Firms and Intellectual Property Rights: who, which, when and where

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Marcel Seip

FIRMS AND INTELLECTUAL PROPERTY RIGHTS:

WHO, WHICH, WHEN AND WHERE

MARCEL SEIP

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FIRMS AND INTELLECTUAL PROPERTY RIGHTS:

WHO, WHICH, WHEN AND WHERE

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1. Introduction

Intellectual Property Rights (IPRs) are the formal legal tools to protect and leverage intangible assets. Firms file IPRs which, if granted, provide them the exclusive rights to economically exploit those focal intangible assets (Maskus, 2000; Bekkers *et al.*, 2002; Reitzig, 2004). Intangibles that can be protected by IPRs include technological inventions (patents), reputation and goodwill (trademarks), distinctive design (design rights) or characteristic features of specific products such as plant varieties (breeders' rights). These intangible assets can all contribute directly or indirectly to innovation and growth of firms, hence IPRs filed by firms can signal the extent to which firms leverage their intangibles for innovation and growth purposes. This thesis focuses on IPRs as an indicator of those firm capabilities which drive innovation and growth through the successful realization of new economic opportunities. The main question which this thesis aims to answer is:

How do firms employ different IPRs for innovation and growth purposes?

The main question of this thesis will be addressed by decomposing it into four sub-questions which are

1. *Who is filing IPRs?* What are the main characteristics of firms employing IPRs?
2. *Which IPRs do firms file?* How do firms employ the range of IPRs to enable growth?
3. *When are IPRs filed?* At which stage in innovation processes and for which time period in the lifecycle of a firm are IPRs filed?
4. *Where are IPRs filed?* What do regional IPR filings indicate about local firm capabilities?

This thesis contributes to the existing literature which has addressed these sub-questions in various ways.

A first contribution is that it answers the ***who*** question. Regarding who is filing IPRs chapter 2 studies which firms apply for IPRs, chapter 3 asks the question whether IPR filing is more widespread across scale-ups, firms which have grown at least 20% every year for a period of at least three consecutive years. Chapter 4 provides insights about whether different firms file at a different phase of the innovation process.

A second contribution is connected to answering the ***which*** IPRs question. This thesis considers the most widely used types of IPRs which can be filed at official IPR offices by Dutch firms: patents, trademarks, design and plant breeders' rights[1]. Chapter 2 considers all of these types of IPRs and studies which types of IPRs Dutch firms prefer to file. It also studies the differences between firms in their number of filings for different types of IPRs. In chapter 3 we ask the question whether scale-ups file certain types of IPRs more often. The focus in the literature on the use of IPRs as an indicator for innovation is still very much on patents (Candelin-Palmqvist *et al.*, 2012; Hall *et al.*, 2014). Chapter 4 studies the use of trademarks as an indicator for innovation during the different phases of the innovation process. Chapter 5 studies the differences in the concentration of patent and trademark filings in Dutch NUTS-3 regions.

A third contribution of this thesis is that it answers the ***when*** question. Chapter 3 investigates the filing of different types of IPRs during the lifecycle of scale-ups. Chapter 4 contains the first study which specifically addresses the *when* question in connection with trademark filing during innovation processes. Hence, this study provides a better

[1] *Copyrights have not been included because official registration is not necessary to obtain copyright. Copyright starts automatically at the moment of creation, contrary to the four IPRs considered in this thesis. Geographical Indications also have been excluded from this analysis. They have been rarely filed in case of the Netherlands (a total of 16 Dutch filings in the period 1995-2020).*

understanding of the use of trademark filings by firms in innovation processes and the kind of innovation to which trademarks may refer.

A fourth contribution of this thesis is that it studies the ***where*** question for patent and trademark filings across regions in the Netherlands. Chapter 3 studies the location of scale-ups in connection with their IPR filings at NUTS 1-level. Chapter 5 studies the distribution of all Dutch firms with patent and/or trademark filings in the period 2006-2010 at NUTS 3-level. The distribution of the technologies to which patent filings refer reflects the technological diversification within a region. The patent and trademark filing rates are also used to signal the concentration of different capabilities which are key in enabling the successful realization of new opportunities which contribute to regional economic resilience in case of economic crisis.

The next sections will further discuss the different sub-questions and how they have been covered in the IPR literature. In the final section an outline will be given on how these sub-questions are covered in this thesis.

1.1. Who is filing IPRs?

Not every firm with intangible assets uses IPRs. In fact, surveys in many countries showed that a majority of firms with intangible assets do not rely on IPRs (see for example Cohen *et al.*, 2000 or Hall *et al.*, 2014 for a review). This may have an impact on their ability to exploit such assets (Burrone, 2005). Being unable to exploit them can negatively affect the willingness of firms to invest in the development of new intangible assets, especially costly investments in complex innovation processes (Boldrin and Levine, 2002; Boldrin and Levine, 2013). Whether firms choose to rely on IPRs covaries with many characteristics including several firm characteristics. The most important characteristics used to classify firms in most official statistics are the sector of economic activity of the firm (NACE classification) and firm size. The use of certain types of IPRs greatly covaries with the economic activity of the firm (EUIPO/EPO, 2016). Patent protection only applies to firms in sectors where innovation is mainly of a technological nature. The main economic activities of most of these firms are manufacturing, construction activities or technological services such as engineering and R&D activities. Instead, design or breeders' rights tend to be used only by firms in low-tech sectors where products stand out from similar products by their aesthetic design or the distinctive features of plant varieties in case of firms whose main activities are in plant breeding or seed trading. Contrary to patents, design and breeders' rights, the use of trademarks is not limited to firms in specific sectors. This is also reflected in the number of firms filing trademarks which is much larger than for the other types of IPRs (EUIPO/EPO, 2016; WIPO, 2019).

Firm size also matters significantly. Rammer (2002) found a positive relation of the size of a firm with both patents and trademarks filing. It is costly and complex to file a patent. Therefore, large firms are likely to file patents more often than SMEs (Rammer, 2002; Helmers *et al.*, 2011; van der Poel *et al.*, 2010; Seip and Winnink, 2017). SMEs seem to prefer cheaper and less complex types of IPRs like trademarks. Therefore, they may use these IPRs as substitutes for patents (Llerena and Millot, 2020).

Different IPR studies indicated that the use of IPRs also covaries with firm age and the stage in the lifecycle of a firm (see Castaldi *et al.*, 2020 for a review). Start-ups may file IPRs in order to attract venture capital, needed to start business or for further development and growth (Block *et al.*, 2014; Block *et al.*, 2015; Zhou *et al.*, 2016; de Vries *et al.*, 2017). Millot (2011) showed that the share of firms filing trademarks in the total sample increases with firm age, although younger firms (less than 15 years old) account for the majority of all trademark filings. As firms become mature, they enter a stage in their lifecycle where they scale-up their activities. This may also trigger the filing of IPRs to safeguard assets whose value may have grown also, together with the activities and the growth of the firm in general.

Table 1.1. provides an overview of the different firm characteristics covered in this thesis, the chapters in this thesis which cover them and the classifications used to describe these characteristics.

Table 1.1: Thesis outline: Who is filing? Firm characteristics covered

Firm characteristics	Classification/Conceptualization	Chapter
Economic activity	NACE Rev. 2 [2]	Ch. 2. Ch. 3. Ch. 4.
Firm Size	size classes based on nr of employees used by LISA as defined by the Netherlands Chamber of Commerce[3]	Ch. 2. Ch. 3.
	OECD Business Size Class based on nr of FTEs	Ch. 4.
Firm age	firm age in years at first filing	Ch. 3.
Lifecycle stage	start-ups	Ch. 4.
	scale-ups as defined by Eurostat and OECD (2007)	Ch. 3.

1.2. Which IPRs do firms file?

IPR literature still provides a rather fragmented view of how firms use the range of IPRs. Most research on the use of IPRs by firms is limited in its coverage of either firms or the different types of IPRs considered and often relies on self-reported measures. A key strength of this thesis is that most evidence on the use of IPRs by firms was based on linked data from official IPR and firm registers, which allowed for an exhaustive coverage of all firms filing IPRs within a country (the Netherlands), also including firms in sectors which consider the IPR system only marginally. This thesis focuses on the following types of IPRs:

- *Patents:* the World Intellectual Property Organization (WIPO) defines a (utility) patent as "*an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution*

[2] *https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF*
[3] *https://www.lisa.nl/include/LISA_Handboek_versie_maart_2015.pdf*

to a problem. To get a patent, technical information about the invention must be disclosed to the public in a patent application."[4] Patents are granted to anyone who invents something novel (unknown in the prior art), non-obvious and susceptible of industrial application (in European patent law). Patents concern all fields of technology including medical technologies and pharmaceuticals. Depending on the patent law involved, there are some inventions exempted from patent protection such as mathematical methods, art, programs for computers and business methods. In most countries patents can remain in force for a period up to 20 years. In case of certain pharmaceutical and plant protection products this period can be extended for a maximum of five years in contracting states of the European Patent Convention (EPC).

- *Trademarks:* according to the definition of WIPO, a trademark is "*a sign capable of distinguishing the goods or services of one enterprise from those of other enterprises.*"[5] Unlike patents, trademarks apply to a wide range of intangible assets and can also be used to protect services or more abstract intangible assets like marketing assets (e.g. a slogan or the reputation of a firm). There are three reasons why trademarks are the most widespread type of IPR used among all firms (EUIPO/EPO, 2016; WIPO, 2019). First, there are only a few requirements for trademark filing and these requirements are less stringent than those for other types of IPRs. Second, the cost of filing trademarks is low, especially compared to the costs of filing other types of IPRs. Third, trademarks can be used in all sectors, whereas other IPRs have more limited areas of application. If granted, trademarks remain in force for a period of 20 years but, unlike patents, can be renewed forever as long as they are

[4] *https://www.wipo.int/patents/en/*
[5] *https://www.wipo.int/trademarks/en*

being used in commerce and renewal fees are duly paid. Firms can therefore still use trademarks when all other IPRs have lapsed.

- *Design rights:* according to WIPO a design right *"constitutes the ornamental aspect of an article. An industrial design may consist of three dimensional features, such as the shape of an article, or two dimensional features, such as patterns, lines or color."*[6] Many firms use aesthetic design as one of the ways to ensure that their products stand out from similar products in the market and to prevent competitors from copying their products and in this way create confusion among consumers. Traditionally, design rights have been used to protect innovative and/or original industrial designs of low-tech consumer products, such as furniture, textiles, lighting, accessories, kitchen utensils and appliances, and ornamental goods in general such as jewelry and watches. In the past years they have gained in importance also for the protection of high-tech products. An example of their importance is the legal battle between Apple and Samsung. Apple accused Samsung of "slavishly copying" both aesthetic and technical features of their smartphones and tablets (Saardchom, 2014). In the European Union protection for a registered community design is for up to 25 years, subject to the payment of renewal fees every five years.
- *Breeders' rights:* according to the USPTO a breeders' right (also known as plant variety right) "*may be granted to anyone who invents or discovers and asexually reproduces any distinct and new variety of plant"*[7]. This specialized type of IPR for the protection of seeds and crops is used almost exclusively by plant breeders and seed breeding firms. In order to qualify for these exclusive rights, a variety must be new, distinct, uniform, and stable[8]. After the rights have been granted the breeder can

[6] *https://www.wipo.int/designs/en/*
[7] *https://www.uspto.gov/learning-and-resources/glossary*
[8] *https://www.plantvarietyrights.org/plant-variety-rights.html*

become the exclusive marketer of the variety, or can license the commercial use of the variety to others. In the European Union these rights are granted for a period of 20 years. In the case of trees and vines this period is 25 years.

All of these types of IPRs have in common that they require that the asset which is to be protected has to be different from what is already registered or from what can be found on the market. Some types of IPRs only apply to certain specific assets and only if these assets meet certain novelty requirements. These requirements apply in particular to patents, design and breeders' rights. Table 1.2 lists the requirements for the nature of the assets and novelty requirements for the different types of formal IPR which are covered in this thesis.

Trademarks are the most widespread type of IPR used among all firms. They are used across all sectors in the economy. On the other hand, breeder's rights are the most specific type of IPR. They only apply to one specific type of good, plant varieties. This is also reflected in the IPR filing numbers and the use of different types of IPRs across firms in different industries (EUIPO/EPO, 2016; WIPO, 2019).

Table 1.2: Thesis outline: Which IPRs do firms file? Types of IPRs and assets

IPR	Intangible assets which can be protected	Requirements
patent	Inventions: products, (industrial and technological) processes	technological invention (new to the world)
trademark	a sign (brand, logo) which distinguishes products and/or services of one firm from similar products and/or services from other firms	distinctiveness of sign: the product or service covered by the trademark does not need to be novel.
design right	aesthetic design of articles (products)	distinctive from existing designs of similar products
breeders' right	plant varieties	distinctive from existing plant varieties

1.3. When are IPRs filed?

In order to maximize the benefit from IPRs firms have to time their filing of IPRs carefully. Empirical studies into the timing of IPR filings are limited and most focus on the timing of patenting only (Harhoff and Reitzig, 2001; Johnson and Popp, 2001; Hipp and Grupp, 2005;). IPR legislations are based on the priority principle meaning that the first filer of an IPR will obtain the right to exploit an intangible asset. Being unaware of the necessity of IPR protection or postponing the filing of IPRs to delay the information disclosure required for IPR protection increases the risk that competitors will be able to monopolize the same intangible asset.

