options. In this case it is always necessary to omit one option from the regression, and hence the coefficients on the other dummies are interpreted relative to the omitted option. For example, data from numerous industrial sectors is included in the analysis. The regressions below include dummy variables for all industrial sectors except Manufacturing, and so a positive coefficient on, say, a dummy variable for the Construction sector should be interpreted as follows:

> *Relative to companies in the Manufacturing sector, companies based in the Construction sector have higher revenue per employee, all else being equal.*

It is also important to note that the dummy variables enter into the models without a logarithmic transformation. All the models with IPR dummies have the log-linear form. In such models, for a small change in log (y), the coefficients, when multiplied by 100, *approximate* well the percentage change in the dependent variable. However, as the change in log (y) becomes larger, the approximation $\% \Delta y \approx 100 * \Delta \log(y)$ becomes inaccurate. To obtain the exact percentage change in the predicted dependent variable, an additional calculation using properties of exponential and logarithmic functions is necessary: [37]

$$\% \Delta \hat{y} = 100 * [\exp(\hat{\beta}) - 1]$$

In the results tables below, the entry in the "Coef" column for all dummy variables presents this calculated marginal effect, not the coefficient.

37 See for example Wooldridge (2013).

6.3.2 IPR ownership and firm performance

The purpose of this first set of models is to analyse whether those companies that own formal IPRs exhibit superior economic performance to those that do not hold formal IPRs. The variables of interest in these models are dummy variables which take a value of either zero or one, indicating

- ➔ whether or not a company owns any form of IPR ("IPR owner"); and
- ➔ whether or not a firm owns a specific combination of IPRs ("Patents only", "Trade marks only", "Designs only", "Patents and trade marks", "Patents and designs", "Trade marks and designs", "Patents, trade marks and designs").[38]

IPR owners overall

The first set of results presented in Table 15 is based on a model (Model 1) in which a single dummy variable 'IPR owner' is added to the set of control variables to identify whether or not a company has ever owned any type of formal IPR protection. In Model 2, the 'IPR owner' dummy is replaced with a set of dummy variables that identify the specific combinations of formal IPRs that were owned by the firm during the period under consideration. In both cases, the marginal effect on the dummy variables indicates the percentage by which the revenue per employee of the relevant group of IPR owners exceeds that of non-owners. For example, in both models the negative coefficients of the SME variable (-27.23 and -27.69, respectively) indicate that, **all else being equal**, the revenue per employee of small and medium-sized enterprises is lower than that of large firms.

38 The group of non-owners will serve as the base category and the "No IPRs" variable will therefore be omitted from the regressions.

Table 15: Results of models with IPR ownership dummies, all firms

	Model 1 (Coef))	Model 2 (Coef)
Dependent variable		
Log revenue per employee		
Explanatory variables		
IPR owner ~	27.97***	–
Patents only ~	–	15.30***
Trade marks only ~	–	29.91***
Designs only ~	–	14.62***
Patents and trade marks ~	–	16.83***
Patents and designs ~	–	15.03***
Trade marks and designs ~	–	38.53***
Patents, trade marks and designs ~	–	16.27***
Country dummies	Not reported°	Not reported
Sector dummies	Not reported	Not reported
Year dummies	Not reported	Not reported
SME ~	-27.23***	-27.69***
Age of company	<0.01***	<0.01**
Constant	5.04***	5.07***

Number of observations = 705 929 and number of firms = 130 555 for both models
Model 1 – R2 overall = 0.277; Prob > Chi2 = 0.000
Model 2 – R2 overall = 0.278; Prob > Chi2 = 0.000
~ = dummy variable; * = significant at the 10 per cent level; ** = significant at the 5 per cent level; *** = significant at the 1 per cent level.
° Country, sector and year dummy variables were included in the analysis as control variables. In order to maintain readability, these are not included in the table. The regression results can be provided on request.

The results in Table 15 clearly indicate that IPR owners have greater revenue per employee than do non-owners. All coefficients on the IPR-related dummy variables are positive and strongly significant. Overall, the revenue per employee of IPR owners is 28 per cent higher than of non-owners, but this average masks some significant differences between the different groups of IPR owners. In particular, the results suggest that trade mark owners exhibit an almost 30 per cent superior performance compared to non-owners. At the same time the revenue per employee of patents-only and trade marks-only owners exceeds that of non-owners by around 15 per cent.

There is also some suggestion of complementarity between IPRs: those firms that own a combination of different forms of IPR exhibit superior performance difference to those not owning IPRs and, on average, improve on the performance of at least the lowest-performing IPR in the combination. For example, firms that own both trade marks and designs have higher revenue per employee compared with those that own only trade marks or only designs. However, it is important to note that one cannot conclude on the basis of these findings that dropping one type of IPR from a worse-performing combination of IPRs would improve a firm's economic performance. Similarly, adding an IPR to another single IPR or combination of IPRs, would not improve performance. The results on performance essentially compare different groups of companies in the sample, which are characterised by ownership of specific IPRs.

SMEs and large companies

The descriptive statistics of IPR owners suggested that there are some significant differences between SMEs and larger firms. For this reason, results are also presented separately for SMEs and large companies.

The purpose of this analysis was to understand the extent to which the overall impact estimated above is consistent for firms of all sizes, and to what extent the relationship between IPRs and revenue per employee differs between SMEs and large companies.

The results presented in Table 16 indicate that there are significant differences between SMEs and large companies with respect to the relationship between IPR ownership and revenue per employee. In particular, the coefficients on the IPR dummy variables are significantly greater for SMEs than for large companies: **whereas SMEs that own IPRs have revenue per employee that is 32 per cent higher than non-owners, the equivalent statistic for large firms is 4 per cent.**

One possible explanation for this result may be that there is a fundamental difference between SMEs and large firms in terms of their propensity to use intangible assets,[39] for which the variables in the data were not able to control. Larger firms are more inclined to make use of intangible assets (see Arrighetti et al. (2014)). Therefore, Model 2 in Table 16, where only large firms are analysed, is likely to measure the difference in performance between large firms that own patents, designs or trade marks on the one hand and large firms that are relying on other types of formal (copyright) and/or informal (trade secrets) IPRs.

This is in contrast to the sample of SMEs, of which a considerable proportion does not invest in any types of intangible asset (either formal or informal) at all. Hence, in Model 1, the IP ownership variables are potentially capturing the difference in performance between SMEs that are innovative and rely on registered IPRs such as patents, trade marks and designs, and a group of firms that includes many non-innovative SMEs. Therefore, the observed coefficients of IPR ownership should be larger for SMEs than for large companies.

Furthermore, in Model 2, while all IPR-related variables are significant in the SME regressions, the picture is different for large companies. The results indicate that only large firms that own trade marks (and no other IPR) exhibit significantly higher revenue per employee than non-owners of IPRs. Moreover, the results suggest that large firms that own some specific combinations of IPRs (i.e. patents + trade marks, and patents + trade marks + designs) even have significantly lower revenue per employee than the group of firms that does not rely on IPRs.

A possible explanation would be the nature of the ORBIS data. Some large firms are subsidiaries of other companies, with those links not reported in ORBIS, so that some of the apparent non-owners of IPRs may in fact be benefiting from IPRs held by other entities in the group. Using the available data, the validity of neither of these hypotheses can be tested. Alternatively, this result may be driven by the inability to control for certain time-variant differences among firms, for example within industry clusters, that are correlated with IPR ownership variables.

---

39 Intangible assets consist of the stock of immaterial resources that enter the production process and are necessary for the creation and sale of new or improved products and processes (see Arrighetti et al., 2014). They can be internally produced or externally acquired assets and include formal as well as informal IPRs.

Table 16: Results of models with IPR ownership dummies by firm type

	SMEs		Large	
	Model 1 (Coef)	Model 2 (Coef)	Model 1 (Coef)	Model 2 (Coef)
Dependent variable				
Log revenue per employee				
Explanatory variables				
IPR owner ~	31.71***	–	4.04***	–
Patents only ~	–	15.99***	–	-0.25
Trade marks only ~	–	33.05***	–	8.44***
Designs only ~	–	17.23***	–	0.46
Patents and trade marks ~	–	20.78***	–	-5.56***
Patents and designs~	–	19.50***	–	-9.21
Trade marks and designs ~	–	47.60***	–	4.73
Patents, trade marks and designs ~	–	34.33***	–	-12.65***
Country dummies	Not reported°	Not reported	Not reported	Not reported
Sector dummies	Not reported	Not reported	Not reported	Not reported
Year dummies	Not reported	Not reported	Not reported	Not reported
Age of company	<0.01***	<0.01***	<0.01***	<0.01***
Constant	4.59***	4.60***	5.33***	5.38***

Number of observations = 575 565 and number of firms = 109 159 for both SME models
Number of observations = 130 364 and number of firms = 21 396 for both large companies models
SMEs model 1 – R2 overall = 0.268; Prob > Chi2 = 0.000 and SMEs model 2 – R2 overall = 0.269; Prob > Chi2 = 0.000
Large companies model 1 – R2 overall = 0.216; Prob > Chi2 = 0.000 and Large companies model 2 – R2 overall = 0.218; Prob > Chi2 = 0.000
~ = dummy variable; * = significant at the 10 per cent level; ** = significant at the 5 per cent level; *** = significant at the 1 per cent level.
° Country, sector and year dummy variables were included in the analysis as control variables. In order to maintain readability, these are not included in the table. The regression results can be provided on request.

Overall, this first set of econometric models has found that **IPR owners have higher performance in terms of revenue per employee than do non-owners, especially in the case of SMEs.**

6.3.3 Stocks of IPRs and firm performance

The results presented in the previous section showed that the performance of companies that own formal IPRs, as measured by their revenue per employee, is superior to that of non-owners. However, the models did not distinguish between IPR owners with respect to the number of rights held. For example, a company that holds one national design is treated in these models in an identical manner to a company that holds 300 national designs and 200 European designs. Therefore, in this section, the relationship between a firm's performance and the number of patents, designs or trade marks it holds is investigated.

The number of patents, designs and trade marks is measured using the 'stock' held at any given point in time. The stock is transformed by dividing by the number of employees and taking the logarithm, such that the coefficient captures the elasticity of revenue per employee with respect to the stock of IPRs per employee.

Separate variables in the models for national and European stocks are included, reflecting significant differences between national and European IPRs (not least the fact that national rights confer protection in a single country, whereas European designs and trade marks confer rights in all Member States and EPO-granted patents are typically validated in several countries).

Table 17 presents the results of a regression model based on both owners and non-owners of IPRs.[40]

40 Annex 8.5.2.2 presents the results based on owners of IPRs only, corrected for a possible sample selection bias. The results are similar to those presented in this section.

Table 17: Results of stocks of different IPRs, all firms

	Model 1 (Coef)
Dependent variable	
Log revenue per employee	
Explanatory variables	
Log EU patent stock per employee	0.18*
Log NAT patent stock per employee	0.46***
Log EU trade mark stock per employee	0.28***
Log NAT trade mark stock per employee	0.52***
Log EU design stock per employee	0.01
Log NAT design stock per employee	0.07***
Year dummies	Not reported°
Constant	4.97***

Number of observations = 705 929 and number of firms = 130 555 for all firms model
Model based on owners and non-owners – R2 within = 0.03 Prob > F = 0.000
~ = dummy variable; * = significant at the 10 per cent level; ** = significant at the 5 per cent level; *** = significant at the 1 per cent level.
° Year dummy variables were included in the analysis as control variables. In order to maintain readability, these are not included in the table. The regression results can be provided on request.