On the other hand, if firms file patents too early and subsequently disclose their new knowledge or information, they may lose their competitive advantage. This is also one of the most important reasons why firms might prefer informal protection methods to the use of formal protection methods (Cohen *et al.*, 2000; Arundel, 2001).

Other considerations may apply depending on the type of IPR, the firm filing and the type of asset involved. The general assumption here is that IPRs which are connected to R&D activities, such as patents, are filed during the early stages of innovation. On the other hand, trademarks are expected to be filed later on in the innovation process just before market introduction when R&D has been completed and market related activities start to play a major role. In Chapter 4 we find that this overall pattern is not always true, as specific firms file trademarks even in earlier stages of the innovation process.

1.4. Where are IPRs filers located?

Firms operate in specific geographical contexts and innovative firms tend to cluster in space (Feldman, 1994; Breschi and Malerba, 2001; Florida *et al.*, 2017). Firms and regions benefit from this clustering in different ways. Clustering enables firm growth and regional economic resilience. There is uncertainty about the mechanisms that make some regions more resilient to economic crises than others. Research in evolutionary economic geography indicated that regional economic and technological diversity may be sources of opportunities leading to new growth paths and increased resilience (Frenken *et al.*, 2007; Boschma, 2015; Castaldi *et al.*, 2015). Besides economic and technological diversity the literature on firm-level technological and market capabilities provides evidence that these capabilities are also crucial in driving innovation (Teece *et al.*, 1997; Duysters and Hagedoorn, 2000; Ortega, 2010). This thesis uses patent and trademark filings at regional level as a proxy for technological and market capabilities, to study their effect in fostering the development of regional growth paths arising from regional industrial and technological diversity. While regional patent filings indicate the presence of technological capabilities (Fritsch and Kublina, 2018; Filippetti *et al.*; 2020) regional trademark filings indicate market capabilities which cover market-oriented activities such as market exploration, the development of a market strategy and marketing activities (Mendonça, 2014; Castaldi, 2020).

1.5. Thesis outline

In summary, this thesis studies differences in IPR filings across firms, sectors, phases of the innovation process and regions. Research in this area provides insights about the factors which influence the propensity to file IPRs. This can inform both firms and policy makers on how IPRs enable firms to protect and leverage their intangible assets and on the use of IPR filings as indicators for innovation and capabilities which drive innovation.

This thesis aims to provide an account of how firms use the whole range of types of IPRs. Table 1.3. gives an overview of the different chapters which make up this thesis and the sub-questions covered by these chapters. With the exception of chapter 4, the evidence presented in this thesis is based on the IPR filings by Dutch firms, i.e. firms located in the

Netherlands and registered at the Dutch Chamber of Commerce. The data used in chapter 4 also include trademark filings by firms in other European countries.

Table 1.3: Thesis outline: Factors covered

Chapter	Who?	Which IPRs?	When?	Where?
Ch. 2.	Firms; all firms in the Netherlands	All registered types of IPRs		
Ch. 3.	Firms; Scale-ups in the Netherlands	Patents, trademarks, design rights	Firm lifecycle	NL Regions; NUTS-1
Ch. 4.	Firms; survey of trademark filers incl. start-ups	Trademarks referring to innovation	Phases of the innovation process	
Ch. 5.		Patents, trademarks		NL Regions; NUTS-3

Figure 1.1 provides information about the unit of analysis in each of the chapters and the IPRs covered. Chapter 2 covers all four types of IPRs. Also, the unit of analysis varies across chapters, although firms using IPRs are the subject of study in all chapters.

Figure 1.1: Thesis outline: IPRs covered and unit of analysis

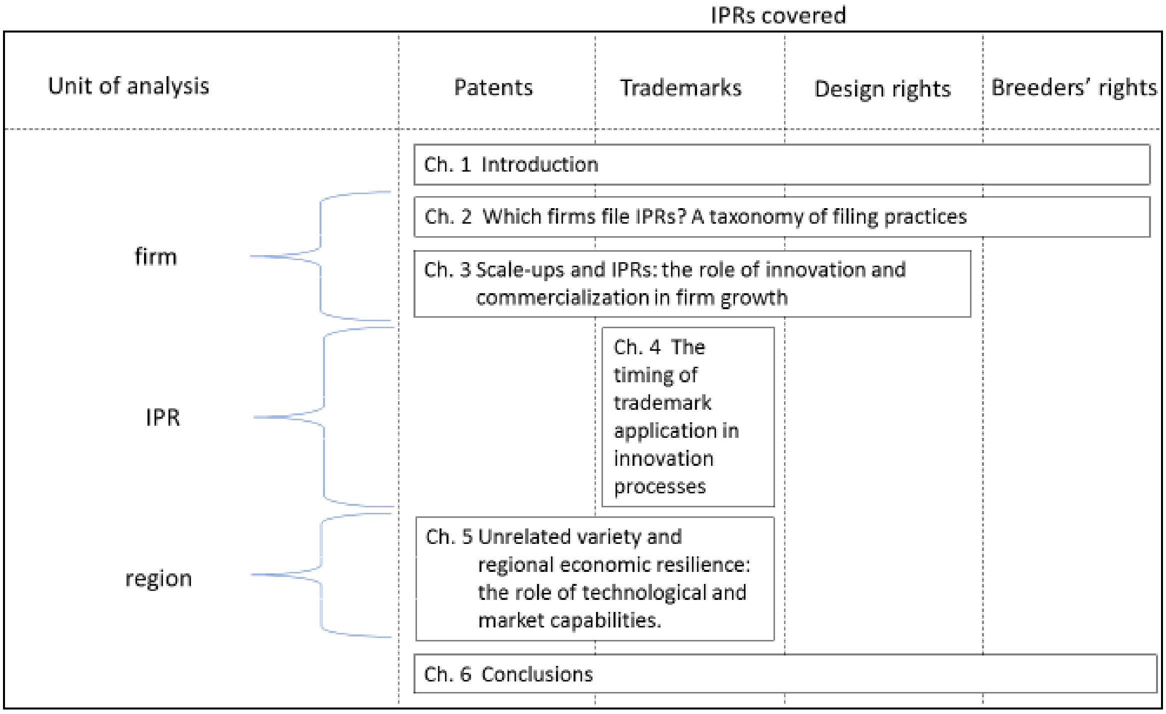


Table 1.4. provides more information about the research presented in the thesis chapters, in particular methods, data and dissemination at conferences and in academic papers. Except for Chapter 4 the evidence presented in this thesis is based on linked data from Dutch firm registers and both national and international IPR registers allowing for an exhaustive coverage of all firms filing IPRs. Next to data on firm characteristics, data was collected on firm level IPR filing variety and intensity within a period of five years. The evidence presented in chapter 4 is based on a survey among trademark filers in the Benelux and other countries in the European Union. The last two columns provide information about the dissemination of the studies included in the thesis.

Table 1.4: Research context and output of the studies in chapters 2 to 5

Title	Study	Context	Method	Data	Conference presentation	Journal publication status
Ch.2. Which firms file IPRs? A taxonomy of filing practices with Carolina Castaldi (Utrecht University), Meindert Flikkema (Vrije Universiteit) and Ard-Pieter de Man (Vrije Universiteit)	Empirical study	A taxonomy of firm-level IPR practices based on an exhaustive dataset of Dutch firms with IPR filings	Quantitative research: linking firm and IPR register data	Patent, trademark, design and breeders' right filings of Dutch firms in the period 2006-2010	Presented at AoM-conference (Academy of Management) 2018 in Chicago and EPIP-conference (European Policy for Intellectual Property) 2019 in Zürich Poster presentation at OECD (Organisation for Economic Co-operation and Development) Blue Sky Conference 2016 in Ghent	Under Review in Technovation
Ch. 3. Scale-ups and IPRs: the role of innovation and commercialization in firm growth with Anne van der Heijden and Marleen Bax (Erasmus Centre for Entrepreneurship)	Empirical study	A study of IPR filings of scale-ups: firms which have grown at least 20% every year for a period of at least three consecutive years	Quantitative research: linking firm and IPR register data	Patent, trademark and design right flings of Dutch scale-ups in the period 2000-2017		Submitted to International Journal of Innovation Management
Ch. 4. The timing of trademark application in innovation processes with Carolina Castaldi (Utrecht University), Meindert Flikkema (Vrije Universiteit) and Ard-Pieter de Man (Vrije Universiteit)	Empirical study	The use of trademarks in the phases of the firm innovation process	Quantitative research: survey	Trademark filings at BOIP (Benelux Office for Intellectual Property) or EUIPO (European Office for Intellectual Property) in 2009	Presented at EPIP-conference (European Policy for Intellectual Property) 2014 in Brussels and DRUID-conference 2015 in Rome	Published in Technovation
Ch. 5. Unrelated variety and regional economic resilience: the role of technological and market capabilities. with Carolina Castaldi (Utrecht University), Meindert Flikkema (Vrije Universiteit) and Ard-Pieter de Man (Vrije Universiteit)	Empirical study	Different types of IPRs are used to signal different capabilities at regional level which stimulate regional economic resilience	Quantitative research: economic and IPR data at NUTS 3 -level	Patent and trademark flings of Dutch firms in the period 2006-2010 in 40 NUTS-3 regions combined with economic data at NUTS-3 level.	Presented at GEOINNO-conferences 2018 in Barcelona and 2020 in Stavanger	

2. Which firms file IPRs? A taxonomy of filing practices

2.1. Introduction

Intellectual property right (IPR) systems are in place to regulate the ownership of intangibles for the sake of societal benefits, ranging from incentivizing innovation to avoiding market failures (Greenhalgh and Rogers, 2006). Increasingly, IPR systems have been the object of several critiques around their actual returns to society (Jaffe and Lerner, 2011; Heller, 2010). One of these critiques has concerned questions of *access*: to what extent are all firms able to find their way to the opportunities offered by these systems? Critical observers have suggested that IPR systems mostly serve the strategies of large corporations operating in specific sectors (Dosi *et al.*, 2006; Bessen *et al.*, 2008). Others have instead claimed that smaller and/or younger firms are also able to leverage IPRs, for instance to attract capital or via knowledge spillovers (Ziedonis, 2008; Castaldi *et al.*, 2020). Resolving these debates is hampered by a lack of solid and comprehensive empirical evidence. Studies often rely on non-random case-studies or small samples covering either large firms only or small firms only, which implies several sources of bias. A group of firms may be over-represented in the sample which makes it difficult to draw any conclusions about the whole population of firms. Even in case of random sampling of firms in surveys there may be a bias when there is a difference between firms in their willingness to participate in surveys. Moreover, empirical evidence is limited to specific sectors and firm types. This is problematic since sectoral differences and firm characteristics are considered important contingencies of firm-level IPR strategies and their instrumental validity (James *et al.*, 2013; Milesi *et al.*, 2013; Neuhäusler, 2012; Zobel *et al.*, 2017). An additional limitation is that empirical efforts have mostly been directed at investigating patent filing practices, while studies covering filings of different types of IPRs are much less common.

In this paper we rely on the construction of a unique database of a national population of IPR-active firms covering four types of IPRs (patents, trademarks, design rights and breeders' rights) to provide a much-needed overview of filing practices. Our goal is to address the topical question: *which firms file IPRs?* Our data cover all Dutch firms that filed IPRs in a five-year period. Specifically, we are able to investigate which different types of IPRs (variety) and how many filings (intensity) each firm engaged in. Through analysing the patterns of filing variety and intensity, we propose a taxonomy of IPR filing practices that can further inform debates on how and which firms access the different IPR systems.

The structure of the remainder of this paper is as follows: Section 2.2 will review the literature on firm-level IPR filing practices, while Section 2.3 will explain the data collection and data matching. Section 2.4 will present the descriptive statistics, and Section 2.5 will present our taxonomy of firm-level IPR filing practices. In the final section, we will discuss the implications of our findings and outline an agenda for future research.

2.2. Literature review of firm-level studies into IPR filing practices

2.2.1. Firm-level IPR filing practices: differences in data sources and data collection

Since the late 1970s, a large number of studies have been conducted to gain an understanding of the role and importance of IPRs in innovation processes in different industries (see the review in Hall *et al.*, 2014). However, most studies have not considered the aspect of variety in the use of IPRs, and predominantly focused on the role of patents, tending to ignore other IPRs (Hanel, 2006; Candelin-Palmqvist *et al.*, 2012). Several economics scholars, however, have emphasized the importance of looking beyond patents. For example, Graham (2008, p. 159) pointed to the need to look at the combination of IPRs in innovation research:

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

The focus of our review will be those empirical firm-level studies that have covered more than one IPR. Table 2.1 lists these studies, including the data source used and their coverage, in terms of geography, IPR variety and firms, together with the key results. These studies used data originating from two different sources: innovation surveys, including the CIS series and IPR registers.