When interpreting the results it is important to recognise that both the dependent variable and the IPR variables are measured in logs. In these cases, the coefficient measures the elasticity of firm performance (that is, revenue per employee) with respect to IPR stocks per employee. In other words, the coefficient identifies the percentage change in revenue per employee given a one per cent change in the stock of IPRs per employee.

The results of the model presented in Table 17 indicate that larger stocks of European designs per employee are not necessarily associated with higher revenue per employee since the coefficient, although positive, is insignificant.[41] For other types of IPR there is evidence of a positive relationship between increases in the per-employee stock of IPRs and revenue per employee.[42] For example, all else being equal, an increase in the stock of national designs per employee by 1 per cent goes along with a 0.07 per cent increase in a firm's performance measure. In the case of national patent stocks per employee, the estimated elasticity is 0.46, and it is as high as 0.52 for national trade marks per employee. In the case of European patents and trade marks, the elasticity is 0.18 and 0.28, respectively.

41 Tests were conducted to check whether these insignificant results might be explained by multicollinearity, but no evidence was found of correlation among the continuous explanatory variables for the whole sample.

42 Models with quality-weighted stocks of European patents were also assessed, using an index which incorporated the key variables suggested in the survey of the literature conducted by the OECD (Squicciarini et al., 2013). The results of these models which are presented in 8.5.3 were almost identical to those of the models where a simple count of European patents was used.

Box 3: How do the results compare with other studies?

As noted by Munari (2012), prior research has found mixed results on the impact of patent counts on firm performance. While some papers found that the number of patents has a positive influence on performance (Bloom and Van Reenen, 2002; Ernst, 1995, 2001; Helmers and Rogers, 2011; Lerner and Zhu, 2007; Kim et al., 2012), others have found the opposite and still others have found no relationship between patent counts and economic performance (Cheng et al., 2010; Coombs and Bierly, 2006).

With respect to trade marks, Greenhalgh and Rogers (2011) found a positive correlation between trade marks and performance, while Helmers and Rogers (2011) found that trade marks have a positive association with survival and firm growth.

With respect to designs, Bascavusoglu-Moreau and Tether (2011) found a positive association between sales per employee and UK designs, but no significant association for European designs.

Differences between SMEs and large companies

Similarly to the previous section, results of models based on sub-samples of SMEs and large companies are presented in Table 18.

Table 18: Models of IPR stocks by firm type

	SMEs (Coef)	Large companies (Coef)
Dependent variable		
Log revenue per employee		
Explanatory variables		
Log EU patent stock per employee	0.19*	0.30
Log NAT patent stock per employee	0.49***	0.27
Log EU trade mark stock per employee	0.31***	-0.10
Log NAT trade mark stock per employee	0.53***	0.54***
Log EU design stock per employee	0.00	0.11
Log NAT design stock per employee	0.07***	0.12
Year dummies	Not reported°	Not reported
Constant	4.89***	5.34***

Number of observations = 575 565 and number of firms = 109 159 for SMEs model
Number of observations = 130 364 and number of firms = 21 396 for large companies model
SMEs model – R2 within = 0.03 Prob > F = 0.000
Large companies model – R2 within = 0.05 Prob > F = 0.000
~ = dummy variable; * = significant at the 10 per cent level; ** = significant at the 5 per cent level; *** = significant at the 1 per cent level.
° Year dummy variables were included in the analysis as control variables. In order to maintain readability, these are not included in the table. The regression results can be provided on request.

The results in Table 18 show that increases in IPR stocks per employee have a positive and significant association with revenue per employee for SMEs, with the exception of European designs. By contrast, only the coefficient on national trade marks is positive and significant for large companies: all other coefficients on the IPR variables are insignificant. These results are consistent with the findings in previous sections.

Box 4: How do the results compare with other studies?

There is scant literature on the relationships between firm size, IPR ownership and economic performance. However, Munari and Santoni (2010) and Helmers and Rogers (2011) both find that patenting SMEs tend to perform better than their non-patenting counterparts. Munari (2012) interprets these findings as an indication that IPR give SMEs a competitive advantage.

6.4 Conclusions of the econometric analysis and discussion

Overall, the econometric analysis has led to the following key findings:

- **IPR owners perform better than non-owners.** Overall, revenue per employee is approximately 28 per cent higher for IPR owners than for companies that do not own IPRs.

  This relationship is particularly pronounced for small and medium-sized enterprises (SMEs): SMEs that own IPRs have almost 32 per cent higher revenue per employee than SMEs that do not own IPRs at all. In the case of large companies, revenue per employee is 4 per cent higher for IPR owners than for non-owners.

- **Increases in both European and national IPR stocks are associated with improved performance of the firm.** A 10 per cent increase in the stock of European trade marks of a firm is associated with a 2.8 per cent increase in revenue per employee, and a 10 per cent increase in the stock of national trade marks is associated with a 5.2 per cent increase. For patents, a 10 per cent increase in the stock of patents leads to a 1.8 per cent increase in the case of European rights and to a 4.6 per cent increase in the case of national rights. For national designs the analysis suggests that a 10 per cent increase in stock is associated with a 0.7 per cent increase in performance. For European designs the econometric analysis could not establish a statistically significant relationship, which means that it is not possible to state with more than 90 per cent confidence that there is a relationship between increases in a company's stock of the relevant IPRs and its economic performance.

- **Increases in firm performance depend on type and combination of IPRs.** The highest revenue-per-employee increases are linked to trade mark-only and combined trade mark and design owners: 30 per cent and 39 per cent, respectively. Patent-only owners have 15 per cent higher revenue per employee, design-only owners 15 per cent, patent-and-trade mark owners 17 per cent, patent-and-design owners 15 per cent and owners of all three IPRs 16 per cent.

Although due care was applied in all phases of the research, some methodological choices, necessary in all applied research, may potentially bias the econometric results.[43] The overall direction and exact size of those biases are hard to estimate. In any case, they should not impact the sign and the order of magnitude of the IPR coefficients.

Furthermore, it is important to note, that although the econometric analysis was able to show strong and significant correlation between the variables of interest, given the available data a causal link between IPR ownership and firm performance cannot be established. Previous studies (see O'Mahony and Vecchi, 2009, or Marrocu et al., 2011) have shown that there is a positive influence of intangible assets on firms' performance. Intangible assets can be protected by formal, registered IPRs or by other informal forms of protection that did not manifest itself in the IPR registries. It is likely that firms that use formal IPR protection also invest more in intangible assets and innovate more than firms that do not use formal IPR protection.

In addition, it cannot be ruled out that the IPR measures in the models are correlated with some omitted variable representing the propensity to invest in intangible assets, which cannot be observed in the data. As a result of this possible omitted variable bias, IPR coefficients estimated in econometric models capture not only the effect of the use of formal IPRs for intangible assets protection, but also the positive effect of those intangible assets themselves. The result that the relationship is found to be stronger for SMEs than for large companies is consistent with this hypothesis. Most large companies rely in some way or another on intangible assets, whereas many smaller firms often build their business on tangible assets alone. Trade marks, designs and patents provide legal protection for specific but not all types of intangible asset. Hence, the group of large firms not owning these particular forms of IPR may consist of firms that generate other types of intangible asset (e.g. copyrights or trade secrets) and therefore exhibit high economic performance. In contrast, the group of SMEs not owning trade marks, patents or designs is likely to consist of many companies that do not own any intangible assets at all.

An alternative reasoning suggesting a different causal relationship cannot be ruled out. The positive relationship between IPR ownership and performance could also stem from a possible impact of higher revenue per employee on the ownership of registered IPRs. Firms that already enjoy high revenue without using formal IPRs could decide to start using trade marks, patents, or designs to protect their future returns and to secure income with enforceable and tradable rights.

Nonetheless, economic theory provides a number of arguments that can support the claim of IPRs' positive impact on firm performance. IPRs provide incentives that increase a firm's propensity to engage in innovative activity. By providing legal certainty, IPRs promote licensing activity and enable firms to increase their revenue without the necessity to expand their production capabilities. Patents, trade marks and designs guarantee the right to exclude competitors and reduce competitive pressure on their owners, thus leading to higher revenue and profits. These hypotheses, however, cannot be exhaustively tested with the data at hand.

43 See Annex 8.1 for a discussion on how dataset construction choices can possibly affect the results.

07 / Conclusions of the study

The main contribution of this study lies in the construction and subsequent analysis of a unique and very large dataset with financial information and IPR data at the firm level.

The overarching result of this analysis is that the **ownership of IPRs, specifically patents, trade marks and designs, is strongly associated with improved economic performance at the level of the individual company. This association is especially strong in the case of SMEs.**

In particular, the descriptive statistics in Chapter 5 show that:

- First, revenue per employee for owners of IPRs (patents, trade marks and/or designs, national and/or European) is 28.6 per cent higher than for non-owners of IPRs. This IPR "revenue premium" is largest for design owners at 31.4 per cent, followed by trade mark owners at 29.5 per cent and patent owners 25.7 per cent. All the differences found are statistically significant, meaning that they are very unlikely to have come about purely by chance.
- Second, IPR owners on average employ almost six times as many employees as non-owners. Also, wages paid by IPR owners are almost 20 per cent higher than by firms that do not own IPRs. In this case, the "wage premium" is highest for patents at 40.6 per cent, followed by designs at 23.0 per cent and trade marks at 18.8 per cent. Again, these differences are statistically significant.
- Third, a considerable number of firms (89.9 per cent) do not own any of the three IPRs. Moreover, a greater proportion of SMEs than large firms are non-owners (90.9 per cent of SMEs versus 59.7 per cent of large companies). In other words, only 9.1 per cent of SMEs own any of the three IPRs included in this study, but 40.3 per cent of large firms do. This does not imply that 59.7 per cent of large companies do not use IPRs in their commercial activities. They may use IPRs, but not be the formal owners – if part of a larger group structure, IPR ownership may be with other entities within the group.
- Fourth, IPRs are mostly owned by manufacturing firms, although there are differences between IPRs. About one-third of trade mark owners are manufacturing firms, whilst they represent almost two-thirds of all patent owners. Besides manufacturing firms, firms in wholesale and retail trade constitute the highest group of trade mark and design owners.
- Finally, there are noticeable differences among IPR-owning firms. Those differences are particularly notable in comparisons between SMEs and large companies as regards average stock (counts) of IPRs. On average, large companies own more rights than SMEs, independent of the type of right. Compared to large companies, SMEs tend to use national rights more often than European rights, and they have a relatively greater reliance on trade marks.

The econometric analysis in Chapter 6 confirms the link between ownership of IPRs and economic performance of companies. In particular, companies that own IPRs were found to have 28 per cent greater revenue per employee than companies that do not own IPRs, supporting the indicative result from the descriptive statistics. Thus, while a cause-and-effect relationship has not been proven, there is a strong indication that such a relationship might exist.

Table 19: IPR ownership and revenue per employee, all firms and SMEs* (difference between owners of the respective IPRs and non-owners)

IPR or combination	All firms*	SMEs
IPR owner ~	28%	32%
Patents only ~	15%	16%
Trade marks only ~	30%	33%
Designs only ~	15%	17%
Patents and trade marks ~	17%	21%
Patents and designs~	15%	20%
Trade marks and designs ~	39%	48%
Patents, trade marks and designs ~	16%	34%

*Based on Tables 15 and 16 of the econometric analysis

Furthermore, **this positive relationship between IPR ownership and revenue per employee is particularly strong for SMEs.** As shown by the results reported in Table 19, SMEs that own IPRs have 32 per cent higher revenue per employee than SMEs that do not. In addition, these results hold for all three IPRs under study and for combinations of those IPRs.