Table 2.1. Review of empirical studies into IPR variety and intensity

Data source type	Source	Citation	Countries	IP rights covered	Firm coverage	Key results
Survey	Dun and Bradstreet	Kitching and Blackburn (1998)	South-East England	Formal and informal	400 SMEs in 4 sectors (software, design, electronics and mech engineering)	IPR variety and intensity: increased use of different types of IPR in sectors where IPRs help to increase the appropriability of innovation
Survey	CIS + interviews with 50 large service companies + Patstat (not matched)	Blind *et al.* (2003)	International	Formal types of IPR especially patents	Service industries	Patent intensity: propensity to patent and patent intensity is lower in the services sector than in the manufacturing sector
Survey	French CIS3 survey	Mairesse and Mohnen (2004)	France	Formal and informal	All sectors and firm sizes	IPR variety and intensity: innovating firms use all protection mechanisms more intensively than non-innovating firms
Survey	German Innovation Panel	Licht and Zoz (1998); Rammer (2007)	Germany	Formal and informal	All sectors and firm sizes	IPR variety and intensity: patent intensity increases with R&D expenditure; complementary use of patents and trademarks (IPR variety) in case of continuous R&D
Survey	SCIS (Statistics Canada Innovation Survey)	Amara *et al.* (2008); Hanel (2008)	Canada	Formal and informal	KIBS (Amara *et al.*, 2008) or manufacturing (Hanel, 2008)	IPR variety: patents, registration of design rights, trademarks, secrecy and lead-time advantages are used jointly
Survey	ETLA survey	Leiponen and Byma (2009)	Finland	Formal and informal	504 SME's	SMEs prefer informal protection over formal protection
Survey	CIS	Peneder (2010)	International	Formal and informal	Survey including all sectors and firm sizes	IPR variety ("full arsenal") in case of high-tech sectors
Survey	Survey on Business Strategies (SBS)	Revilla and Fernández (2012)	Spain	Formal and informal	2000 manufacturing firms	IPR intensity: regimes stimulating IPR use associated with innovative activity in small firms
Survey	German Innovation Panel	Thoma and Bizer (2013)	Germany	Formal and informal	1257 SME's	IPR variety in case of SME's: SMEs combine trademarks with technical IPRs
Survey	CIS	Brem *et al.* (2017)	Spain	Formal and informal	2873 firms > 10 employees	IPR variety: high correlation between use of different IPR types
Survey/ firm data	Carnegie Mellon Survey with Compustat	Cohen et al.(2000)	USA	Formal and informal	Large firms, all sectors	IPR variety in sectors: most sectorsreport high effectiveness scores for two or more mechanisms (both formal and informal)
Survey/ IPR registers/ firm data	MIBS survey, Australian IP databases, IBISWorld	Jensen and Webster (2009)	Australia	Patents, trademarks, design rights	1400 firms covering most sectors and sizes	IPR variety: SMEs have higher rates of patent, trademark and design usage once industry effects are controlled for
Survey/ firm data	French CIS4 survey with additional official registers	Gallié and Legros (2012)	France	Patents, trademarks, design rights, copyright	3628 firms from various sectors	IPR variety: statutory and non-statutory means of protection are complementary within their own category
Survey/ IPR registers/ firm data	Survey of German firms combined with IRP data	Neuhäusler (2012)	Germany	EPO patents (incl. intensity), domestic patents, utility models, design rights	534 manufacturing firms with at least 3 patent filings at EPO	IPR variety: different IPRs are used complementary, patent intensity and variety are correlated.

Data source type	Source	Citation	Countries	IP rights covered	Firm coverage	Key results
Linked IPR + firm data	OIPRC/OFLIP database (various firm and IP databases)	Greenhalgh and Rogers (2006); Helmers *et al.* (2011)	UK	Patents, trademarks	Broad coverage (exhaustive matching)	IPR intensity: median R&D intensity and patent intensity are higher in science-based and specialized suppliers sectors. Trademark intensity is more even across sectors.
Linked IPR + firm data	NSF, USPTO	Daizadeh (2009)	USA	Patents, trademarks	33 very large firms	IPR intensity: stronger correlation between R&D spent and trademark intensity than between R&D spent and patent intensity
Linked IPR + firm data	Compustat (firms), PATSTAT (patents), OHIM (trademarks)	Sandner and Block (2011)	International	Patents, trademarks	1216 very large firms	IPR variety and intensity: patent stock and trademark stock show strong correlation
Linked IPR + firm data	Orbis (firms), OHIM (trademarks), PATSTAT (patents)	Millot (2011)	France, Germany	Patents, trademarks	Broad coverage (exhaustive matching)	IPR variety and intensity : significant and positive correlation between trademarks and patents in high-tech manufacturing
Linked IPR + firm data	Orbis (firms), OHIM, DPMA, UKIPO (trademarks + designs), PATSTAT (patents, from EPO, WIPO, DPMA and UKIPO)	Filitz and Tether (2015a)	Germany, UK	Patents, trademarks, design rights	48.000 firms in both countries with annual revenues ≥10 million EUR	IPR intensity: in high-tech and medium high-tech sectors, German firms have considerably larger IPR portfolios than similar UK firms
Linked IPR + firm data	Compustat (firms), USPTO (patents, trademarks, copyright)	USPTO (2012)	USA	Patents, trademarks, copyright	Broad coverage of industries	IPR intensity: considerable overlap between patent intensive and trademark intensive industries
Linked IPR + firm data	Bureau van Dijk (firms), Espacenet + UIBM (patents), UIBM (trademarks)	Agostini *et al.* (2016)	Italy	Patents, trademarks	373 firms in mechanical and fashion industry	IPR variety: higher IPR variety in medium and high-tech manufacturing as compared to low-tech manufacturing
Linked IPR + firm data	ORBIS (firms), OHIM (trademarks, design rights), EPO (patents)	EUIPO/EPO (2016)	EU countries	Patents, trademarks, design rights, geographical indications	240.000 European firms	IPR intensity: many industries have intensive use of more than one of the IPRs
Linked IPR + firm data	Reach + Lisa (firms), EPO+WIPO+OCNL (patents), OHIM+BOIP (trademark, design rights), CPVO+RvP (breeding rights)	*This study*	Netherlands	Patents, trademarks, design rights, breeders' rights	More than 80% of Dutch firms applying for IP	IPR variety and intensity: full account based on exhaustive data on IPR variety, intensity, firm sector and size

The initial studies benefited from innovation surveys. They revealed the variety in both formal and informal appropriation measures but were constrained by the well-known limitations of survey studies: they sampled firms, the information was self-reported, and they did not include IPR intensities. Several widely distributed national surveys, such as the French, German, Canadian and Spanish innovation panels, have been included in Table 2.1 (Mairesse and Mohnen, 2004; Licht and Zoz, 1998; Rammer, 2007; Thomä and Bizer, 2013; Amara *et al.*, 2008; Hanel, 2008; Brem *et al.*, 2017). The use of IPRs in surveys such as the Community Innovation Surveys (CIS) (Blind *et al.*, 2003; Livesey and Moultrie, 2008; Peneder, 2010) was always self-reported using a simple dichotomy (y/n). To overcome this limitation Revilla and Fernández (2012) used the number of years during which a firm declared it had filed a certain type of IPR as a proxy for filing intensity, but this remained an imperfect measure.

Another limitation of these survey-based studies was the underrepresentation of SMEs and small firms particularly. This also applies to most studies in the middle rows of Table 2.1, where survey data were combined with firm-level IPR data from various IPR registers (Cohen *et al.*, 2000; Gallié and Legros, 2012; Neuhäusler, 2012). Most of these survey studies which included data from IPR registers, only considered patent and trademark filings. Yet another concern is the lack of in-depth information on IPRs, for example about the subject matter of protection, as the main focus of most surveys was always to study innovation and not IPRs as such. Therefore, the number and scope of the questions devoted to IPRs was typically very limited.

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

In the past two decades, the number of studies using data from IPR registers has risen substantially (see also the reviews by Hanel, 2006 and Candelin-Palmqvist *et al.*, 2012). Researchers have put considerable effort into the matching of patents and/or trademarks with firm-level economic data. Matching IPRs has proven to be doable for specific industry-focused and technology studies, but not yet in studies with a broad approach to industries or technologies. A few focused studies matched more than one type of IPR with firm-level economic data, usually patents and trademarks. These studies have been listed at the bottom of Table 2.1. Some of these studies covered a limited number of firms, which were predominantly large (Daizadeh, 2009; Sandner and Block, 2011). Most of them aimed to achieve a broad coverage of firms across all sectors and sizes by matching IPR and firm data either at the firm level (Greenhalgh and Rogers, 2006; Millot, 2012; Filitz and Tether, 2015) or by comparing aggregated IPR and firm data at the sector level (USPTO, 2012; EUIPO/EPO, 2016). Yet, none of these studies managed to be representative of all IPR types.

2.2.2. Filing variety

Concerning filing variety, a handful of studies investigated patent-trademark combinations, either in specific sectors (Amara *et al.*, 2008), in large firms (Daizadeh, 2009; Sandner and Block, 2011) or in a limited number of SMEs (Munari and Santoni, 2009; Agostini *et al.*, 2016). Studies by Greenhalgh and Rogers (2006) and Millot (2012) covered a broad range and found higher rates of firms filing both patents and trademarks, and especially by large firms in high-tech manufacturing sectors and knowledge-intensive services. Amara *et al.* (2008) also studied the use of design rights and showed that firms in Knowledge-Intensive Business Services (KIBS) relied simultaneously on patents, design rights and trademarks.

2.2.3. Filing intensity

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

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

2.3. Data collection and data matching

2.3.1. Data collection

The Netherlands Patent Office (OCNL), in cooperation with the BOIP (Benelux Office for Intellectual Property) and Panteia Business Research, linked all patent, design rights and trademark filings by Dutch firms registered at the Netherlands Chamber of Commerce between 2006 and 2010 to business register data (the REACH database[9] of Bureau van Dijk and the Dutch LISA employment register,[10]). The database covered filing at both national and international offices, specifically at the EPO (European Patent Office, patents), the WIPO (World Intellectual Property Organization, patents), the OCNL (patents), the EUIPO (European Intellectual Property Office, trademarks and design rights) and the BOIP (Benelux Office for Intellectual Property; trademarks and design rights). IPR filings by Dutch firms that were filed directly at other national offices (such as the patent and trademark offices of the US, Japan or Germany) or by foreign subsidiaries of Dutch firms were not taken into account. This implies a possible underestimation of the variety and intensity of the IPRs for firms with a broad international market scope. However, closer examination of the registers of foreign patent and trademark registers demonstrated that the number of direct filings by Dutch filers (mostly SMEs) at these offices was very small compared to those filings at offices which were included in our research. Only firms registered at the Dutch Chamber of Commerce were considered, including Dutch subsidiaries of foreign firms. Therefore, IPR filings by foreign firms (not registered at the Dutch Chamber of Commerce) at Dutch national IPR offices were also excluded.

The goal of the matching procedure was to maximize the matching percentage, i.e. the share of firms in the IPR databases matched to firms in the firm register, and reach a level higher than 80% to obtain a reliable picture of the distribution and use of different forms of IPR protection. We started by matching the name and address data for patent, trademark and design rights filers to firm register data. Because of the importance of horticulture for the Dutch economy, breeders' right filings by Dutch firms were also included: they represent a very

[9] *www.bvdinfo.com/reach*
[10] *www.lisa.nl*

specific kind of IPR and allow us to obtain a more complete picture of all IPR filings by Dutch firms. NACE codes and size classes were taken from the LISA Employment register. LISA covers all firms registered at the Dutch Chamber of Commerce and also includes information about Dutch governmental organizations with employees. This source also included information about the legal structure of firms. We used it to match a firm entity filing IPRs with the correct legal entity of a firm representing its main economic activity within a corporate tree. We would have preferred to relate the number of filings to exact firm size numbers but only firm-size classes were available. Ideally, we also would have liked to include copyrights, but we were limited to the types of IPRs requiring active filing for registration.

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

2.3.2. Data matching

To link the IPR data to firm data, we used both assignee names and harmonized address data obtained from the administrative databases of the EPO, EUIPO, BOIP, OCNL, CPVO (Community Plant Variety Office) and the Dutch Board for Plant Varieties. Thoma *et al.* (2010) provided an overview of the matching methods that are useful in matching assignee names.

Some of these methods have also been used in some of the following steps (those which involve the matching of assignee names) taken to maximize the matching rate:

1. Automated labelling of all assignees on the basis of their names: as firms, private persons, universities, non-profit organizations, etc. + manual validation of assignees labelled other than as firms

2. Removal of common Dutch firm acronyms such as B.V. and N.V.

3. Separation of IPR assignee address data into street name and number, postal code and town/city name.

4. Matching of all IPR assignees to firms in the firm database by linking the combination of postal code and street number in each database.

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

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

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

The final two steps included a manual check of the matched pairs for IPR assignees with more than 100 filings, and large firms (more than 100 employees), to verify if a link was made to the correct legal entity within the legal structure of a firm (i.e. the legal entity that represents the core business of a firm where most employees are active). In the case of large firms, many IPRs were found to be registered by entities within the legal structure of the firm that represented the holding activities rather than the main activities of the firm. In the case of such a 'mismatch', or in the case of multiple possible matches, the legal entity that represented the activities of a majority of its employees was manually selected. The final results of the matching process, which involved both automatic and manual name and address matching, are shown in Table 2.2. On average, 79% of firms filing IPRs were linked to firms in the business register. Due to the large number of trademark filers, the sixth step, which also involved assignee name matching and manual validation of the remaining unmatched assignee names, was only done for the patent, design and breeders' rights filers. As a consequence, the final matching rate was lower for the trademark filers than for the other types of IPRs. Closer examination of the trademark filing firms which were not matched indicated that most of them were small firms with only one trademark filing, probably start-ups with no active registration at the Chambers of Commerce.

Table 2.2.: Matching results of IPR filers to the Dutch business register

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

2.4. Descriptive results

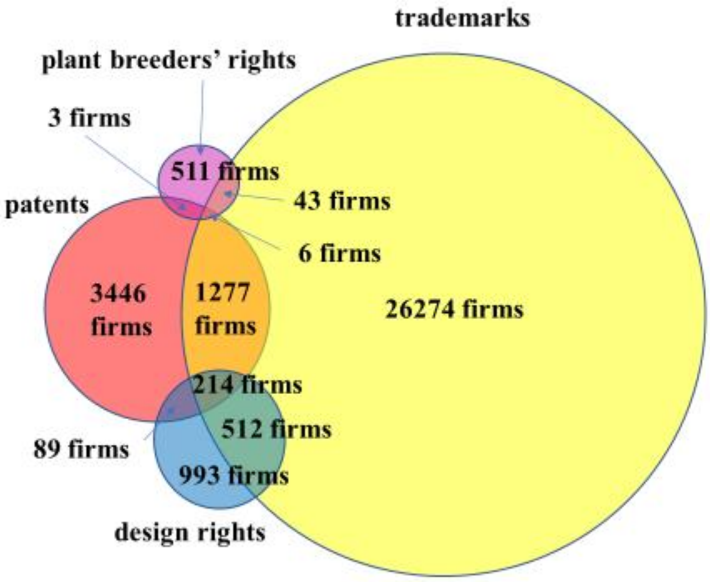
2.4.1. Filing variety

Figure 2.1 shows a proportioned Venn diagram with the frequencies of firms filing IPRs (including both "firms matched" and "firms unknown") for the four different types of IPRs covered in this study. Most firms with IPR filings in the period 2006-2010 used only one type of IPR – predominantly trademarks. The number of trademark filers was 5.6 times higher than the number of patent filers. This is in line with evidence from the USA, where the number of trademark filers was 7.7 times higher than the number of patent filers in the same period (Dinlersoz *et al.*, 2018). This is also in line with the notion that trademarks are used across more sectors and also by more firms of all sizes than other IPRs (Mendonça *et al.*, 2004).

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

Our data show that many firms with design right filings also use patents. However, the firms with plant breeders' right filings are a special group. Few of these firms combine plant breeders' rights with other types of IPRs. Those firms that did exhibit variety included a few large agrochemical firms specializing in seed production, that also filed patents and trademarks and that were also responsible for the majority of all breeders' right registrations; and firms with seed trading as their main economic activity, combining breeders' rights with trademarks.

Figure 2.1.: IPR variety: Dutch firms filing one or more types of IPRs (2006-2010)

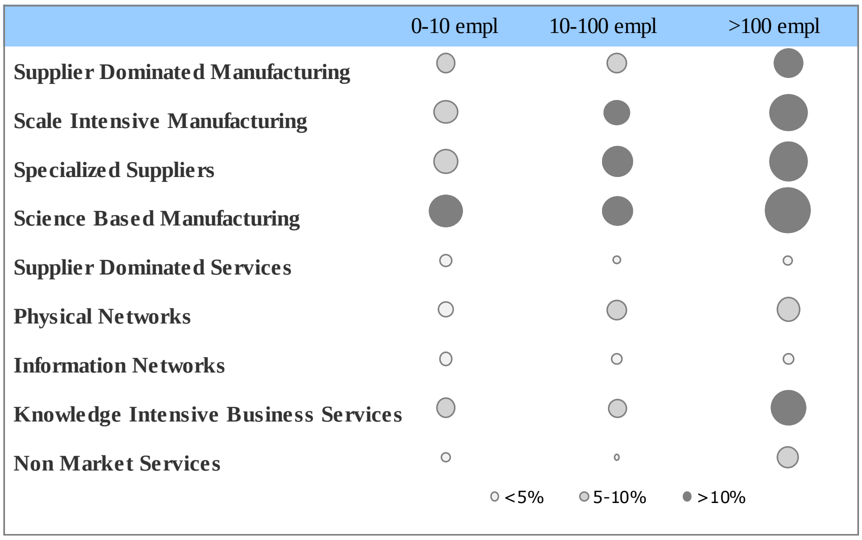


To study cross-sectoral differences in IPR variety, we relied on an innovation-based taxonomy for both the manufacturing and the services sectors proposed by Castellacci (2009) and we followed Castaldi (2009) for its implementation. The taxonomy integrated the one proposed by Pavitt (1984) for sectors in manufacturing, including supplier-dominated (SD), scale-intensive (SI), specialized suppliers (SS) and science-based (SB) sectors, and the extension by Miozzo and Soete (2001) to cover services, such as supplier-dominated services (SDS), physical networks (PN), information networks (IN), knowledge-intensive business services (KIBS) and non-market services. Castaldi (2009, Table 1) presented the classification of industries at NACE two-digit level according to this taxonomy.

The extent of filing variety depends strongly on both sector and firm size. Figure 2.2 shows the share of firms with variety in IPR practices compared to all firms filing IPRs across different sectors and size classes. The share of firms with high variety is higher in the manufacturing (SD, SI, SS and SB) than in the services sectors. In nearly all sectors, IPR variety increases with firm size. For most sectors other than manufacturing, other types of IPRs beside trademarks are also relevant. This includes the physical networks sector (PN) which includes firms with wholesale and retail as main economic activity. Most of these firms trade goods produced elsewhere, or their IPRs refer to marketing activities for existing goods. Figure 2.2 also indicates that large firms tend to combine different types of IPRs more often than small firms, especially in manufacturing sectors. In the low-tech services sectors (SDS and IN), variety does not increase with firm size. In these sectors, only trademarks are generally filed by firms, irrespective of a firm's size.

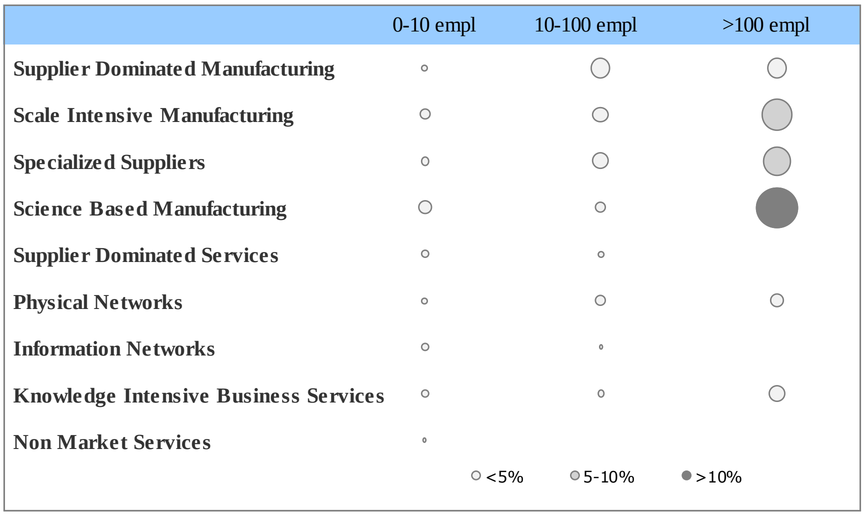
Figure 2.2: IPR variety across firm sizes and sectors

N=2 (two types of IPRs)*



*** circle size represents the share of firms with two types of IPRs among all firms with IPR filings**

N=3 (three types of IPRs)*



*** circle size represents the share of firms with three types of IPRs among all firms with IPR filings**

Differences in variety were also examined at the NACE two-digit sector level of economic activity. This level was chosen because very few firms are diversified across two-digit classes (Leiponen and Drejer, 2007) and because there were still a sufficient number of firms within each sector to obtain a reliable picture of the IPR practices within each sector. At this level, most sectors included at least 50 firms with IPR filings. The two sectors with the highest share of firms that exhibit IPR variety (i.e. filing more than one type of IPR) are the manufacture of pharmaceuticals (39.3% of all firms with at least one IPR filing) and the manufacture of computer, electronic and optical products (38.9% of all firms filing IPRs), both innovation-intensive sectors in science-based (SB) manufacturing. Table 2.3 shows the share of all filings for the different types of IPRs for firms using one type of IPR (low variety) or which use more than one type (high variety) for different sectors for the innovation-based taxonomy outlined earlier in this section. In service sectors (PN, IN, KIBS, non-market services) and low-tech sectors in manufacturing (SD) most trademarks originate from firms filing only one type of IPR. This also applies for patents although a majority of the filings in the medium and high-tech sectors in manufacturing (SI, SS and SB) originate form firms with multiple IPR practices. Most firms with design rights also use other types of IPRs. This applies to almost all sectors where these applicants can be found. The breeders' right filings show mixed results. Most filings originate from plant growers within the horticulture sector (SD). Most applicants within this sector do not file other types of IPRs.

Table 2.3: Share of firms with single and multiple practices in all filings for different types of IPRs

	trademark filings		patent filings		design right filings		breeders' right filings	
	single practices	multiple practices	single practices	multiple practices	single practices	multiple practices	single practices	multiple practices
SD	71%	29%	62%	38%	30%	70%	71%	29%
SI	41%	59%	10%	90%	13%	87%		
SS	53%	47%	27%	73%	27%	73%		
SB	27%	73%	3%	97%	5%	95%		
SDS	92%	8%	58%	42%	22%	78%	6%	94%
PN	85%	15%	51%	49%	50%	50%	43%	57%
IN	92%	8%	60%	40%	42%	58%	79%	21%
KIBS	81%	19%	57%	43%	50%	50%	100%	0%
Non market services	95%	5%	47%	53%	44%	56%		

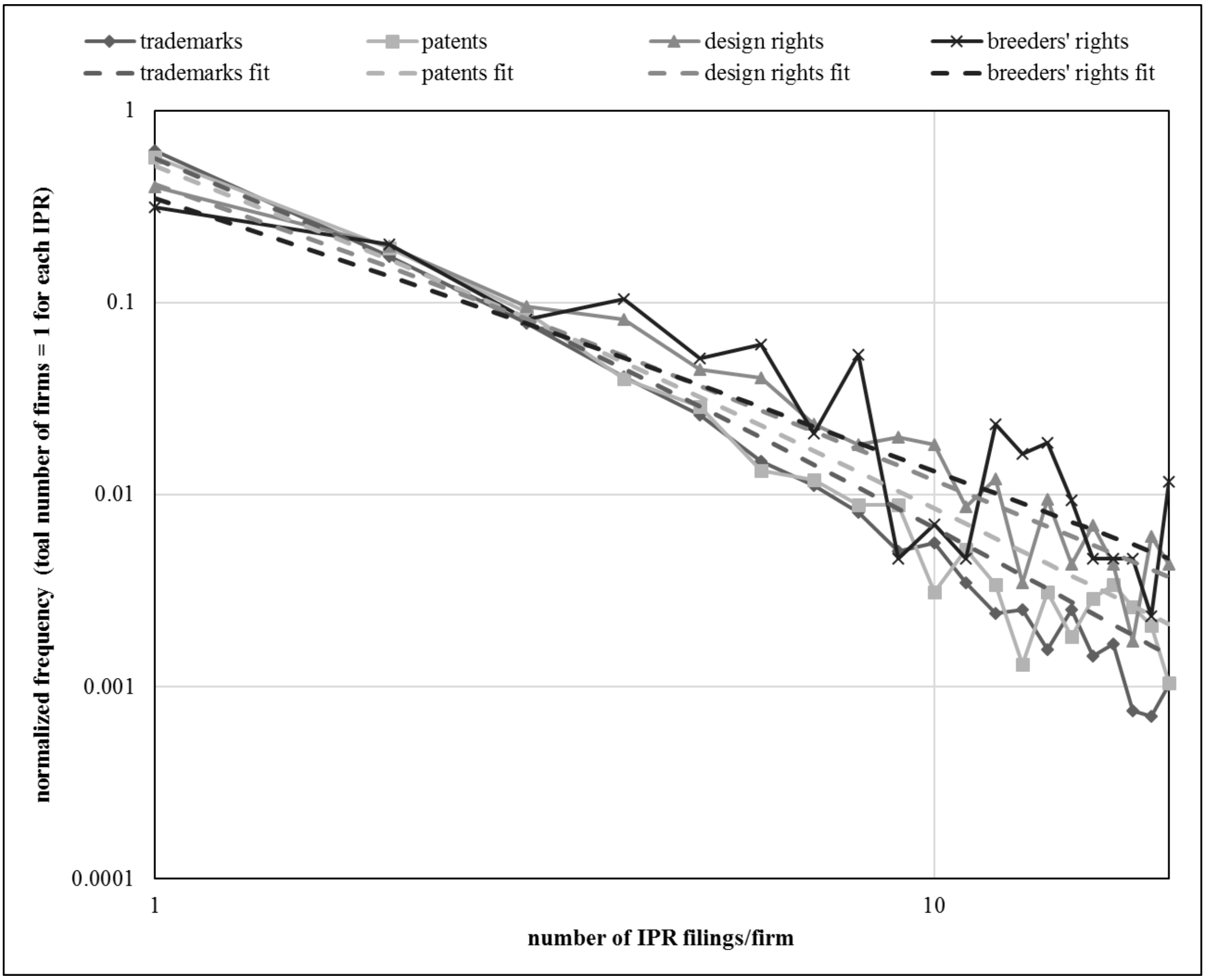
2.4.2. Filing Intensity

Figure 2.3 shows the distribution of filing intensities across firms for different types of IPRs. This distribution is highly skewed for all IPR types, implying that for most types of IPRs just a few firms are responsible for a large share of all filings. Most firms have only one filing over a five-year time period. In the case of patents and trademarks, these one-time filers account for more than 50% of all IPR filers. The increased skewness of the patent ownership distribution was observed already a few decades ago by Watson and Holman (1970) for US patent ownership between 1921 and 1962 and replicated by Moir (2009) for both US and Australian patent ownership. In accordance with their study, we also found that the distribution of the number of IPR filings by firms has a Pareto or power law distribution (Newman, 2006). Moreover, this applied to all four types of IPRs considered. In the case of discrete variables, the normalized distribution obeys the following equation (Newman, 2006):

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

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

Figure 2.3**:** IPR intensity: distribution of number of filings for one type of IPR per firm (2006-2010)



The skewness of the intensity distribution of IPR filings was also analysed at a NACE two-digit sector level of economic activity (see Table 2.4). For each sector, we calculated the following parameters capturing concentration: i) the share of patent filings within a sector by the top 5% of firms with most patent filings within a sector, ii) the share of trademark filings within a sector by the top 5% of firms with most trademark filings within a sector, and iii) the share of design rights filings within a sector by the top 5% of firms with most design rights filings within a sector. Breeders' rights were not included in this analysis because most filings originated from firms in the same sector, which was the horticulture sector.