Specifically, SMEs that own patents have only 16 per cent higher revenue per employee than non-owners of IPR. In the case of trade marks, this "performance premium" is 33 per cent, in the case of designs it is 17 per cent. SMEs that own patents in combination with trade marks have a performance premium of 21 per cent compared with non-owners, while those that own patents and designs have a 20 per cent premium. Finally, SMEs that own trade marks and designs enjoy a premium of 48 per cent while those that own all three IPRs have a premium of 34 per cent. Across all individual IPRs and all combinations of IPRs, these performance premiums are larger in the case of SMEs than in the case of all companies (see Table 19). Moreover, the fact that the firms that own a combination of IPRs often perform even better than those that own just one of these rights is an indication that IPRs complement each other. This "combination bonus" is particularly large for SMEs.

When examining the effect of increasing the stock of IPRs in companies that already own those rights, it was found that **increases in both European and national IPR stocks per employee are associated with the improved performance of the firm.** A 10 per cent increase in the stock of European trade marks of a firm is associated with a 2.8 per cent increase in revenue per employee,

a 10 per cent increase in the stock of national trade marks is associated with a 5.2 per cent increase, while for patents a 10 per cent increase in the stock of national patents leads to a 4.6 per cent increase. For national designs the analysis suggests that a 10 per cent increase in stock is associated with a 0.7 per cent increase in performance. Again, this relationship was particularly pronounced for SMEs.

To sum up, this report has shown that companies in Europe that own any of the three IPRs examined in this study perform significantly better (+ 28 per cent) in terms of revenue per employee than companies that do not own these IPRs. Furthermore, companies that own IPRs on average employ far more workers and pay higher salaries than those that do not. Finally, while the vast majority of SMEs in Europe (9 out of 10) do not own any of the three IPRs analysed in this study, the positive relationship between IPR ownership and revenue per employee is particularly strong for SMEs: among SMEs, IPR owners have 32 per cent higher revenue per employee than non-owners.

08 / Annex

8.1 Data preparation process

Matching methodology

The methodology used to create the dataset for the present study was based on the methodology developed for the previous study on IPR-intensive industries published in 2013. The approach was modified to allow the inclusion of national filings.[44]

The first step in the data preparation process (name harmonisation) was carried out using an algorithm developed at the Catholic University Leuven (KUL) and further refined by the project team. The second part, the actual matching of the databases, was based on an original methodology developed by the project team. In order to overcome the inherent difficulties resulting from data inconsistencies (e.g. spelling, abbreviations, etc.) between different databases, firms were matched using name, legal form, postal code and other criteria.

It is worth mentioning that the matching process was not successful in all cases. A considerable number of IPRs are owned by physical persons that obviously do not have corresponding records in ORBIS. In addition, some name differences, even after using sophisticated algorithms, could not be uniformly normalised and matched to each other. There were also multiple matches in ORBIS to a unique record in IPR registries. Therefore, additional checks based on geographical location, legal form and the structure of economic groups were implemented in order to disambiguate the multiple matches. The matching algorithms were constructed in such a way as to reject a match when it could not be clearly confirmed that the matched records in the various datasets corresponded to the same company.

The analysis in this report is performed at the firm level, which is complicated by the fact that many companies are part of a group. Therefore, companies might enjoy the benefits of some IPRs that are held by a subsidiary, parent or sister company.[45] Conversely, some companies might own IPRs that are not exploited directly by themselves but by another company in their group. The decision was made to match the IPRs with their owners, regardless of the role played by the company within the economic structure of the group. There was one exception to this general rule. Within the matching process, where disambiguation between multiple matches was necessary to identify a unique ORBIS record, the domestic ultimate owner (DUO) information provided by ORBIS was used to assign IPRs to the company (subsidiary or parent) with the highest turnover. That procedure was

44 Further details of the matching methodology are provided in Appendix A.9 of the EPO/OHIM (2013) study on IPR-intensive industries.

45 During the econometric analysis the large companies sample has been reduced by removing those firms with non-owner status that were economically linked with the company that had IPRs in its portfolio. This procedure was applied to the data of 1 393 out of total 8 810 large companies with non-IP owner status in the sample. Identification of the economic group has been done on the basis of linkages with the same DUO parent.

used in very few cases. In particular, it was used when all ORBIS companies were subsidiaries of the same DUO and all other methods of disambiguation were not effective.[46]

The methodology used in the study allows for identification of owners of IP rights by company name, as it appears in the IP registers, and matches this name to the ORBIS database. ORBIS is the most extensive source of demographic and financial information of European firms available to researchers. However, there is not sufficient information in ORBIS to identify all beneficiaries/users of IP rights beyond their immediate owners.

Although the ORBIS database contains information on the economic links between companies (Domestic Ultimate Owner and Global Ultimate Owner) this information is not complete. In other words, there appear to be companies in ORBIS that are part of larger economic groups but for which ORBIS does not report ownership links.

Ownership links were taken into account as much as possible in the randomised sample that was used for all econometric models that form the core of this study (Chapter 6). This smaller sample was cleaned as much as possible, so that companies that are part of a larger group structure are considered as one entity. Thus, in the econometric analysis companies that could benefit from the IP rights owned by other entities in their group were not treated as the non-owners of IP rights. This cleaning process, however, could be done only partially for reasons explained above, and it is not feasible to carry it out on the larger sample of 2.3 million companies that is used for the descriptive statistics.

Although lack of sufficient information about the potential beneficiaries of IP rights affects both large companies and SMEs, the impact on the results for large companies is larger. Large companies are more likely than SMEs to set up branches in many European countries and group IP ownership in one entity that manages the whole IP portfolio. Although registered as an ownership of only one firm, this IP portfolio brings benefits to all the firms that are part of the economic group.

Economic analysis of the benefits accrued to all the IP users (owners, users and licensees) would potentially be more informative. However, there is no publicly available repository containing sufficient information on IP licensing. Therefore all economic studies similar to the present study, that are based on large samples of firms, are necessarily limited to the benefits of IP *ownership* rather than *use*.

The matching methodology combines European and national patent, trade mark and design data in a given country with financial information of companies that are located in that same country only. The decision to limit the analysis to European and home-country applications was driven by two factors: the efficiency of the matching algorithm and the quality of the data available for trade marks and designs. Matching all firms in the dataset with all IPR repositories available in the sample would have considerably increased the matching time and effort. However, it would not have provided complete information on the firms' IPR portfolios since many firms may have registered their IPR in countries which are outside the scope of the present study.

---

46 One possible alternative, based on ORBIS data availability, would be to use global ultimate owner (GUO) information. However, GUO owners could have their seat in countries not covered by available IPR data.

Additionally, the IPR dataset does not contain enough information on the trade mark or design priorities to be able to distinguish between, on the one hand, entirely novel IPR applications, and, on the other hand, applications for trade marks already registered in another country. This means that the same trade mark or design would be counted multiple times, if registered in different jurisdictions. To avoid this bias, it was decided to limit the matching exercise to only IPR applications in the country where the company has its headquarters and European IPRs. To follow a consistent approach and to avoid skewing the relative weights of different IPRs in each company's portfolio, only patents for companies located in the same country as the national IP office were included.[47]

Potential biases

As previously discussed, some IPR owners were not successfully matched with ORBIS records. Thus, companies that were in fact IPR owners may have been treated as though they did not have any intangible assets (false negative error). Another problem can be attributed to potential limitations stemming from the matching algorithm itself. There might be firms that filed for IPR protection in third countries, but that have no IPR activity in the home country and at the European level. Due to these effects it is likely that fewer IPR owners are observed in the dataset. Therefore, the differences in firm performance observed in the data and thus the coefficients of national IPR ownership variables could potentially be overstating or understating the true effect. Similarly, this feature of the matching process might cause a bias in the estimation of the relationship between IPR stocks and firm performance. In addition, since IPRs registered in third countries only are not captured, for some firms the national IPR stock variables in the dataset might be biased downwards. Therefore, the coefficients of national IPR stocks might overstate the real effect. However, these biases are likely to be fairly small since there should be relatively few such firms in the data.

47 For example, the information contained in the dataset for German companies contains European patents, Community Trade Marks (CTMs) and Registered Community Designs (RCDs), national patents, national trade marks and national designs granted by the German Patent and Trade Mark Office. It does not contain information on national rights held by German companies in other countries.

8.2 Codes used for expiration or lapse dates for national patents

AT	Code	Description	Frequency on PATSTAT[49]
AT	RER	CEASED AS TO PARAGRAPH 5 LIT. 3 LAW INTRODUCING PATENT TREATIES	39 874
AT	REN	CEASED DUE TO NON-PAYMENT OF THE ANNUAL FEE	32 873
AT	ELJ	ERRONEOUS LAPSE	24 184
AT	EELA	CANCELLED DUE TO LAPSE OF TIME	1 731
AT	ELA	EXPIRED DUE TO LAPSE OF TIME	1 529
AT	MM9K	LAPSE DUE TO NON-PAYMENT OF RENEWAL FEE	1 521
AT	RZN	PATENT REVOKED	1 288
AT	MN9K	CANCELLED DUE TO LAPSE OF TIME	617
AT	ELV	CEASED DUE TO RENUNCIATION	22
AT	EELV	LAPSED DUE TO WITHDRAWAL	13
AT	EN	DECLARATION OF NULLIFICATION	9
AT	A1WR	REVOCATION	6
AT	MA9K	LAPSE DUE TO RENUNCIATION	5
AT	RH	DECLARED NULL AND VOID	5
AT	EEN	DECLARATION OF NULLIFICATION	1
AT	EGA	DECISION OF GRANT WAS REVOKED	1
BE	RE	LAPSED	5 576
BE	RE20	PATENT EXPIRED	629
BE	ERE	LAPSED	14
BE	E20	PATENT EXPIRED	6
DE	8339	CEASED/NON-PAYMENT OF THE ANNUAL FEE	9 126
DE	R071	EXPIRY OF RIGHT	336
DE	R119	APPLICATION DEEMED WITHDRAWN, OR IPR LAPSED, DUE TO NON-PAYMENT OF RENEWAL FEE	301
DE	EHJ	CEASED/NON-PAYMENT OF THE ANNUAL FEE	92
DE	8139	DISPOSAL/NON-PAYMENT OF THE ANNUAL FEE	23
DE	R157	LAPSE OF IPR AFTER 6 YEARS	16
DE	R158	LAPSE OF IPR AFTER 8 YEARS	16
DE	8340	PATENT OF ADDITION CEASED/NON-PAYMENT OF FEE OF MAIN PATENT	15
DE	R123	APPLICATION DEEMED WITHDRAWN DUE TO NON-PAYMENT OF FILING FEE	10
DE	R156	LAPSE OF IPR AFTER 3 YEARS	10
DE	8136	DISPOSAL/NON-PAYMENT OF THE FEE FOR PUBLICATION/GRANT	9
DE	8361	NOTIFICATION OF GRANT REVOKED	8
DE	R142	LAPSE OF PATENT OF ADDITION DUE TO NON-PAYMENT OF RENEWAL FEES FOR PARENT PATENT	5
DE	EHZ	PATENT OF ADDITION CEASED/NON-PAYMENT OF ANNUAL FEE OF PARENT PATENT	3
DK	PBP	PATENT LAPSED	4 893
DK	PUP	PATENT EXPIRED	1 407
DK	AHB	APPLICATION SHELVED DUE TO NON-PAYMENT	129

48 The frequency was obtained based on entries in PATSTAT for each of the patenting authorities in all years. That is, the frequencies are not restricted to the period 2002-2010.