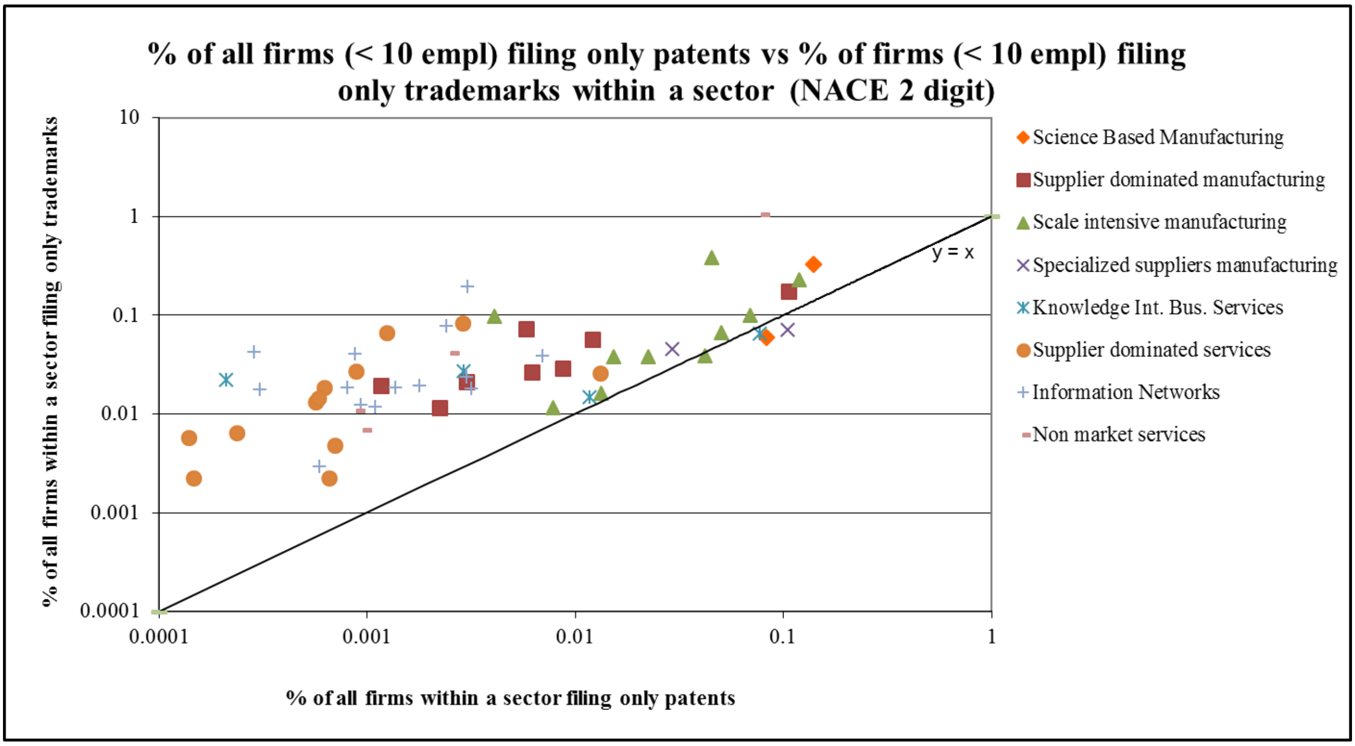
We calculated these shares for sectors at NACE two-digit level with at least 20 filers for the types of IPRs considered. Table 2.4 shows that there is considerable overlap in the sectors for each of the top-five lists. Sectors with a high concentration of one type of IPR also had a high concentration of other types of IPRs. The correlation results, based on more than 50 sectors at NACE two-digit level, revealed a significant correlation ($p < 0.05$) between the three concentration parameters.

Table 2.4: Top-five sectors (NACE 2 digit) with highest skewness of patent, trademark and design right distribution

	Share of patent filings by top 5% firms with most patent filings				Share of trademark filings by top 5% firms with most trademark filings				Share of design filings by top 5% firms with most design right filings			
Top 5 sectors	NACE 2	Sector description	nr of firms with IPRs within sector	Share (%)	NACE 2	Sector description	nr of firms with IPRs within sector	Share (%)	NACE 2	Sector description	nr of firms with IPRs within sector	Share (%)
1	26	Manufacture of computer, electronic and optical products	250	96.0	26	Manufacture of computer, electronic and optical products	250	70.0	26	Manufacture of computer, electronic and optical products	250	95.4
2	20	Manufacture of chemicals and chemical products	220	88.8	20	Manufacture of chemicals and chemical products	220	67.6	10	Manufacture of food products	220	69.7
3	72	Scientific research and development	477	72.0	10	Manufacture of food products	384	60.8	46	Wholesale trade	4548	61.1
4	10	Manufacture of food products	384	71.5	11	Manufacture of beverages	76	55.2	32	Other manufacturing	190	59.4
5	62	Computer programming, consultancy and related activities	1146	66.3	30	Manufacture of other transport equipment	97	55.0	62	Computer programming, consultancy and related activities	1146	58.4

To investigate whether high concentration within a few firms within a sector impedes small firms to use formal protection for their intellectual assets we also calculated the share of firms within all small firms (0-10 employees) within a sector (NACE two-digit level) which file either patents or trademarks. In sectors where trademarks are the only relevant type of IPR for most firms we expect that the number of firms with trademark filings exceeds the number of firms filing patents or design rights much more as compared to sectors where patent protection is much more relevant. However, figure 2.4 clearly shows that firm-level patent tendency covaries with the trademark tendency at the NACE two-digit level for firms only filing one type of IPR, although the firm-level patent tendency is on average six times lower. This holds for sectors where patents are relevant (like the science-based sectors in manufacturing, SB) as well as for sectors where patents are not relevant (like most services sectors). This indicates that in industries with a high number of patent filers the number of trademarks filers is also high, although these are not necessarily the same firms (as shown in figure 2.4). Surprisingly, the sectors with the most skewed distribution of patent and trademark intensity are also among the sectors with the highest number of small firms filing patents and trademarks. In descending order, the top three sectors with the highest amount of IPR applicants among all small firms are: manufacture of pharmaceutical products (NACE 20, SB), chemicals (NACE 21, SI) and beverages (NACE 11, SI). The manufacture of chemicals and the manufacture of beverages are also among the top five sectors with the most skewed patent and trademark intensity distribution.

Figure 2.4: Correlation between the share of firms filing only patents within all firms at NACE 2 digit sectors (< 10 employees) and the share of firms filing only trademarks within all firms at NACE 2 digit sectors (< 10 employees)



These results already indicate that the distribution of firm-level IPR filing practices varies not only between sectors but also within sectors. In the next section we will study the main IPR filing practices at the firm-level which can be discerned and how they depend on the main firm characteristics.

2.5. A taxonomy of IPR filing practices

The previous sections provided a descriptive account of the variety and intensity of new IPR filings for different sectors and firm sizes independently. In this section, we examine variety and intensity simultaneously, with the ultimate goal of developing a taxonomy of IPR filing practices. We applied a two-step cluster analysis that included all firms in our database that had filed at least one IPR in the period 2006-2010, and for which both the sector and firm-size class were known. Ideally, we would have preferred to relate the number of filings to actual firm size, but we only had firm-size classes. We controlled for this by including the firm-size class in the cluster analysis. Only firms in sectors (NACE 2-digit) covered by the innovation taxonomy outlined in section 2.4.1 (see also Table 1 in Castaldi, 2009) were considered. More than 22,000 out of almost 27,000 matched firms were included in the analysis.

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

Differences between the clusters were found mainly in IPR variety, IPR intensity and the types of IPRs used. The largest cluster contained all firms that only applied for trademarks or whose IPR portfolio is dominated by a large majority of trademarks. The smaller cluster consisted of firms filing other types of IPRs or firms that attempted to benefit from a variety of IPRs. To reveal archetypes among these firms we carried out a second cluster analysis for all firms in the smaller cluster, which amounted to 4,970 firms in this second stage of the cluster analysis. This resulted in a four-cluster solution and an average silhouette of 0.3 for cluster quality, indicating fair separation of the different clusters. Table 2.5 shows the variables that were part of the analysis and their importance for each of the two stages of the cluster analysis.

Table 2.5: Input variables for the cluster analysis.

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

The combined results for the five clusters from the two-step cluster analysis are shown in Table 2.6.

Table 2.6: A taxonomy of IPR filing practices: cluster analysis results.

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

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

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

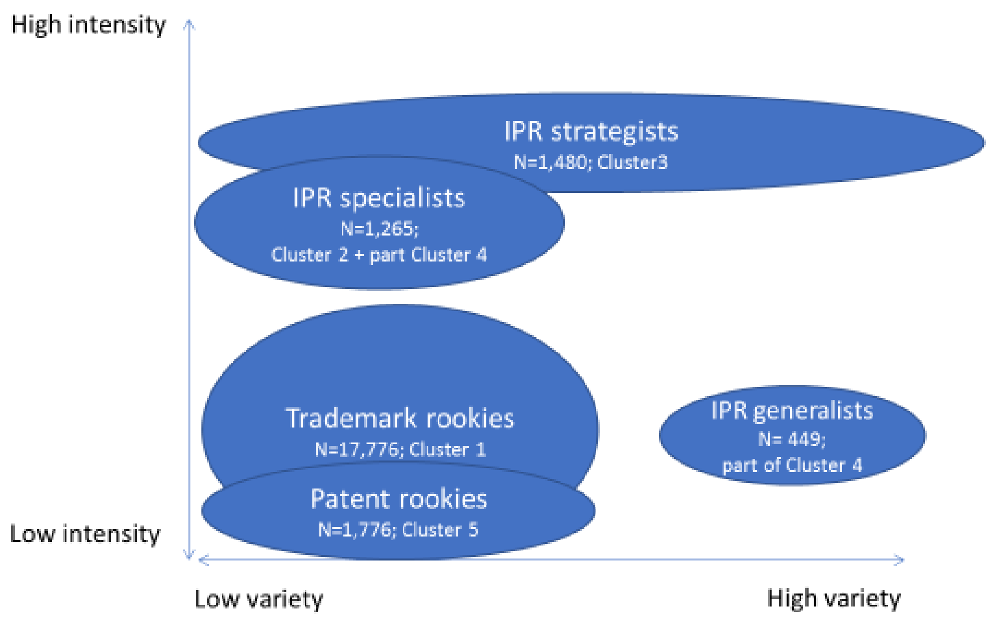
Overall, the cluster analyses resulted in five groups of IPR applicants covering all of the combinations of high and low IPR variety and intensity. When plotted in a stylized diagram, where the x-axis represents IPR variety and the y-axis IPR intensity (figure 2.5), our taxonomy reveals five archetypes, that we discuss below. Our labels were partly inspired by Alkaersig *et al.* (2015), that also proposed a taxonomy of IPR practices. Their taxonomy was based on survey data and did not consider trademarks.:

- **Trademark rookies (n = 17,776):** low IPR variety and low intensity. This was the largest cluster in the first cluster analysis, and it consisted solely of trademark filers. More than 60% of the firms in this cluster had only one trademark filing. A very small number of firms (2.6%) exhibited some variety in their IPR filings. The firms in this cluster are typically small and found in the low-tech service sectors (IN, PN and SDS). However, many small firms in the trade sector (wholesale or retail, NACE sectors 46 and 47), filing trademarks to protect the products they market with private labels, can also be found here.
- **Patent rookies (n = 1,776):** low IPR intensity and variety. All of the firms in this cluster had only one patent filing. These are typically small firms from services sectors such as Information Networks (IN) and KIBS. It is reasonable to assume that there are many high-tech start-ups in this cluster.
- **IPR specialists (n = 1,265):** low IPR variety but high intensity. The firms in this cluster are typically found in supplier-dominated manufacturing (SD) using IPRs that serve specific sector needs, such as plant breeders' rights and design rights. The cluster predominantly contains plant breeders with up to five employees, mainly filing plant breeders' rights. About 8% also used other types of IPRs, which were mainly trademarks that secured brand protection of new plant varieties. Cluster 4 also contained the majority of design rights applicants. IPR variety was also low for the majority of them.
- **IPR generalists (n = 449):** high IPR variety and moderate intensity. Typically, this cluster contained small firms in service industries – mostly in the trade sector (wholesale or retail, NACE sectors 46 and 47) – which combine different types of IPRs to safeguard protection of their offers. In this cluster, almost 55% of the firms combine trademarks with design rights. Nevertheless, IPR intensity is moderate;

almost half of the firms in this cluster applied for fewer than five IPR filings between 2006-2010.