DK	**PSP**	PATENT SURRENDERED	38
DK	**PUG**	PATENT REVOKED	12
DK	**PHB**	APPLICATION SHELVED DUE TO NON-PAYMENT	5
DK	**UUP**	UTILITY MODEL EXPIRED	3
DK	**UBP**	UTILITY MODEL LAPSED	2
ES	**FD1A**	PATENT LAPSED	9 630
ES	**FD1K**	UTILITY MODEL LAPSED	3 349
ES	**FA2A**	APPLICATION WITHDRAWN	1 758
ES	**SA6**	EXPIRATION DATE (SNAPSHOT 920101)	771
ES	**FD2A**	ANNOUNCEMENT OF LAPSE IN SPAIN	385
ES	**MM4A**	PATENT LAPSED	365
ES	**FC2A**	GRANT REFUSED	192
ES	**FA1K**	APPLICATION WITHDRAWN	172
ES	**RD1A**	PATENT SEIZED	88
ES	**MM1K**	UTILITY MODEL LAPSED	38
ES	**SY**	EXPIRATION DATE (SNAPSHOT 920101)	33
ES	**RL2A**	ANNULMENT BY COURT DECISION	28
ES	**FC1K**	UTILITY MODEL REFUSED	25
ES	**MH1K**	ABANDONMENT	5
ES	**MH1A**	ABANDONMENT	2
ES	**SB3**	EXPIRATION DATE (SNAPSHOT 920101)	1
FR	**ST**	NOTIFICATION OF LAPSE	30 877
FR	**RG**	LIEN (PLEDGE) CANCELLED	45
FR	**D3**	DECISION TO REVOKE THE DECISION OF LAPSE	40
FR	**RT**	COMPLETE RENUNCIATION	6
GB	**PCNP**	PATENT CEASED THROUGH NON-PAYMENT OF RENEWAL FEES	88 465
GB	**PLNP**	PATENT LAPSED THROUGH NON-PAYMENT OF RENEWAL FEES	11 818
GB	**PE20**	PATENT EXPIRED AFTER TERMINATION OF 20 YEARS	9 173
GB	**773K**	PATENT REVOKED UNDER SECT. 73(2)/1977	649
GB	**PE**	PATENT EXPIRED	382
GB	**7732**	CASE DECIDED BY THE COMPTROLLER ** PATENT REVOKED (SECT. 73(2)/1977)	185
GB	**729U**	OFFER TO SURRENDER ACCEPTED BY THE COMPTROLLER (SECT. 29/1977)	30
GB	**SPCE**	SPC EXPIRED	27
GB	**433B**	CASE DECIDED BY THE COMPTROLLER ** PATENT REVOKED (SECT. 33/1949)	19
GB	**S29**	SURRENDER OF PATENT (SECT. 29/PAT. ACT 1977)	19
GB	**4333**	PROCEEDING TERMINATED BY SURRENDER OF PATENT UNDER SECTION 34 PATENTS ACT 1949	12
GB	**772R**	PATENT REVOKED (SECT. 72/1977)	9
GB	**772B**	CASE DECIDED BY THE COMPTROLLER ** PATENT REVOKED (SECT. 72/1977)	8
GB	**433**	PROCEEDING TERMINATED BY VOLUNTARY SURRENDER OF THE PATENT (SECT. 33/1949)	6
GB	**434I**	ORDER MADE REVOKING THE UNDERMENTIONED PATENT (SECT. 34/1949)	6
GB	**7B**	PATENT EXPIRED AFTER PROLONGATION OF 20 YEARS	4
GB	**434C**	PATENT REVOKED (SECT. 34/1949)	3
GB	**434D**	OFFER TO SURRENDER ACCEPTED ** PATENT REVOKED (SECT. 34/1949)	3

GB	**434B**	CASE DECIDED BY THE COMPTROLLER ** PATENT REVOKED (SECT. 34/1949)	2
GB	**434G**	PROCEEDING TERMINATED BY SURRENDER OF PATENT UNDER SECTION 34 PATENTS ACT 1949	2
GB	**731A**	CASE DECIDED BY THE COMPTROLLER ** PATENT REVOKED (SECT. 73(1)/1977)	2
GB	**773L**	PATENT REVOKED UNDER SECT. 73(1)/1977	2
GB	**775E**	PATENT REVOKED (SECT. 75/1977)	2
GB	**429X**	PATENT REVOKED (SECT. 29/1949)	1
GB	**430D**	PATENT REVOKED (SECT. 30/1949)	1
GB	**772D**	PROCEEDING TERMINATED BY VOLUNTARY SURRENDER OF PATENT (SECT. 72/1977)	1
GB	**7A**	PATENT REVOKED (SECT. 117/1977)	1
GB	**PR**	PATENT REVOKED	1
HU	**HMM4**	CANCELLATION OF FINAL PROT. DUE TO NON-PAYMENT OF FEE	1 186
HU	**MM4A**	LAPSE OF DEFINITIVE PATENT PROTECTION DUE TO NON-PAYMENT OF FEES	662
HU	**DFD9**	TEMPORARY PROT. CANCELLED DUE TO NON-PAYMENT OF FEES	335
HU	**DFC4**	CANCELLATION OF TEMPORARY PROT. DUE TO REFUSAL	198
HU	**DFA9**	TEMPORARY PROT. CANCELLED DUE TO ABANDONMENT	99
HU	**FD9A**	LAPSE OF PROVISIONAL PROTECTION DUE TO NON-PAYMENT OF FEES	29
HU	**HMH4**	CANCELLATION OF FINAL PROT. DUE TO RELINQUISHMENT	15
HU	**FA9A**	LAPSE OF PROVISIONAL PATENT PROTECTION DUE TO RELINQUISHMENT OR PROTECTION CONSIDERED RELINQUISHED	7
HU	**MH4A**	LAPSE OF DEFINITIVE PATENT PROTECTION DUE TO RELINQUISHMENT	6
HU	**BFD9**	TEMPORARY PROT. CANCELLED DUE TO NON-PAYMENT OF FEES	3
LT	**MM9A**	LAPSED PATENTS	670
LT	**MK9A**	EXPIRY OF A PATENT	10
LT	**MG9A**	PATENT INVALIDATED	1
LT	**SPCW**	WITHDRAWAL OF AN SPC	1
NL	**VD1**	LAPSED DUE TO NON-PAYMENT OF THE ANNUAL FEE	7 048
NL	**V1**	LAPSED BECAUSE OF NON-PAYMENT OF THE ANNUAL FEE	4 155
NL	**V4**	LAPSED BECAUSE OF REACHING THE MAXIMUM LIFETIME OF A PATENT	818
NL	**VD2**	LAPSED DUE TO EXPIRATION OF THE TERM OF PROTECTION	704
NL	**BV**	THE PATENT APPLICATION HAS LAPSED	66
NL	**VD4**	LAPSED DUE TO RESIGNATION BY THE PROPRIETOR	31
NL	**VJC**	LAPSED DUE TO NON-PAYMENT OF THE DUE MAINTENANCE FEE FOR THE PATENT OR PATENT APPLICATION	11
NL	**VD3**	ANNULMENT	6
NL	**V6**	PATENT SURRENDERED (ART. 48)	3
NL	**VIT**	LAPSED DUE TO NON-PAYMENT OF THE DUE MAINTENANCE FEE FOR THE PATENT OR PATENT APPLICATION	2
NL	**V5**	ANNULMENT (ART. 51)	1
PT	**MM3A**	ANNULMENT OR LAPSE	1 736
PT	**MM4A**	ANNULMENT/LAPSE DUE TO NON-PAYMENT OF FEES; SEARCHED & EXAMINED PATENT	439
PT	**MM4K**	ANNULMENT OR LAPSE (GRANTED UTILITY MODEL)	56
PT	**FC3A**	REFUSAL	6
PT	**MA3A**	WITHDRAWAL OF PATENT	3

8.3 Reduced sample characteristics

Table 20: Average values of selected variables by IPR ownership (reduced sample)

		Number of employees	Revenue per employee (EUR/year)	Wages per employee (EUR/year)	Age (years)
Non-owner		27.1	295 289	41 098	17.6
All IPRs	Owner	264.4	634 084	64 650	23.4
	% difference (owner/non-owner)	876.8%***	114.7%***	57.3%***	33.4%***
Patent	Owner	1 052.2	915 440	82 031	31.4
	% difference (owner/non-owner)	3 787.6%***	210.0%***	99.6%***	78.9%***
Trade mark	Owner	270.2	639 954	64 852	23.3
	% difference (owner/non-owner)	898.3%***	116.7%***	57.8%***	32.8%***
Design	Owner	1 135.0	701 905	59 786	29.8
	% difference (owner/non-owner)	4 093.4%***	137.7%***	45.5%***	69.8%***

Note: Age is defined at 2013 according to the date of incorporation reported by ORBIS. The asterisks denote the following significance levels: 10 per cent (*), 5 per cent (**) or 1 per cent (***).

8.4 Distinctive groups of similar IPR owners: cluster analysis

8.4.1 Introduction: cluster analysis

In addition to the basic descriptive statistics reported in the previous section, it is possible to own IPR indicators to identify typical profiles of IPR ownership. For example, profiles may be defined on the basis of:

- the intensity with which IPRs are used (e.g. distinguishing between “Heavy IPR users”, “Moderate IPR users” and “Light IPR users”);
- the specific way in which IPRs are used (e.g. by distinguishing between firms that own multiple types of IPR simultaneously — e.g. patents and trade marks — and those that focus on a particular type of IP); or
- any other relevant combination of the two (e.g. “Heavy multiple-IPR users”, vs. “Heavy patent-only users”, etc.).

Different approaches can be used to determine the thresholds defining IPR ownership profiles. For example, threshold levels could be based on simple percentiles (e.g. with “Heavy users” being defined as those companies whose intensity index level belongs to the top 75 per cent, “Light users” being defined as those companies whose intensity index level belongs to the bottom 25 per cent, etc.), or depending on whether different IPRs are owned simultaneously (e.g. distinguishing between “Patent-only owners” and “Patent and trade mark owners”). Another way would be to define thresholds using a measure of age (e.g. age of oldest patent, age of most recent patent, etc.). Alternatively, threshold levels could be determined on the basis of analysis of variance (ANOVA) techniques such as cluster analysis.

8.4.2. Specific approach

The cluster analysis conducted in this study is based on six variables: the stocks of patents, trade marks and designs, at both the national and European levels. The analysis was conducted using stocks of IPRs measured in both absolute and per-employee terms. For consistency with other sections of the report, only the cluster analysis results obtained by using the stocks of IPRs normalised by the number of employees are presented here (however, where appropriate, the results obtained by using the absolute number of IPRs are mentioned). 2010 is the base year, and the variables were normalised to account for differences in scale and variability. In line with the descriptive statistics presented above, the analysis was performed on the randomised sample. In addition, only firms that are owners of at least one type of IPR were included.

The chosen clustering method is *k-means* with random starting points. The number of starting points is the same as the number of clusters, *k*, which is pre-specified. The algorithm randomly chooses starting points as the centres of the initial set of clusters and groups all observations in clusters so that the Euclidean distance between the observations and the centres is minimised. After this first iteration, new centres are chosen by calculating the mean within each of the clusters (other algorithms might choose other rules for selecting the new centres, e.g. *k-medians* selects the median observation within each cluster). The algorithm then repeats this process until convergence is achieved: the distance between the centres before and after an iteration are below a certain (small) threshold. In other words, upon convergence the centre of the clusters and the mean coincide.

This analysis was performed systematically, specifying all possible configurations from 2 to 20 clusters. However, many of the clusters are small. Clusters that contain fewer than 500 firms were discarded. Finally, the clustering that offered the largest number of distinct patterns was selected.

8.4.3. Results: five clusters of typical owners

Figure 1 shows the clusters obtained for IPR indicators normalised by the number of employees. For the stocks of IPRs per employee, the clustering method described above produced five large clusters that cover 97.7 per cent of the firms in the sample. These are reported in Table 21. The variables on the radar graph y-axis represent the values of different cluster centres. For each cluster, a centre is the average value of the standardised IPRs/per employee across all firms belonging to that cluster. So, for example, if a cluster has a positive (negative) value along the "EU trade mark" dimension, this indicates that the number of EU trade marks per employee of firms belonging to this cluster is above (below) the average number of EU trade marks for the overall sample of firms considered. A larger magnitude of the centre indicates a larger distance above (if the number is positive) or below (if the number is negative) the overall sample mean. The exact values of cluster centres are reported in the table.

Figure 1: Cluster centres for stocks per employee

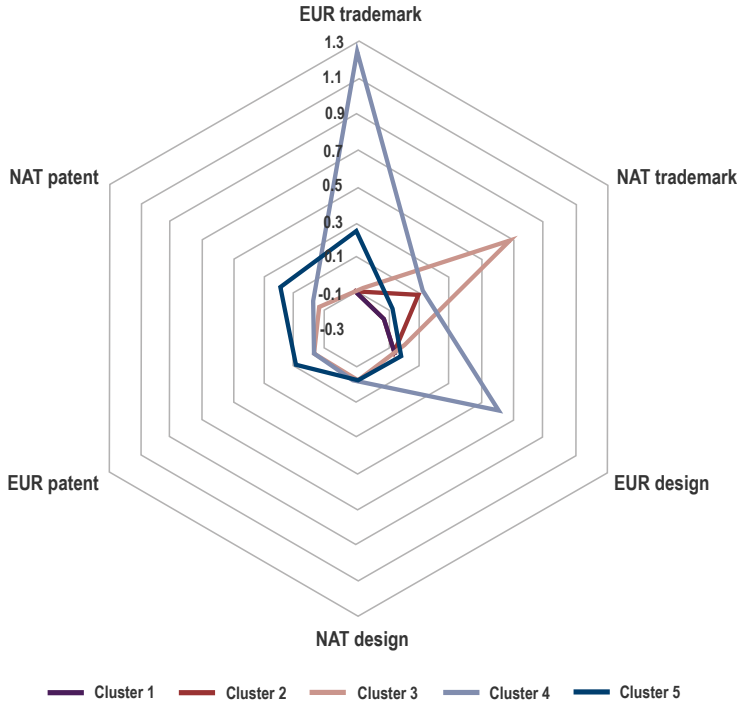

Table 21: Cluster centres in terms of (standardised) stocks of IPRs per employee

	EUR trade mark	NAT trade mark	EUR design	NAT design	EUR patent	NAT patent
Light IPR users (Cluster 1)	-0.087	-0.134	-0.045	-0.014	-0.039	-0.050
Moderate national trade mark users (Cluster 2)	-0.093	0.091	-0.051	-0.014	-0.045	-0.057
Intensive national trade mark users (Cluster 3)	-0.084	0.674	-0.052	-0.008	-0.045	-0.052
Intensive EU trade mark and EU design users (Cluster 4)	1.243	0.123	0.620	-0.001	-0.022	-0.023
Patent users (Cluster 5)	0.252	-0.080	-0.002	-0.013	0.096	0.182

As can be seen from Figure 1, the five clusters[49] identified have an intuitive interpretation:

- **"Light" IPR users (Cluster 1)** — firms belonging to this cluster have a small number of IPRs per employee. The cluster centres typically have the lowest values in almost all rights compared to the other clusters.
- **Moderate national trade mark users (Cluster 2)** — firms belonging to this cluster own a modest number of national trade marks.
- **Intensive national trade mark users (Cluster 3)** — the IPR ownership profile of firms belonging to this cluster is similar to that of firms belonging to Cluster 2, but they own significantly more national trade marks.
- **Intensive European trade mark and European design users (Cluster 4)** — this cluster contains firms that possess an unusually high number of European trade marks and European designs per employee. They also possess national trade marks in volumes comparable with moderate national trade mark users (Cluster 2).
- **Patent users (Cluster 5)** — this cluster contains firms that own significantly more patents (both national and European) compared to those belonging to other clusters. It should be noted that firms in this cluster also possess a modest number of European trade marks.

49 The clustering variables are defined on an IPRs-per-employee basis. When the cluster exercise is conducted based on absolute stock of IPRs (as opposed to stocks normalised by number of employees), only three clusters are obtained. No chart for the three clusters is reported but, for completeness, it can be noted that these can be intuitively ranked from lighter to heavier IPR usage as follows: Light IPR users (Cluster 1b) — the IPR usage profile of this cluster is similar to that of Cluster 1 obtained when using IPRs per employee; Intensive national trade mark users (Cluster 2b) — the IPR usage profile of this cluster is similar to that of Cluster 3 (obtained when using IPRs/per employee); and Heavy IPR users (Cluster 3b) — the IPR usage profile of this cluster appears to incorporate features of both Cluster 4 and Cluster 5, as it includes firms that own many European trade marks, European designs, and patents (both national and European).

8.4.4. Statistical analysis of clusters

There are several interesting statistical features of the clusters identified above. This section presents the breakdown of these groups into a number of categories to identify some of the patterns exhibited by the data.

Table 22 first provides details of the number of firms that are contained in each of the clusters. The "light IPR users" cluster is the largest, accounting for 33 728 firms, whilst the "intensive EU trade mark and EU design users" cluster (Cluster 4) is the smallest, accounting for 784 firms.

Perhaps of more interest is the breakdown of these clusters by company size, i.e. the percentage of SMEs versus large firms contained in each cluster. First, the "light IPR users" cluster has the smallest proportion of SMEs. Again, this is due to the fact that the clustering exercise is based on IPRs per employee as opposed to absolute stocks of IPRs.[50] A more interesting pattern can be observed when comparing the other clusters. More specifically, the "patent users" group (Cluster 5) has the largest share of large companies of the remaining clusters (16.9 per cent), followed by "intensive EU trade mark and EU design users" (Cluster 4), and then "trade mark users" (Cluster 2 and Cluster 3).

Table 22 also presents the average number of employees for firms within each cluster. The first striking result is that firms in the "light IPR users" cluster tend to have significantly more employees than firms belonging to any other cluster. As already explained above, this is due to the fact that the clustering variables are IPR stocks defined on a per-employee basis and therefore, for a given value of IPR stock, firms with more employees will necessarily have lower IPR indicator values.[51] With regard to other clusters one notes that patent users (Cluster 5) have on average more employees than firms in Clusters 2, 3 and 4, and firms that make intensive use of both European trade marks and European designs (Cluster 4) have more employees than those that rely primarily on trade marks (Cluster 2 and Cluster 3).

50 In fact when using stocks of IPRs as clustering variables, as expected the percentage of SMEs contained in the "light IPR users" cluster (Cluster 1b) is found to be significantly larger (i.e. 80.1 per cent) than that for the two more IPR-intensive clusters (Cluster 2b and Cluster 3b, with respectively 43.1 per cent and 39.5 per cent of SMEs).

51 When the clustering analysis is based on the absolute value of IPR stocks, the firms in the "light IPRs users" cluster (Cluster 1b) are found to have the smallest average number of employees, which confirms the well-established finding that smaller firms tend to own less IPRs.

Table 22: Characteristics of firms in each cluster

	Light IPR users (Cluster 1)	Moderate national trade mark users (Cluster 2)	Intensive national trade mark users (Cluster 3)	Intensive EU trade mark and EU design users (Cluster 4)	Patent users (Cluster 5)
Number of firms	33 728	6 281	3 061	784	2 663
Large	32.2%	3.9%	1.8%	6.8%	16.9%
SME	67.8%	96.1%	98.2%	93.2%	83.1%
Average number of employees	761.79	16.16	4.88	24.63	89.14
Average revenue per employee (EUR/year)	302 540	301 087	388 499	487 423	381 476
Average age (years)	44.8	22.4	18.1	21.9	28.7

When looking at the average age of firms in different clusters one notes that light IPR users are the oldest firms with on average 44.8 years. The group of patent users is second with an average age of 28.7 years. The group of intensive national trade mark users contains the youngest firms with a mean value of 18.1 years.

Finally, revenue per employee is reported below. Firms with a light and moderate use of IPRs (i.e. Clusters 1 and 2) tend to have lower revenue per employee compared to firms that use IPRs more intensively (i.e. Clusters 3, 4 and 5). The group of intensive EU trade mark and EU design-using firms (Cluster 4) has the highest average value with EUR 487 423 per employee.

The composition of the clusters according to the main NACE activities of the firms in each of them is presented in Table 23.

Table 23: Distribution of firms by NACE activity in each cluster (share of firms in per cent)

NACE section	Light IPR users (Cluster 1)	Moderate national trade mark users (Cluster 2)	Intensive national trade mark users (Cluster 3)	Intensive EU trade mark and EU design users (Cluster 4)	Patent users (Cluster 5)
C: Manufacturing	37.4	23.9	37.4	35.3	51.6
D: Electricity, gas, steam and air-conditioning	1	0.1	1	0	0.2
E: Water supply, sewerage, waste management	0.8	0.4	0.8	0.8	0.3
F: Construction	5	5	5	1.3	2.3
G: Wholesale and retail	21.6	30.2	21.6	30.7	21.2
H: Transportation and storage	3.1	1.4	3.1	1	0.5
I: Accommodation and food services	3.1	3	3.1	0.9	0.6
J: Information and communication	6.2	9.2	6.2	6.1	6.4
K: Financial and insurance activities	3.8	2.4	3.8	3.8	2.1
L: Real-estate activities	1.8	3.3	1.8	2	0.9
M: Professional, scientific and technical services	7.4	10.2	7.4	9.7	9.1
N: Administrative and support services	4.1	5.4	4.1	5.2	2.8
O: Public administration and defence	0.1	0	0.1	0	0
P: Education	0.7	1	0.7	0.5	0.3
Q: Human health and social work activities	1.5	1.4	1.5	0.1	0.3
R: Arts, entertainment and recreation	1.4	1.4	1.4	1.5	0.8
S: Other service activities	1.1	1.7	1.1	0.9	0.6

The clearest pattern that can be observed by comparing across clusters is the share of firms operating in the three largest sectors: Manufacturing, Construction and Wholesale and retail. Trade mark-focused clusters (Clusters 2, 3, and 4) have a larger percentage of firms in the wholesale and retail trade sector compared to the patenting cluster (Cluster 5). In contrast, the patent cluster contains an absolute majority of manufacturing firms.