- **IPR strategists (n = 1,480):** both low and high IPR variety but high intensity. This cluster included firms who frequently use patents or different types of IPRs to maximize the protection of their intellectual property; in other words, the most frequent IPR users. About 40% of the firms combined different types of IPRs, mainly patents and trademarks. More than 50% of the firms that combined different types of IPRs had ten or more IPR filings, which were predominantly patent filings. These serial IPR filers are mainly medium-sized and large firms in high-tech sectors such as KIBS, scale-intensive and science-based manufacturing.

Figure 2.5: A taxonomy of IPR filing practices: five archetypes



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

2.6. Discussion and conclusions

The main aim of the current study was to provide a comprehensive overview of the firms within one country which have access to IPR systems and to identify the most common practices used by firms. By using a unique dataset of a national population of firms filing IPRs this study identified five archetypes of IPRs filing practices. In this section, we will first reflect on how insights from our taxonomy may contribute to the existing literature on IPR filing practices by firms and to debates on access to IPRs for SMEs in particular. We will subsequently outline a research agenda inspired by our findings. Finally, we will offer some concluding remarks.

2.6.1. Implications for the literature on the use of IPRs by firms

The first finding is that filing across different types of IPRs (high IPR variety) and high levels of filings (high IPR intensity) are found predominantly within the same group of firms. In our taxonomy, these firms fall under the archetype of ‘IPR strategists’. They are predominantly large firms in high-tech sectors such as science-based (electronics, pharmaceutics), scale-intensive manufacturing (chemistry) and knowledge-intensive business services (R&D services). This is in line with Neuhäusler (2012) who found that firms using patents strategically did not simply rely on patents, but utilized other methods as well to appropriate their returns from innovation. Our results further reveal that these large high-tech firms not only resort to file *different* types of IPRs but also have a high filing intensity for all types of IPRs. Reitzig (2004) pointed out that combinations of patents and trademarks can help to sustain the competitive advantage firms have because of their intellectual assets. The Apple versus Samsung battle has already demonstrated that in these sectors trademarks and design rights are the subject of legal battles as much as are patents. Our study looked beyond these highly visible cases and found that there is systematic reliance on variety of IPR filings in the whole group of IPR strategists. However, these firms also reside in high-tech sectors, like the science-based (SB) and scale-intensive (SI) sector in manufacturing or the knowledge intensive business services sector (KIBS). These sectors are often characterized by (high-tech) product innovation whose different features can be protected by different types of IPRs. New technologies involved in this innovation can be protected by patents while the aesthetic design of these products can be protected by design right and trademarks can be used to distinguish these new products from similar products. Low-tech sectors in manufacturing and services, like the supplier dominated sectors (SD and SDS) are limited in their choice of IPRs. In the case of services often only trademarks apply. For the protection of specific low-tech products differentiated through design or appearance, the use of design or breeders' rights (in case of new plant varieties) may also apply. Often patents cannot be used because the innovation by firms in these low-tech sectors does not meet the criteria for patent protection.

The second finding concerns the two groups of firms labelled patent and trademark rookies. The majority of these firms showed very low filing variety and intensity, with most firms only filing one type of IPR on a very ad hoc basis. The skewness of the distribution of the different types of IPRs indicates that the tendency towards high IPR intensity is extremely low, and very few firms are serial filers. The group of patent rookies consists almost entirely of firms that used the patent system once. In this paper we confirmed evidence that patent filings are highly concentrated, while we found that this less the case for the other IPS. Additionally, the relative number of SMEs with multiple filings is higher for design and breeders' rights than patents and trademarks, suggesting that firms of all sizes are able to access these rights.

The implication of this finding is that although firms with high IPR variety and intensity are very interesting to study and are a big part of IPR-related debates, the large group of firms who only marginally use IPRs should also be considered. Our findings indicated that IPR rookies are predominantly SMEs. Other studies found that these firms tend to be in a weak position when it comes to IPR in general (Lanjouw and Shankerman, 2004; Leiponen and Byma, 2009; Thomä and Bizer, 2013). In the case of patents, Spithoven *et al.* (2013), for example, found that SMEs experience a higher threshold to file patents because of a lack of resources. However, our findings indicated that some of the sectors with the most skewed patent and trademark intensity distribution also have the highest percentage of small firms with IPR filings. This implies that, although a few large firms (IPR strategists) dominate the IPR landscape within these sectors and the filing intensity is high as well within these sectors, this does not keep small firms within these sectors from filing IPRs.

The third finding concerns firms labelled as IPR specialists. Our study shows that SMEs, in general, have low filing intensity, with the exception of some 'IPR specialists' filing design or breeders' rights that meet their specific needs. Plant breeders' rights were introduced to accommodate the special needs of plant breeders (Louwaars *et al.*, 2009; Dutfield, 2018). This might explain the popularity of these rights among SMEs as well. In the case of plant breeders' rights, SMEs especially value what is known as the 'breeders' exemption', which allows the use of protected plant varieties for further breeding and, therefore, stimulates the innovation necessary for SMEs to survive in this sector (Louwaars *et al.*, 2009).Similar arguments apply to design rights, although they are more broadly applicable IPRs. Firms in some low-tech manufacturing sectors acknowledge that design rights are the only IPR which meets the needs of their sector (Filitz *et al.*, 2015). Our results point to these IPRs being accessed by firms of all sizes, which could be taken as an indication of efficiency. We found that the distribution of both design and breeders' rights across firms was less skewed compared to patents and trademarks. Some legal scholars (e.g. Carroll, 2009) have voiced support for more tailored IPRs which meet the specific needs of firms, rather than enlarging the scope of what can be protected by more general types of IPRs such as patents and trademarks.

Finally, our findings showed that high variety also comes with low intensity, and low variety with high intensity. The firms that fall into these categories have thus far received less attention than the IPR strategists and the rookies. The most commonly used high variety/low intensity IPR combination concerns trademarks combined with design rights (55% of all IPR generalists). This combination is especially used by SMEs with trade or supplier dominated manufacturing as their main economic activity. Possible explanations for the frequent use of this combination are: i) they are combined to protect different elements of the firm intangibles, ii) they are combined frequently because in the Netherlands they are handled by the same IPR office and the application procedures are also similar, and iii) what is covered by the two IPRs significantly overlaps (Carboni, 2006). Closer examination shows that the intellectual assets which they protect tend to involve primarily low-tech product innovation focusing on differentiation through aesthetic design in simple consumer goods or domestic appliances. The corresponding trademarks may refer to this design as well or other features of the innovation involved. Additional research into these rights may reveal the most appropriate explanation for combining these rights.

2.6.2. Implications for further research

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

The first research avenue could tackle the question of how IPR filing practices relate to the properties of underlying innovation processes. Further research could look into the relation between the different archetypes in our taxonomy which is based on their IPR filings and the innovation strategy used by firms. A specific research question is whether the IPR variety, which characterizes the IPR strategists and generalists in our taxonomy, is the result of a more differentiated innovation strategy. Germeraad (2010) pointed out that the use of a certain type of IPR also depends on the innovation strategy of firms and the time to market of the type of innovation involved. One of the reasons to expect more IPR variety is a changing focus from technological innovation to broader types of innovation. Manufacturers not only compete by creating new products (including their design) or processes, but also in service innovation and their distinctive business models. The latter implies the use of various types of IPRs to protect the different elements of a new business model, from technology to new concepts and designs (Desyllas and Sako, 2013). At the same time, several service sectors have not only become more innovative, often thanks to information technologies, but have also professionalized and matured up to the point that appropriability considerations have become pressing (Miles, 1993). One key limitation of our study is that we can only observe the bundling of IPRs at the firm level and not at project level. Ongoing methodological efforts to match patent and trademark data at the project level (Thoma, 2015) will hopefully provide the opportunity to investigate the motives behind IPR variety in more detail and incorporate factors such as the complexity of a new project or its radical nature. Another limitation is that we have not taken into account the differences between IPRs of the same type like the differences in the breadth of the technologies protected between patents (number of IPC-classes involved and breadth of the claims) or the specific markets covered by the trademarks (number and types of Nice classes). For example, strategic patenting often involves “narrow” patents, i.e. in a very specific technology (Bekkers and West, 2009). Future research should also include these qualitative differences.

The second direction for further research could involve analysing the reasons why most firms focus on a preferred type of IPR (the IPR specialists in our taxonomy) and/or why they only rarely use IPR systems (the IPR rookies in our taxonomy). There may be various reasons why firms find themselves in one of the categories of our taxonomy. These reasons may include barriers to access, such as lack of resources and knowledge (Castaldi, 2018) or strategic practices by competitors (Reitzig, 2004; Germeraad, 2010), while some other related to explicit strategies circumventing IPRs, such as secrecy (Arundel, 2001; Hussinger, 2006) or lack of belief in IPR systems (Berland, 2013). The importance of these reasons may differ per category in our taxonomy. Most of the patent and trademark rookies and IPR specialists in our taxonomy were small firms with limited resources. This may lower the accessibility of types of IPRs which require the availability of sufficient resources, like patents, to these firms. The observation that all patent rookies in our taxonomy only applied once may point towards a lack of resources as a likely explanation for their limited use of IPRs. Our results also indicated that the participation of small firms in sectors with very skewed IPR distributions and high filing intensity is still very high compared to other sectors. Therefore, this does not seem to prevent them from filing IPRs. Further sector specific research is needed to give a definite answer to the question whether or not small entrants in sectors are impeded by incumbents dominating the IPR landscape within a sector. One reason why small firms within these sectors still file IPRs may be possible differences in motives between the IPR strategists responsible for the high IPR-intensity within these sectors and the small firms which are predominantly IPR rookies. The main motive for IPR strategists may be protection while small firms may use IPR to enhance reputation or involve motives related to marketing (Block *et al.*, 2015; Talvela *et al.*, 2018).

A third area of research concerns the dynamics of our taxonomy. Research may establish whether firms change categories or not and if so, which development trajectory they follow. Such research may shed light on impediments to change filing practice and factors stimulating access. This would require longitudinal research of a qualitative and quantitative nature. Qualitative research may follow individual firms to identify the mechanisms that lead and enable them to change filing practices. One of these may be the building up of capabilities in the field of IPRs, as evidenced by the presence of knowledge and resources in this area. The process of capability building may present insights that are relevant for IPR policy, as it may help to identify more targeted measures to help firms file IPRs. Quantitative longitudinal research may reveal the extent to which firms change category. If in the long run many firms develop from, for example, rookie to strategist, access may be less of an issue than when all firms stay within the same categories.

A fourth area relates to the performance implications of our taxonomy. An interesting question to research is whether there are differences in performance between the different categories in the taxonomy or whether within category performance is more diverse than across category performance. Different categories may also differ in performance according to different criteria, like innovativeness, longevity or profitability. Performance differences may provide an indication of the seriousness of limited access to IPR for some groups of firms.

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

2.6.3. Conclusions

While previous studies into IPR filing practices were limited in terms of the firms chosen or the IPRs covered, we leveraged a unique dataset providing a complete overview of all officially registered IPR filings within one country in a five-year period. Our results indicate that firms with high patent filing intensity also use other types of IPRs very frequently. Firms tend to combine different types of IPRs for the appropriation of their intellectual assets. Of all these combinations, often used by smaller firms as well, we found that trademarks and design rights are commonly combined but have received little attention in research to date.

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

3. Scale-ups and IPRs
the role of innovation and commercialization in firm growth

3.1. Introduction

Firm-level studies in various countries showed that a large share of the growth in value added and employment in highly developed countries originates from a small group of high-growth firms with year-to-year growth rates of at least 10% for at least three consecutive years (Schreyer, 2000; Almus, 2002; Deschryvere, 2008; Falkenhall and Junkka, 2009; Henrekson and Johansson, 2010; Brown and Mawson, 2016; Daunfeldt *et al.*, 2016). Because of their significant contribution to economic growth the distinctive features and capabilities of these firms have been the focus of various studies. Insight in these features may help policy makers to develop and implement policies which stimulate growth in SMEs and increase the number of high growth firms. Innovation in general and R&D in particular are believed to be the main drivers of growth and have therefore been the focus of both academic research and governmental policies to stimulate growth (Edler and Fagerberg, 2017). Therefore, various studies focused on the role of R&D in fostering firm growth (Coad and Rao, 2008; Stam and Wennberg, 2009). Less attention has been paid to the importance of the downstream activities and capabilities necessary for the commercialization of innovation as compared to the upstream activities and capabilities related to research and development. In this study we focus on the capabilities necessary for the successful development and commercialization of innovation for scale-ups. Scale-ups as defined by Eurostat and the OECD (2007) are the highest growing firms among high growth firms: they are defined as firms which have achieved an annual growth of at least 20% in at least three subsequent years and with at least 10 employees in the beginning of the period.