8.4.5. Summary

The cluster analysis confirms some general patterns already identified in the descriptive statistics reported in Chapter 5. The key added value of this clustering exercise lies in the fact that it provides further information on IPR usage patterns. More specifically, the identified clusters suggest there are two key dimensions across which IPR usage varies across the companies:

- **Intensity of usage**, which appears to be relevant specifically in relation to national trade marks. Companies using national trade marks tend to belong to two different clusters: those that use them extensively (Cluster 3) or moderately (Cluster 2).

- **Range of IPRs used and complementary use**. European trade marks, for example, tend to be used very frequently in conjunction with European designs (Cluster 4) and to a lesser extent in conjunction with patents, at either national or European level (Cluster 5).

- **Breakdown of these clusters by company size**, i.e. the percentage of SMEs versus large firms contained in each cluster. First, the “light IPR users” cluster has the smallest proportion of SMEs. The “patent users” group (Cluster 5) has the largest share of large companies of the remaining clusters (16.9 per cent), followed by “intensive EU trade mark and EU design users” (Cluster 4), and then “trade mark users” (Cluster 2 and Cluster 3).

8.5 Background to regression model specifications

8.5.1. Econometric approach

This section describes the approach to the econometric analysis used in the study. It first explains the rationale for using panel methods, given the available dataset. It then describes the approach to specifying the model. Finally, it explains how several specific econometric challenges have been tackled.

8.5.1.1 Panel data

The dataset has a so-called panel format as it contains both a cross-sectional and a time-series dimension. Panel data makes it possible to exploit not only cross-sectional variation (differences between firms at one point in time) but also time-series variation (changes for one firm over time). Since both dimensions of variation within the data can be exploited simultaneously, panel data estimates are based on a larger sample size, and are thus potentially more accurate than those obtained through simple cross-section or time-series regressions.

Furthermore, a particular type of econometric modelling can be applied, namely panel regression techniques. This method is able to control for unobserved heterogeneity (i.e. the effect of variables that are not observable in the data but which might have an impact on the dependent variable of interest).

This feature is particularly important since it minimises the risk of obtaining spurious results driven primarily by firms' characteristics that have an effect on firms' performance but which are not observed and are not related to the ownership of IPRs. For instance, a company's specific organisational structure, its business model, and its management quality are all factors which may have a significant impact on the relationship between IPR ownership and firm performance but for which data is lacking. Failure to deal with unobserved characteristics could produce biased results. However, unobserved heterogeneity in a panel framework can be dealt with through the use of particular panel estimation techniques, which are designed with the precise goal of controlling for specific company features that are not directly observable in the data.

8.5.1.2 Selection of variables

This section describes how the dependent variable and the independent variables were selected. Moreover, it discusses the use of logs versus levels of variables and provides descriptive statistics for the main variables used.

Dependent variable

The purpose of this study is to analyse the relationship between IPRs and the performance of firms. Therefore, the dependent variable of the models needs to be an indicator of firms' output. The ORBIS database described in Chapter 4 contains several potential candidates, including various measures of revenue, sales and profit or loss. Given that this study relies on data from several EU Member States, it is important that the basis on which the dependent variable is constructed is identical between countries, as this will minimise the risk that weaknesses in the dataset lead to biased results.

To illustrate this concern, it is worth noting that profit measures are affected by factors such as accounting principles and standards as well as decisions concerning the treatment of tax, debt, etc. Given that these issues are not harmonised across Member States, there is a significant risk in using a profit measure as an indicator of performance.[52] For this reason, **revenue** is used as the basis of the performance measure in the models. Given the substantial variation in revenue between firms of different size, the decision was taken to transform the performance measure by dividing it by the number of the firm's employees. This measure (**revenue per employee**) has already been employed by a number of previous studies, including Bascavusoglu-Moreau and Tether (2011), Greenhalgh and Rogers (2011) and Bloom and Van Reenen (2002).

➔ **Revenue per employee**: operating revenue per employee in a given year

Explanatory variables

There are two broad strategies that can be used when estimating econometric models: a 'general to specific' strategy and a 'specific to general' strategy. If the former strategy is adopted, the econometrician starts with a model that contains 'many' potential explanatory variables and eliminates those that are not significant (from either a statistical or an economic perspective) to develop a simpler model that is capable of 'explaining' the dependent variable at least as well as a more complex model but is preferred to this one because it requires fewer explanatory factors. On the other hand, if the latter strategy is adopted, the econometrician starts with a simple model (usually one with a single explanatory variable) and adds additional variables until adding further variables no longer provides additional information to the model.

52 The one exception to this general rule is EBITDA, which is a reasonably standardised measure across countries. However, it was found that EBITDA observations were missing for nearly all observations in Lithuania, while coverage was relatively poor in several other countries, including the UK and Denmark.

There are theoretical reasons why it is usually preferable to adopt a 'general to specific' approach to econometric modelling. However, this is, in practice, not always possible because many of the automated procedures that implement this strategy start with the observations available when the full model is estimated and then keep the same set of observations for the following steps of the procedure. This implies that if an observation is missing at the beginning of the procedure because, say, data on the number of employees for a particular firm is not available, then that observation would not be used in the models.

This concern was particularly relevant for this project because, while the ORBIS database contains a considerable amount of information, there are missing observations for many firms in several years, for many of the financial variables. If these few gaps are summed together, they considerably reduce the amount of information available and so would lead to many observations being lost if a 'general to specific' approach were implemented.

With regard to measures of IPR ownership, the following dummy variables were constructed from the raw dataset:[53]

- **IPR owner:** takes the value 1 if the firm owns any type of IPR, and 0 otherwise
- A set of dummy variables which indicates whether a firm owns a specific **combination of IPRs** or not and which divides the sample into eight corresponding groups:
  - Patents only: takes the value 1 if the firm owns patents but no other type of IPR, and 0 otherwise
  - Trade marks only: takes the value 1 if the firm owns trade marks but no other type of IPR, and 0 otherwise
  - Designs only: takes the value 1 if the firm owns design rights but no other type of IPR, and 0 otherwise
  - Patents and trade marks: takes the value 1 if the firm owns patents and trade marks but not designs, and 0 otherwise
  - Patents and designs: takes the value 1 if the firm owns patents and designs but not trade marks, and 0 otherwise
  - Trade marks and designs: takes the value 1 if the firm owns trade marks and designs but not patents, and 0 otherwise
  - Patents, trade marks and designs: takes the value 1 if the firm owns all three types of IPR, and 0 otherwise
  - No IPRs: takes the value 1 if the firms does not own any type of IPR, and 0 otherwise
- Stock measures of a particular form of IPR were also used, and a distinction was made between stock measures for European and national IPRs. As with the dependent variable, these explanatory variables of interest were transformed by dividing by the number of employees.
  - **EU patent stock per employee:** number of European patents owned by the firm divided by the number of employees in a given year.
  - **NAT patent stock per employee:** number of national patents owned by the firm divided by the number of employees in a given year.

53 Dummy or binary variables are variables which take a value of either zero or one. For example, a dummy variable indicating whether or not the company is domiciled in Spain would take a value of one for all Spanish companies and zero for all other companies.

- **EU trade mark stock per employee:** number of European trade marks owned by the firm divided by the number of employees in a given year.
- **NAT trade mark stock per employee:** number of national trade marks owned by the firm divided by the number of employees in a given year.
- **EU design stock per employee:** number of European design rights owned by the firm divided by the number of employees in a given year.
- **NAT design stock per employee:** number of national design rights owned by the firm divided by the number of employees in a given year.

In addition, the following control variables were also used:

➔ **Country dummies:** 12 dummy variables for the countries AT, BE, DE, DK, ES, FR, GB, HU, IT, LT, NL, PT

➔ **Sector dummies:** 17 dummy variables for the following NACE sections: Manufacturing; Electricity, gas, steam and air-conditioning supply; Water supply, sewerage, waste management and remediation activities; Construction; Wholesale and retail trade repair of motor vehicles and motorcycles; Transportation and storage; Accommodation and food service activities; Information and communication; Financial and insurance activities; Real-estate activities; Professional, scientific and technical activities; Administrative and support service activities; Public administration, defence and compulsory social security; Education; Human health and social work activities; Arts, entertainment and recreation; Other service activities.

➔ **Year dummies:** 9 dummy variables for the years 2002 - 2010

➔ **SME:** dummy variable which takes the value 1 if the company is an SME, and 0 if the company is large[54]

➔ **Age of company:** variable that indicates the age of the company in the year 2013.[55]

54 Firms are classified as SMEs only if they were an SME for the whole time period included in the analysis. If a company was 'large' for at least one year, it was treated as 'large' in the analysis.

55 The variable was calculated by subtracting the year of incorporation reported in ORBIS from the year at the point of analysis - 2013. There are a small number of observations that are particularly old, including one company that has an age of 813 years.ORBIS reports its date of incorporation to be 1200. A few other companies have an age of 300-400 years.

Descriptive statistics for main variables

The models contain two sets of variables that may potentially be log-transformed: revenue per employee; and the stocks of patents, trade marks and designs per employee. The dataset used for the regression analysis consists of 130 555 firms.[56] The basic descriptive statistics for the main variables are shown in Table 24.

Table 24: Descriptive statistics of main variables

Variable		Mean	Std. dev.	Min	Max	Observations
Revenue per employee (EUR'000)	Overall	263.80	315.43	11.34	2 315.10	N = 705929
	Between		308.76	11.36	2 308.00	n = 130555
	Within		128.95	-1 330.31	2 255.70	T-bar = 5.41
IPR owner	Overall	0.53	0.50	0.00	1.00	N = 705929
Owner of patents only	Overall	0.02	0.15	0.00	1.00	N = 705929
Owner of trade marks only	Overall	0.40	0.49	0.00	1.00	N = 705929
Owner of designs only	Overall	0.01	0.08	0.00	1.00	N = 705929
Owner of patents and trade marks	Overall	0.05	0.21	0.00	1.00	N = 705929
Owner of patents and designs	Overall	<0.01	0.05	0.00	1.00	N = 705929
Owner of designs and trade marks	Overall	0.02	0.15	0.00	1.00	N = 705929
Owner of patents, trade marks and designs	Overall	0.02	0.14	0.00	1.00	N = 705929
Never owned any type of IPR	Overall	0.47	0.50	0.00	1.00	N = 705929
European patent stock per employee	Overall	<0.01	0.18	0.00	78.00	N = 705929
	Between		0.19	0.00	62.57	n = 130555
	Within		0.05	-25.23	15.44	T-bar = 5.41
National patent stock per employee	Overall	0.01	0.15	0.00	33.00	N = 705929
	Between		0.16	0.00	32.60	n = 130555
	Within		0.06	-13.39	22.50	T-bar = 5.41
European trade mark stock per employee	Overall	0.01	0.13	0.00	35.00	N = 705929
	Between		0.13	0.00	24.44	n = 130555
	Within		0.07	-20.10	16.28	T-bar = 5.41

56 Compared to Chapter 4, the number of firms has reduced from 132 277 to 130 555. The reason is that for some firms several revenue-per-employee observations were missing, either because there was only data for revenue or for employees (but not for both), or because the reported number of employees was zero.