Innovation is instrumental to the growth of high growth firms (OECD, 2010; EPO/EUIPO, 2019). However, working on innovation alone is not enough. High growth firms distinguish themselves from other firms in their ability to turn innovation into growth. Coad and Rao (2008) found that only among a small proportion of ‘superstar’ high-growth firms, defined by them as the 90% quantiles of firms with the highest growth in their sample of firms in the manufacturing sector, did innovation have a strong effect on turnover growth. This result was supported by Stam and Wennberg (2009) who found that only for these fastest growing firms increasing R&D improves their growth rate. Besides innovation, capabilities connected with the successful commercialization of innovation play an important role in fostering growth (di Benedetto *et al.*, 2008; Cobbenhagen, 2000; Schaufeld, 2015). High growth firms, including scale-ups, not only stand out in one or more of these capabilities, they also stand out in effectively combining these capabilities (OECD, 2010).

This paper studies the importance of these capabilities within scale-ups, the fastest growing firms among high growth firms. This paper studies the role of two specific capabilities instrumental in fostering growth within firms: capabilities connected to technological R&D and innovation and capabilities connected to commercialization including marketing capabilities. This can inform firms and policy makers about the importance of these capabilities in fostering firm and employment growth.

Firms also employ IPRs to safeguard investment in innovation and other intellectuals assets. Therefore, this paper also studies the importance of different IPRs for scale-ups. If many scale-ups use (certain types of) IPRS, this may indicate that IPRs are instrumental in fostering growth through the protection of the assets of these firms. This can inform policy makers about the functioning of different types of IPR and the IPR system in general.

To answer these questions this paper studies the use of different types of intellectual property rights (IPRs) by scale-ups in general and the top 250 fastest growing scale-ups in particular. Different types of IPRs signal these different capabilities: patents signal capabilities related to technological innovation (Pakes and Griliches, 1980; Griliches *et al.*, 1986; Narin *et al.*, 1987) and trademarks the downstream capabilities connected with the commercialization of new products and services through the right positioning, value proposition and complementary assets related to this (Mendonça *et al.*, 2004; Ceccagnoli and Jiang, 2013; Castaldi, 2020). Recent papers suggested that IPR filings can also be used as an indicator of the entrepreneurial quality of start-ups (Guzman and Stern, 2016; Castaldi *et al.*, 2020). Studies by Helmers and Rogers (2010) and EPO/EUIPO (2019) found evidence that high growth firms are more likely to have filed IPRs prior to their growth period. However, both studies also indicated that the relation between the use of IPRs and high growth seems to be stronger for trademarks than for patents. This paper aims to add to these studies by focusing on the differences in capabilities between scale-ups, the firms with the highest growth among all high-growth firms. By comparing scale-ups with a group of "super scale-ups", the top 250 fastest growing firms within a country, this paper aims to provide additional information to answer the question which capabilities contribute most to the growth of these firms.

The remainder of this paper is as follows: Section 3.2 will review the literature on the factors which trigger high growth and their connection with IPR filing practices, while section 3.3 will present the data sample and methods. Sections 3.4, 3.5 and 3.6 will present the results of our analysis. In the final section, we conclude and discuss the implications of our findings for the study of scale-ups and the implication for policies which intend to foster growth in SMEs.

3.2. What makes scale-ups special? A literature review on factors triggering (high) growth

3.2.1. Factors triggering growth

A recent review of the literature on high-growth firms including scale-ups is provided by Monteiro (2019). This review provides a framework of the different factors which trigger the growth of these firms and the ability to maintain it. Many factors can trigger high growth, including exogenous factors, such as market opportunities, and endogenous factors, such as innovation (Hölzl, 2009; Brown and Mawson, 2013). Case-based studies on high growth firms including scale-ups indicated that these firms stand out in combining these factors: *"they link innovation, market and technology"* (OECD, 2010). Many of these firms respond to demand in the market through innovation. Most rely on networking and a close connection to their customers to develop innovative products and processes. Changes in demand or innovation causes the firm to adjust dynamically to these new challenges. In the end of this phase, the firm reaches a turning point (Brown and Mawson, 2013) which can result in the entrance into a phase of accelerated growth which gives the firm the status of a high-growth firm. In case high-growth firms manage to upscale even further and manage to achieve an annual growth rate of at least 20% within a period of at least three years, they obtain the status of a scale-up (Monteiro, 2019). Testa *et al.* (2019) concluded from a study of various evaluations of R&D grants that the effects of dedicated R&D grants for scale-ups in terms of firms' share of innovative sales, employment, and innovative activities are larger than the effects of generic R&D grants and R&D subsidies. This implies that scale-ups are more successful in implementing innovation which increases their potential for growth. Besides innovation and the ability to upscale efficiently other necessary characteristics for firms to become scale-ups include the presence of marketing capabilities and financial capabilities (OECD, 2010; Barbero *et al.*, 2011; Salminen *et al.*, 2019). Marketing capabilities are the routines and skills to develop and market actual new products or services and capture their economic value. Financial capabilities are an essential part of entrepreneurship. They involve the ability to access financial resources and venture capital. Both marketing and financial capabilities can help to strengthen the market position of a firm (Engel, 2002; Murray *et al.*, 2011). A strong market position and market expansion are key conduits for upscaling (Barbero *et al.*, 2011; Filatotchev *et al.*, 2017). During this upscaling process a scale-up must refine these capabilities to become or remain large (Barbero *et al.*, 2011).

3.2.2. IPRs as indicators for capabilities

IPR literature provides evidence that IPR filings by firms are useful as an indicator for technological and commercialization capabilities. Whereas patents can be used as an indicator for R&D and technological capabilities (Pakes and Griliches, 1980; Griliches *et al.*, 1986; Narin *et al.*, 1987), trademarks signal capabilities related to commercialization, including marketing and branding innovation (Mendonça *et al.*, 2004; Castaldi, 2020; Flikkema *et al.*, 2019) and signal the quality of the entrepreneurship of startups through their commercialization capabilities (Guzman and Stern, 2016; Castaldi *et al.*, 2020; Lyalkov *et al.*, 2020). Research on the use of IPRs by firms in knowledge intensive business services (KIBS) revealed that highly innovative KIBS use more trademarks than less innovative firms (Gotsch and Hipp, 2012). Finally, design rights are useful for the protection of new or improved products which distinguish themselves from similar products in the market by their aesthetic design (Filitz *et al.*, 2015). Therefore, design rights are an indicator for the capabilities of firms to use aesthetic design to highlight products in the market. However, IPRs are not perfect indicators for capabilities. Many firms with technological, commercialization or design capabilities do not file IPRs and IPRs filed by firms do not always necessarily refer to firm level capabilities. At firm level there can be a big difference between the technological capabilities of firms filing patents since patents apply to a wide range of technologies and can refer not only to high-tech, but also to low-tech innovation. Similar arguments apply to trademarks. Research on motives by trademark applicants indicated that besides protection and marketing there also many firms which file trademarks for purposes not related to commercialization (Block *et al.*, 2015b).

3.2.3. High growth firms and the use of IPRs

Studies by Helmers and Rogers (2010) and EPO/EUIPO (2019) found evidence of increased filing of trademarks in the time period prior to the high growth of firms. The evidence for other types of IPRs was less clear-cut. The study by EPO/EUIPO (2019) showed that SMEs with one or more IPRs are 21% more likely to grow and even 10% more likely to become a high growth firm (with a year-to-year growth rate of at least 10% for at least three consecutive years) than firms within the group of SMEs that have not filed IPRs. This study also found a significant correlation between high growth and the bundling of patents and trademarks or design rights and trademarks. This result may indicate that high-growth firms combine not only the capabilities to develop new products, processes or services but also the capabilities necessary to commercialize them.

Although the studies listed here found evidence for the increased use of IPRs and high growth firms there are still questions remaining which need to be answered. One of these questions is which capabilities are important for upscaling. The importance of different capabilities may vary between firms across different industries and different capabilities may have to be developed as part of the upscaling process (Hitt *et al.,* 2000; Furlan and Grandinetti, 2011, Feng *et al.*, 2017). Therefore, this study focuses on the use of IPRs by the group of scale-ups in the Netherlands, the highest growing firms with year-to-year growth rates of at least 20% for at least three consecutive years. Differences in IPR usage between the top 250 fast growing firms within these scale-ups, all other scale-ups and all firms in general may provide additional insight into the capabilities which are the most effective in fostering high-growth and effective upscaling of firms.

3.3. Sample and methods

3.3.1. The ScaleUp Dashboard

The ScaleUp Dashboard is an annual survey of fast-growing firms in the Netherlands. This dashboard provides insight into the number of scale-ups in the Netherlands, in which sectors and regions these scale-ups are active and what they contribute to the Dutch economy. This dashboard is an initiative of the Rotterdam School of Management (RSM) and the Erasmus Centre for Entrepreneurship (ECE).

The scale-ups in the dashboard meet the definition of Eurostat and OECD (2007) also mentioned in the introduction:

- Fast-growing firms are firms that have achieved growth of more than 20% per year in employees and/or turnover over a period of 3 years.
- At the beginning of the period, a firm must have 10 or more employees and/or generate a turnover of at least € 5 million.

The number of employees is measured in FTE (full-time equivalent), so that a reliable comparison can be made. This study relies on the firms in the ScaleUp Dashboard of 2017 which contained 3,237 firms which met the criteria for scale-ups. The ScaleUp Dashboard is based on the firm register of the Dutch Chambers of Commerce enriched with data from various other data sources.

The Top 250 growth firms are compiled annually based on the ScaleUp Dashboard. As its name implies, these are the 250 fastest growing firms among the scale-ups in the

Netherlands, measured over a period of three years. Interestingly innovative sectors such as, the consulting, research and technical advisory sectors, information & communication together with wholesale and retail trade account for nearly 65% of firms in the Top 250.

In this study we have compared the top 250 to the sample of other scale-ups: being part of the top 250 is the dependent variable which needs to be explained. We have collected data on various firm characteristics (sector, firm size, age and location) and capabilities as indicated by their IPR filings and used this data as explanatory variables to study which characteristics and capabilities are instrumental in their success so as indicated by their presence in the top 250 scale-ups.

3.3.2. Data sampling and collection

All data of the IPR filings between 2007 and 2017 by the top 250 scale-ups and a representative sample of the remainder of the 3,237 scale-ups were collected from public IPR registers. To check whether the data sample of non-top 250 scale-ups was a good representation of the whole population, we compared the distribution among sectors, regions and size of the firms in our sample with the whole population of scale-ups. The test showed that for a random sample of 100 firms there was substantial variation between the sample and the dashboard. By increasing the size of the random sample to 150 firms, this variation was reduced considerably and the sample proved to be representative of the scale-ups in the dashboard. Table 3.1 compares the distribution of the scale-ups in the sample among sectors (NACE 1-digit level), size (4 size classes) and location (provinces, NUTS 2-digit level) with the distribution of all scale-ups in the ScaleUp Dashboard of 2017.

Table 3.1: The ScaleUp Dashboard and the sample compared: distribution across sectors, size classes and regions

Sector (NACE 1-digit level)			Size (FTE)			Region (NUTS 2-digit)		
	Dashboard	Sample		Dashboard	Sample		Dashboard	Sample
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	20.8%	22.0%	< 25	53.0%	42.6%	North-Holland	22.6%	24.2%
M - Professional, scientific and technical activities	16.1%	17.3%	25-49	26.4%	29.1%	South-Holland	20.4%	22.1%
J - Information and communication	11.6%	11.3%	50-149	14.3%	19.6%	Gelderland	10.3%	13.4%
Q - Human health and social work activities	7.9%	10.0%	150-249	2.8%	2.7%	North-Brabant	16.3%	13.4%
C - Manufacturing	9.9%	8.7%	250-499	1.8%	4.1%	Utrecht	9.8%	10.1%
I - Accommodation and food service activities	6.4%	7.3%	≥ 500	1.7%	2.0%	Overijssel	5.5%	5.4%
H - Transportation and storage	5.8%	4.0%				Limburg	4.9%	4.7%
F - Construction	5.3%	4.0%				Friesland	2.6%	4.0%
N - Administrative and support service activities	5.7%	3.3%				Flevoland	2.5%	1.3%
L - Real estate activities	1.6%	3.3%				Zeeland	1.4%	0.7%
K - Financial and insurance activities	1.4%	2.7%				Groningen	1.8%	0.7%
P - Education	1.4%	1.3%				Drenthe	1.9%	0.0%
B - Mining and quarrying	0.4%	1.3%						
A - Agriculture, forestry and fishing	1.6%	1.3%						
S - Other service activities	1.4%	0.7%						
E - Water supply; sewerage, waste management and remediation activities	0.6%	0.7%						
D - Electricity, gas, steam and air conditioning supply	0.3%	0.7%						

We used Espacenet[11] to collect all data for patent filings at the Netherlands Patent Office (OCNL), the European Patent Office (EPO) and the World Intellectual Property Organization (WIPO). We counted DOCDB simple patent families (Martinez, 2011). We used the online register of the Benelux Office for Intellectual Property (BOIP) to collect all trademark and design right data filed at BOIP and the European Intellectual Property Office (EUIPO). No active search was done for plant breeders' rights for every firm, but the firms that are expected to deal with plant varieties based on their economic activity[12] have been checked. No firm with plant breeders' rights within the Scale Up Dashboard emerged from these checks.

3.4. Descriptive results

This section presents the descriptive results for the distribution of IPR filings for both the scale-ups in the Top 250 and the other scale-ups. Subsection 3.4.1 deals with the differences in the number of firms filing IPRs and the number of filings. Subsequent subsections present results on the distribution of scale-ups with IPR filings across sector, firm size and the timing of IPR filing during the scale-up's lifetime.