National trade mark stock per employee	Overall	0.09	1.27	0.00	610.50	N = 705929
	Between		1.49	0.00	443.28	n = 130555
	Within		0.55	-320.35	167.32	T-bar = 5.41
European design stock per employee	Overall	<0.01	0.12	0.00	41.25	N = 705929
	Between		0.10	0.00	24.34	n = 130555
	Within		0.07	-24.34	16.91	T-bar = 5.41
National design stock per employee	Overall	0.02	1.79	0.00	1 203.00	N = 705929
	Between		3.52	0.00	1 203.00	n = 130555
	Within		0.49	-99.63	317.73	T-bar = 5.41
SME	Overall	0.82	0.39	0.00	1.00	N = 705929
Age	Overall	46.39	200.29	1.00	1 994.00	N = 705929

Note: The number of observations *n* is the number of firms for which there is data. *T-bar* is the average number of years with observations per firm. The number of observations *N* is the product of *n* and *T-bar*. Descriptive statistics are displayed for the overall sample, as well as, decomposed into between (across firms) and within (over time) components.

Logs versus levels

The above discussion has described the variables that are included in the models but has not considered the precise form in which these variables enter the models. More precisely, the issue is whether the numeric explanatory and dependent variables should enter the models as levels or whether they should be log-transformed.

In regression analysis, it is common to logarithmically transform variables where a non-linear relationship exists between the independent and dependent variables. This approach makes the effective relationship non-linear, while still preserving the linear regression model. Logarithmic transformations are also a convenient means of transforming a highly skewed variable into one that is more approximately normal. In this study, the distributions of the performance variable as well as of the stock variables are highly skewed. Finally, it is appropriate to make a logarithmic transformation when it is suspected that a given percentage change in an explanatory variable will lead to a constant percentage change in the dependent variable.

In the case of modelling the impact of IPR stocks per employee on revenue per employee, it seems reasonable to assume that the impact of a given absolute change, say, in the number of trade marks per employee would differ depending on the firm's existing stock of trade marks per employee (i.e. an additional trade mark is likely to have a greater impact if it is the first trade mark held by the firm than if it is the firm's 100th trade mark, all else being equal). By contrast, one might expect that a 1 per cent change in the stock of trade marks per employee would have the same *percentage* impact on revenue per employee irrespective of the initial stock. If this hypothesis is correct, the relationship is most appropriately modelled by taking logs on both sides.

8.5.2 Model specifications

Choice of panel regression model

As explained previously, panel data analyses allow for the use of estimation techniques that are specifically designed to minimise the risk of obtaining spurious results driven primarily by firms' idiosyncratic features. There are two basic panel data models which can be applied, the so-called "fixed-effects" model and the "random-effects" model.

- **Fixed-effects model:** The inclusion of firm-specific fixed effects relies on the assumption that there are some unobservable firm characteristics which have a systematic (non-random) effect on firms' performance and may be correlated with the explanatory variables, i.e. IPR ownership. The value and the effect of these unobserved characteristics are supposed not to vary over time (i.e. they are fixed).
- **Random-effects model:** On the other hand, the inclusion of firm-specific random effects relies on the assumption that the firm-specific unobservable characteristics have a non-systematic (i.e. random) influence on firms' performance and are uncorrelated with the explanatory variables.

An advantage of regressions with random effects lies in the possibility of including time-invariant variables in the regression results (e.g. firm type, country of origin, sector), whereas estimation with fixed effects by construction removes from reported results all variables that do not change over t ime. On the other hand, the fixed-effects model might be better suited to controlling for unobserved heterogeneity in the present context. As the choice between two methods of estimation is not obvious, it was decided to cross-check the results of both whenever appropriate.

All regressions use cluster-robust standard errors.

8.5.2.1 Firm performance and IPR ownership

In the first set of regressions, dichotomous variables of IPR ownership were used as explanatory variables. Therefore, the general panel regression model has the following form:

$$\log(P_{i,t}) = \alpha + \mathbf{IPR\_own'_i}\boldsymbol{\beta} + \mathbf{X'_{i,t}}\boldsymbol{\gamma} + \varepsilon_{i,t} \quad \text{Eq.1}$$

where $P_{i,t}$ denotes the performance indicator (revenue per employee) for firm *i* in year *t*. In the first regression model, IPR_own_i represents the general ownership of IPRs, indicating whether firm *i* owned any type of IPR in any year *t*. In the second regression model, IPR_own_i is a vector of variables for each type of IPR (e.g. patent, design, trade mark) or a combination thereof. Therefore the vector β which measures the relationship between different types of IPR and company performance contains the key coefficients of interest.

Since the main variables of interest IPR_own_i do not change over time only the random-effects model is applicable for this set of regressions. Therefore, throughout all models a number of obvious firm-specific control variables that one would expect a *priori* to have an effect on company

performance was included, such as industrial sector, Member State, firm type and the age of the company.[57] Time-specific effects which affect all firms in the same way, e.g. economic cycles, were also controlled for by including a variable for each time period. These variables are represented by the row vector X' in all regression equations, and γ is their coefficient vector. $\varepsilon_{i,t}$ is the corresponding error term. The regression results are reported in Tables 15 and 16 in Chapter 6.

8.5.2.2 Firm performance and IPR stocks

For the second set of regressions, variables of patent, design and trade mark stocks were constructed from the raw dataset. The stock measures the number of a particular form of IPR that was held by a firm in a given year. Separate stock measures were defined for European designs, national designs, European trade marks etc. such that a total of six stock variables were constructed. As with the dependent variable, these key explanatory variables of interest were transformed by dividing by the number of employees. Since the distributions of these variables are extremely skewed and the relation between them and the performance measure is likely to be non-linear, a logarithmic transformation was applied. This leads to a panel regression model of the following form:

$$\log(P_{i,t}) = \alpha_i + \mathbf{log(IPR\_stock}_{i,t})'\boldsymbol{\beta} + \mathbf{X'_{i,t}}\boldsymbol{\gamma} + \varepsilon_{i,t} \qquad \text{Eq. 2}$$

where, $P_{i,t}$ again denotes the performance indicator, $\mathrm{IPR\_stock}_{i,t}$ is a vector of the stock of different types of IPR of firm *i* in year *t*, X' represents the vector of time-variant and time-invariant control variables and $\boldsymbol{\beta}$ is the vector of coefficients of interest. Since the variables of interest, $\mathbf{log(IPR\_stock}_{i,t})$, are time-variant, fixed-effects and random-effects regressions have been carried out and tested against each other.

Results from the random-effects model

Although the sign, order of magnitude and significance were consistent between random-effects and the fixed-effects methods, there were some differences in the magnitude of estimated coefficients. Additionally, a robust Hausman-type test showed that there are statistically significant differences between the two estimation methods. As a consequence the fixed-effects models should be preferred. The results of the fixed-effects models are reported in Tables 17 and 18 in Chapter 6. The results of the random-effects models are shown in Tables 25 and 26.

57 Due to data limitations it was not possible to use additional explanatory variables. While the ORBIS database contains a considerable amount of information, there are missing observations for many firms in several years, for many of the financial variables. If these few gaps are summed together, they considerably reduce the amount of information available and so would lead to many observations being lost.

Table 25: Results of stocks of different IPRs, random effects, all firms

	Model 1 (Coef)
Dependent variable	
Log revenue per employee	
Explanatory variables	
Log EU patent stock per employee	0.12
Log NAT patent stock per employee	0.36***
Log EU trade mark stock per employee	0.32***
Log NAT trade mark stock per employee	0.52***
Log EU design stock per employee	0.04
Log NAT design stock per employee	0.07***
Country dummies	Not reported°
Sector dummies	Not reported
Year dummies	Not reported
SME ~	-32.90***
Age of company	0.00***
Constant	5.25***
Test of overidentifying restrictions: fixed vs random effects	
Sargan-Hansen statistic	**951 723 Chi-sq(14) P-value < 0.01**

Number of observations = 705 929 and number of firms = 130 555 for all firms model
Model based on owners and non-owners – R2 overall = 0.276; Prob > Chi2 = 0.000
Model based on owners only – R2 overall = 0.263; Prob > Chi2 = 0.000
Note: ~ = dummy variable; * = significant at the 10 per cent level; ** = significant at the 5 per cent level; *** = significant at the 1 per cent level.
° Country, sector and year dummy variables were included in the analysis as control variables. In order to maintain readability, these are not included in the table. The regression results can be provided on request.

Table 26: Models of IPR stocks, random effects by firm type

	SMEs (Coef)	Large companies (Coef)
Dependent variable		
Log revenue per employee		
Explanatory variables		
Log EU patent stock per employee	0.11	0.25
Log NAT patent stock per employee	0.37***	0.21
Log EU trade mark stock per employee	0.35***	-0.08
Log NAT trade mark stock per employee	0.53***	0.60***
Log EU design stock per employee	0.03	0.13
Log NAT design stock per employee	0.07***	0.12
Country dummies	Not reported°	Not reported
Sector dummies	Not reported	Not reported
Year dummies	Not reported	Not reported
Age of company	<0.01***	<0.01***
Constant	4.74***	5.35***
Test of overidentifying restrictions: fixed vs random effects		
Sargan-Hansen statistic	**862 526** Chi-sq**(14)** P-value **<0.01**	**163 753** Chi-sq**(14)** P-value **<0.01**

Number of observations = 575 565 and number of firms = 109 159 for SMEs model
Number of observations = 130 364 and number of firms = 21 396 for large companies model
SMEs model – R2 overall = 0.264; Prob > Chi2 = 0.000
Large companies model – R2 overall = 0.225; Prob > Chi2 = 0.000
~ = dummy variable; * = significant at the 10 per cent level; ** = significant at the 5 per cent level; *** = significant at the 1 per cent level.
° Country, sector and year dummy variables were included in the analysis as control variables. In order to maintain readability, these are not included in the table. The regression results can be provided on request.

Sample selection

In assessing the relationship between firms' performance and their stocks of IPRs, two additional models were estimated. The first one was based on all firms, whether owners or non-owners of IPRs. In the second model the potential sample selection problem arising from the fact that only IPR stocks for firms which own IPRs are observed, was accounted for. Therefore Equation 2 was also estimated on a sub-sample that consists of only those firms that own formal IPRs and corrected for the sample selection problem by adding the Mills ratio as an additional explanatory variable. The Mills ratio was calculated from an explicit selection regression of the decision whether or not to use IPRs on sector dummies and the SME status.[58] As can be seen in Table 27, the results for the coefficients of interest do not significantly differ from the baseline regression results using the full sample. The coefficient of the Mills ratio in the owners-only model indicates that IPR owners have higher revenue per employee than do non-owners, which is also consistent with other findings.

58 Since sector dummies and SME status are time-invariant, the estimations are based on the random-effects model.

Table 27: Models of IPR stocks, random effects, all firms

	Model based on all firms (IPR owners and non-owners) (Coef)	Model based on IPR owners only (Coef)
Dependent variable		
Log revenue per employee		
Explanatory variables		
Log EU patent stock per employee	0.12	0.12
Log NAT patent stock per employee	0.36***	0.34***
Log EU trade mark stock per employee	0.32***	0.31***
Log NAT trade mark stock per employee	0.52***	0.48***
Log EU design stock per employee	0.04	0.03
Log NAT design stock per employee	0.07***	0.07***
Country dummies	Not reported°	Not reported
Sector dummies	Not reported	Not reported
Year dummies	Not reported	Not reported
SME ~	-32.90***	-50.43***
Age of company	<0.01***	<0.01
Mills	-	1.00***
Constant	5.25***	4.87***

Number of observations = 705 929 and number of firms = 130 555 for all firms model
Number of observations = 372 954 and number of firms = 63 171 for all owners model;
Model based on owners and non-owners – R2 overall = 0.276; Prob > Chi2 = 0.000
Model based on owners only – R2 overall = 0.263; Prob > Chi2 = 0.000
~ = dummy variable; * = significant at the 10 per cent level; ** = significant at the 5 per cent level; *** = significant at the 1 per cent level.
° Country, sector and year dummy variables were included in the analysis as control variables. In order to maintain readability, these are not included in the table. The regression results can be provided on request.

Dynamic panel data models

The rationale for including lags of the dependent variable is to allow for the modelling of a partial adjustment mechanism. In this case the actual value of the dependent variable is a compromise between its value in the previous time period and the value justified by the current value of the explanatory variables. The rationale for specifying such a model for assessing the relationship between IPRs and performance is that additions to the stock during the current year may not immediately be reflected in terms of additional revenue. Therefore, the revenue per employee this year will be a function both of the previous year's value and of the value justified by the current stocks of IPRs. The inclusion of a lagged dependent variable means that the standard random-effects panel modelling approach is not appropriate. The lagged dependent variable will be correlated with the random effect in the error term of such a model, which would lead to biased estimates.

To overcome this issue, the Arellano-Bond estimator was used, which takes first differences to remove the individual effects and uses all the past information of the dependent variable as instruments in the regression. Taking first differences implies that all time-invariant characteristics of the firm (e.g. Member State and sector) are dropped from the model. For this reason coefficients for such variables cannot be estimated in a dynamic panel model.

The results of a model in which a single lag of the dependent variable is included alongside time-varying explanatory variables are presented in Table 28.[59]

Table 28: Model of IPR stocks including single lagged dependent variable

	Overall (Coef)	SMEs (Coef)	Large (Coef)
Dependent variable			
Log revenue per employee			
Explanatory variables			
One-year lag of revenue per employee	0.36***	0.376***	0.41***
Log EU patent stock per employee	0.12	0.13	0.30
Log NAT patent stock per employee	0.80***	0.82***	0.52
Log EU trade mark stock per employee	0.57***	0.60***	0.29
Log NAT trade mark stock per employee	0.92***	0.93***	1.07***
Log EU design stock per employee	0.13*	0.11	0.33*
Log NAT design stock per employee	0.12***	0.13***	-0.16
Year dummies	Not reported°	Not reported	Not reported
Age of company	0.07***	0.08***	0.04***

Number of observations = 395 622 and number of firms = 118 239 for overall model
Number of observations = 314 802 and number of firms = 97 892 for SMEs model
Number of observations = 80 820 and number of firms = 20 347 for large companies model
Overall model – Prob > Chi2 = 0.000
SMEs model – Prob > Chi2 = 0.000
Large companies model – Prob > Chi2 = 0.000
~ = dummy variable; * = significant at the 10 per cent level; ** = significant at the 5 per cent level; *** = significant at the 1 per cent level.
° Year dummy variables were included in the analysis as control variables. In order to maintain readability, these are not included in the table. The regression results can be provided on request.

The results show that the lagged dependent variable is positive and significant, providing evidence for the hypothesis that revenue per employee exhibits inertia over time. As in previous models, it was found that the coefficients on the majority of types of IPR are positive and strongly significant in the overall model and also, as before, that the coefficients on national trade marks and patents exceed that on national designs. However, following the inclusion of a lagged dependent variable, the coefficient on European designs is significant at the ten per cent level.

In addition, dynamic panel data models were also considered, including lags of both the dependent and time-varying explanatory variables (stocks of IPR) as additional regressors. The rationale for including lags of IPR stocks, however, is not clear. The stock variable, by definition, includes IPRs that were granted in the current period in addition to all IPRs accumulated in the past that remain valid in the relevant year. Therefore, past decisions are already captured by this variable and the change in stock per employee from one year to the next will, in general, be limited. This means that including a lag of the stock would come with a clear risk of high correlation between two explanatory

59 Given that the literature sometimes includes up to five-year lags, longer lag structures were explored. However, it was found that the number of observations dropped significantly for lags longer than two years, and hence greatest confidence lies in the results presented for a one-year lag.

variables, and this would lead to a multicollinearity problem. For this reason, lagged stocks were not included in the models.[60]

Models of IPR stocks with quality-adjusted European patents

A large literature has explored the issue of patent quality. The constructed index incorporates the key patent quality indicators suggested in the survey of the literature conducted by the OECD and has the following features:[61]

- ➔ it is composed of five variables: patent scope (measured as unique 4-digit IPC symbols), forward citations, claims, number of countries where validated and family size (according to DOCDB classification);
- ➔ normalisation: linear scale for each of the five variables, with minimum set equal to zero and maximum set equal to one;
- ➔ equal weights of all five variables;
- ➔ in contrast to the OECD paper, the extreme values in the data were not limited; and
- ➔ in addition to the simple index described above, three separate count measures were constructed: number of patents that have an associated index in the lowest, middle and highest third of the index distribution, respectively.

As shown in Table 29, the results of these models are almost identical to those of the models where a simple count of European patents was included as an explanatory variable.

60 There would surely be merit in including lagged explanatory variables if the models were based on IPR grants rather than stocks. Grants measure the flow of IPRs, and this variable is likely to vary more significantly from one year to the next than the stock of IPRs. Also, the impact of IPRs on the performance of a firm takes place over time, not only in the current year. Therefore, modelling the impact of IPR grants without including lagged values is likely to generate biased results.

61 See Squicciarini et al. (2013).

Table 29: Contemporaneous models of IPR stocks with quality-weighted European patents, fixed effects (all firms, IPR owners and non-owners)

	Overall (Coef)	SMEs (Coef)	Large (Coef)
Dependent variable			
Log revenue per employee			
Explanatory variables			
Log EU patent stock per employee, quality weighted	0.23	0.23	0.56
Log NAT patent stock per employee	0.47***	0.49***	0.23
Log EU trade mark stock per employee	0.28***	0.31***	-0.10
Log NAT trade mark stock per employee	0.52***	0.53***	0.54***
Log EU design stock per employee	0.01	<0.01	0.11
Log NAT design stock per employee	0.07***	0.07***	0.13
Year dummies	Not reported°	Not reported	Not reported
Constant	4.97***	4.88***	5.34***

Number of observations = 705 929 and number of firms = 130 555 for overall model
Number of observations = 575 565 and number of firms = 109 159 for SMEs model
Number of observations = 130 364 and number of firms = 21 396 for large companies model
Overall model – R2 within = 0.03; Prob > F = 0.000
SMEs model – R2 within = 0.03; Prob > F = 0.000
Large companies model – R2 within = 0.05; Prob > F = 0.000
~ = dummy variable; * = significant at the 10 per cent level; ** = significant at the 5 per cent level; *** = significant at the 1 per cent level.
° Year dummy variables were included in the analysis as control variables. In order to maintain readability, these are not included in the table. The regression results can be provided on request.

Although the coefficients on European patents are slightly larger in the quality-weighted models, they remain insignificant. Moreover, a direct comparison of these coefficients to those of the count models is not appropriate because the interpretation of the coefficients is different. In particular, the coefficients in the count models measure the elasticity of revenue per employee with respect to the patent stock per employee. By contrast, the coefficients in the quality-weighted models capture the elasticity of revenue per employee with respect to a normalised index of patent quality.

Given the difficulties of interpreting the quality-weighted models, a series of regressions was also run in which the count of European patents was separated into three groups: high-quality patents; medium-quality patents; and low-quality patents. The thresholds between the groups were defined on the basis of the quality index, such that one-third of European patents would belong to each group. Each firm could hold a variety of patents of different qualities. An econometric model was then run, which sought to examine whether high-quality patents have a greater impact on firm performance than do low-quality patents. It was found that all European patent variables remain insignificant even when broken down by quality.

09 / References

A. Arrighetti, F. Landini, A. Lasagni, “Intangible assets and firm heterogeneity: Evidence from Italy”, Research Policy, vol. 43(1), February 2014.

E. Bascavusoglu-Moreau, B. Tether, “Design Economics Chapter Two: Registered Designs & Business Performance – Exploring the Link”, Intellectual Property Office, Report 2011/6, 1-36.

N. Bloom, J. Van Reenen, “Patents, Real Options and Firm Performance”, Economic Journal, vol. 112, 2002, 97-114.

Y. Cheng, F.-Y. Kuan, S.-C. Chuang, Y. Ken, “Profitability decided by patent quality? An empirical study of the U.S. semiconductor industry”, Scientometrics 82, 2010, 175-183.

J. Coombs, P. Bierly, “Measuring technological capability and performance”, R&D Management, 36(4), 2006, 421-438.

H. Ernst, “Patenting strategies in the German mechanical engineering industry and their relationship to company performance”, Technovation 15(4), 1995, 225-240.

H. Ernst, “Patent applications and subsequent changes of performance: evidence from time-series cross-section analyses on the firm level”, Research Policy 30, 2001, 143-157.

European Patent Office (EPO) and Office for Harmonization in the Internal Market (OHIM), “Intellectual property rights intensive industries: contribution to economic performance and employment in the European Union”, September 2013.

Eurostat, “Patent statistics at Eurostat: Mapping the contribution of SMEs in EU patenting”, 2014.

C. Greenhalgh, M. Rogers, “Trade Marks Incentives”, UK IPO Report, London: 2011.

C. Helmers, M. Rogers, “Does patenting help high-tech start-ups?”, Research Policy 40, 2011, 1016-1027.

Y. Kim, K. Lee, W. Park, K. Choo, “Appropriate intellectual property protection and economic growth in countries at different levels of development”, Research Policy, 41, 2012, 358-375.

J. Lerner, F. Zhu, “What is the impact of software patent shifts? Evidence from Lotus v. Borland”, International Journal of Industrial Organization, 25, 2007, 511-529.

J. Malackowski, K. Cardoza, C. Gray, R. Conroy, “The Intellectual Property Marketplace: Emerging Transaction and Investment Vehicles”, The Licensing Journal, vol. 2(2), February 2007.

E. Marrocu, R. Paci, M. Pontis, “Intangible capital and firms’ productivity”, Industrial and Corporate Change, vol. 21(2), July 2011.

F. Munari, “Review of the Literature on the Use and Impact of IPRs at the Firm Level: Patents, Trade Marks, and Designs”, Working Paper commissioned by OHIM, 2012.

F. Munari, S. Santoni, “Exploiting complementarities in IPR mechanisms: the joint use of patents, trade marks and designs by SMEs”, paper presented at the Strategic Management Society Annual Conference, Rome, IT, September 9-12, 2010.

M. O’Mahony and M. Vecchi, “R&D, knowledge spillovers and company productivity performance”, Research Policy, vol. 38(1), February 2009.

OECD, “OECD Science, Technology and Industry Scoreboard 2013”, OECD Publishing, 2013.

P. Schautschick, C. Greenhalgh, “Empirical studies of trade marks - the existing economic literature”, Working paper No. 659, Department of Economics Discussion Paper Series, University of Oxford, June 2013.

M. Squicciarini, H. Dernis, “A Cross-Country Characterisation of the Patenting Behaviour of Firms based on Matched Firm and Patent Data”, OECD Science, Technology and Industry Working Papers, OECD Publishing, May 2013.

M. Squicciarini, H. Dernis, C. Criscuolo, “Measuring Patent Quality: Indicators of Technological and Economic Value”, OECD Science, Technology and Industry Working Papers, OECD Publishing, March 2013.

J. Wooldridge, “Introductory Econometrics. A modern approach”, 5th edition, South-Western CENGAGE Learning, 2013.

TB-01-15-452-EN-C

Published and edited by OHIM

www.oami.europa.eu

ISBN 9789291562039

doi:10.2814/966299