3.4.1. IPR Frequencies

Table 3.2 shows the total number of IPR filings in the Top 250 and the sample of the other scale-ups, as well as the number of scale-ups with patent, trademark or design right filings. For example, a total of 856 trademarks were filed by 166 firms among the Top 250 scale-ups. From this table, two observations can be made:

- the Top 250 stand out in terms of the number of firms filing IPRs and the number of IPR filings compared to the other scale-ups from the dashboard. 66% of the Top 250

[11] *www.espacenet.com*
[12] *NACE classes 01, 4611, 462, 4776 or 72111 including underlying classes*

firms filed one or more trademarks, compared to 25% among the rest of the scale-ups. In addition, there are four Top 250 firms with a total of five design right filings, compared to zero filings by the sample of other scale-up firms

- the number of firms with patent filings in the Top 250 is comparable to the number of firms with one or more patent filings in the sample of the other scale-ups, but the total number of patent filings by the other scale-ups is very high. This is due to two outliers in the sample of other scale-ups: one firm with 78 patent filings and another firm with 34 patent filings.

Table 3.2: IPR frequencies: number of filings and scale-ups filing IPRs

	Top 250			Sample (150 scale-ups)		
	Number of IPRs	Number of firms (% of all firms in sample)		Number of IPRs	Number of firms (% of all firms in sample)	
Patent	33	13	5.2%	122	8	5.3%
Trademark	856	166	66.4%	142	39	26.0%
Design right	5	4	1.6%	0	0	0.0%
Total	894	250	100.0%	264	150	100.0%

All firms in the top 250 with patent filings also filed one or more trademarks. In addition, more than 66% of the firms in the Top 250 filed some type of IPR, compared to less than 30% of the rest of the scale-ups.

3.4.2. Sector and size

Table 3.3 gives an overview of the most common sectors among scale-ups with one or more patent and/or trademark filings. Some notable findings are:

- the share of scale-ups in the sector of firms in professional, scientific and technical business services and the sector information & communication is higher than expected from their presence among all firms in the Netherlands (scale-ups + non scale-ups) with 10 or more employees.

- firms with patent filings are often active in the sectors: business services specializing in professional, scientific and technical activities (mainly firms with R&D, engineering and management consultancy as main economic activity), manufacturing, information & communication and wholesale & retail.
- most firms with trademark filings are found in the sectors: information & communication, business services specializing in professional, scientific & technical activities and wholesale & retail.

Not surprisingly, these sectors are similar to those where most scale-ups are found. In addition, most scale-ups with patent filings are found in the sectors focusing on scientific and technical capabilities. Scale-ups with trademark filings show a more diverse picture. Many scale-ups which are active in e-commerce, both in wholesale and in information & communication, file trademarks.

Table 3.3: Sector distribution (NACE 1-digit level)

	Dashboard	All firms CBS Statline	Patents Top250	Patents Sample	Trademarks Top250	Trademarks Sample	Design rights Top250	Design rights Sample
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	20.8%	20.8%	23%	14%	20%	10%	75%	0%
M - Professional, scientific and technical activities	16.1%	10.2%	38%	14%	23%	20%	25%	0%
J - Information and communication	11.6%	7.3%	15%	29%	24%	20%	0%	0%
C - Manufacturing	9.9%	10.6%	23%	14%	7%	10%	0%	0%
Q - Human health and social work activities	7.9%	7.5%	0%	0%	1%	5%	0%	0%
I - Accommodation and food service activities	6.4%	8.5%	0%	0%	0%	3%	0%	0%
H - Transportation and storage	5.8%	5.2%	0%	14%	0%	3%	0%	0%
N - Administrative and support service activities	5.7%	13.1%	0%	0%	12%	3%	0%	0%
F - Construction	5.3%	4.6%	0%	14%	1%	5%	0%	0%
R - Arts, entertainment and recreation	1.7%	1.9%	0%	0%	1%	0%	0%	0%
A - Agriculture, forestry and fishing	1.6%	2.3%	0%	0%	0%	3%	0%	0%
L - Real estate activities	1.6%	1.0%	0%	0%	0%	5%	0%	0%
K - Financial and insurance activities	1.4%	1.7%	0%	0%	9%	5%	0%	0%
P - Education	1.4%	1.9%	0%	0%	2%	3%	0%	0%
S - Other service activities	1.4%	2.1%	0%	0%	1%	0%	0%	0%
E - Water supply; sewerage, waste management and remediation activities	0.6%	0.3%	0%	0%	0%	3%	0%	0%
B - Mining and quarrying	0.4%	0.1%	0%	0%	0%	0%	0%	0%
D - Electricity, gas, steam and air conditioning supply	0.3%	0.1%	0%	0%	1%	3%	0%	0%
O - Public administration and defence; compulsory social security	0.0%	0.6%	0%	0%	0%	0%	0%	0%
	3237	8300	13	7	164	39	4	0

Table 3.4 shows how the scale-ups with patent or trademark filings are distributed across the different size classes. Most scale-ups are small firms; almost 80% of the scale-ups in the dashboard have less than 50 employees. For the top 250 scale-ups this number is a bit lower, 66% of the scale-ups in the top 250 have less than 50 employees. This is because the Top 250 firms have grown very fast, causing them to have a sharp rise in the number of full-time-equivalent employees (FTE) and to outgrow the smaller firm size classes a bit sooner than the other scale-ups. Firms with patent filings in both the Top 250 and the other scale-ups are relatively more often found in the larger size classes. However, it has to be mentioned that the number of scale-ups with patent filings are low. On the other hand, trademarks are also filed by the smaller scale-ups. Almost 60% of the scale-ups with trademark filings have less than 50 employees. This holds for both the scale-ups in the top 250 and the sample of other scale-ups.

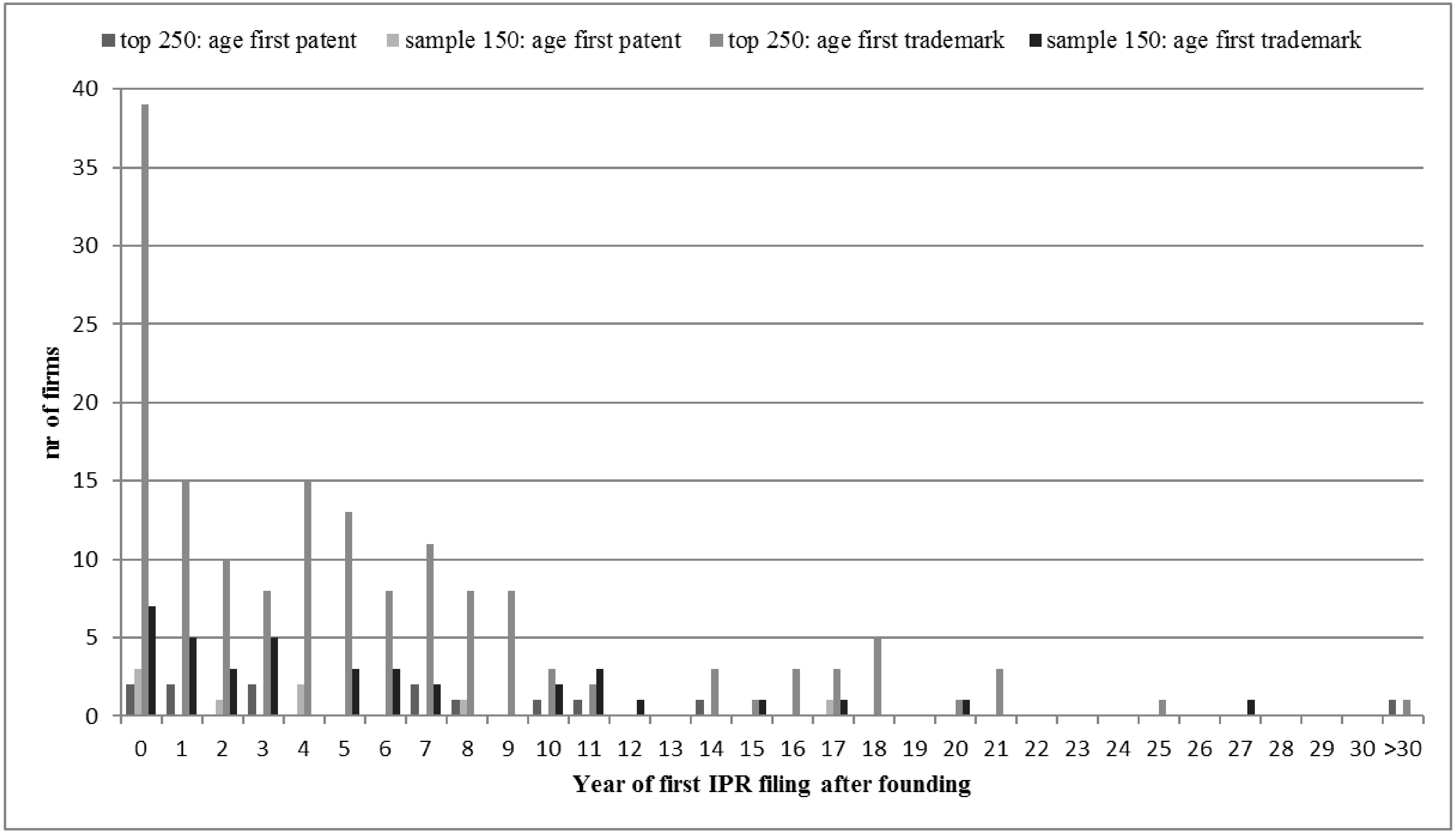
Table 3.4: Firm size distribution of scale-ups with at least one IPR filing compared to the size distribution of all scale-ups in the dashboard

	Dashboard	Patents		Trademarks		Design rights	
FTE		Top250	Sample	Top250	Sample	Top250	Sample
10-19	40.8%	31%	0%	27%	21%	50%	0%
20-49	38.5%	31%	43%	32%	36%	25%	0%
50-99	11.3%	8%	29%	14%	18%	0%	0%
100-199	4.7%	31%	14%	17%	13%	0%	0%
200-499	3.1%	0%	14%	4%	13%	25%	0%
≥ 500	1.7%	0%	0%	6%	0%	0%	0%
Total nr of scale-ups	3237	13	7	144	39	4	0

3.4.3. Timing

The age of scale-ups at the moment of IPR filing provides information about the importance of different types of IPRs during the different stages in the lifetime of a scale-up. IPRs not only can be used as a signal to the market but also as a signal to essential stakeholders whose resources are needed to outgrow the startup phase and enter the scale-up phase. Early IPR filing during the startup phase may indicate entrepreneurial capabilities which are already present when the firm is founded and which are essential for its success, for example in order to attract necessary venture capital to achieve growth (Block *et al.*, 2014, Zhou *et al.*, 2016; De Vries *et al.*, 2017; Castaldi *et al.*, 2020; Lyalkov *et al.*, 2020). An overview of the age of the scale-up when their first patent or trademark is filed is shown in figure 3.1. The results indicate that scale-ups tend to file trademarks already at a young age. This holds especially by firms in the top 250. Patents tend to be filed more widespread throughout the lifetime of scale-ups.

Figure 3.1: Distribution of the age of scale-ups at the time of their first IPR filing: Top 250 and sample of other scale-ups (150 firms)



3.5. Regression analysis: the influence of technological and commercialization capabilities on scale-up growth

We used binary logistic regression to study the contribution of technological and commercialization capabilities (as indicated by their IPR filings) to the growth of scale-ups. As dependent variable we used a dichotomy indicating whether or not a scale-up belongs to the top 250 firms, the fastest growing firms among the scale-ups. Various firm characteristics and capabilities entered into the analysis as independent variables. We used filings of different types of IPRs as indicators for the different capabilities which are necessary for upscaling. The distribution of the number of IPR filings per firm is very skewed. More than 70% of all patent filings were filed by two of the 21 scale-ups with patent filings and in the case of trademarks 70% of all trademark filings were filed by 25% of the more the 205 scale-ups with trademark filings in our sample. To prevent the few outlier scale-ups with a high number of IPR filings have a much larger influence from dominating the results of the regression we used a dummy indicating whether a scale-up had any patent filings in the 2007-2017 period as an indicator for technological capabilities and another dummy indicating whether the scale-ups had any trademark filings in the same period as an indicator for commercialization capabilities. For an additional analysis which included all scale-ups with trademark filings we also considered IPR variety, i.e. the use of more than one type of IPR, and trademark intensity, i.e. the filing of more than one trademark (see also chapter 2). Various other dummies, nominal and ordinal variables represented the other firm characteristics which entered the analysis as independent variables:

- four different sector dummies for the four most prominent sectors of economic activity at NACE 1-digit level of the scale-ups (C - Manufacturing, G - wholesale and retail trade, J - Information and communication and M - Professional, scientific and technical activities)

- an ordinal variable for the six different firm size classes used for the scale-ups in section 4.3 (10-19, 20-49, 50-99, 100-199, 200-499 and 500 or more FTE)
- scale-up age (in years) at the start of the period of high growth
- four location dummies at NUTS 1-digit level to control for the influence of regional fixed effects

Table 3.5 shows the results of the correlation analysis. Scale-ups in the ICT sector and scale-ups with trademark filings show a significant positive correlation with being part of the top 250 whereas scale-ups residing in the eastern provinces of the country (Overijssel, Gelderland and Flevoland) show a significant negative correlation with the top 250. The other characteristics, scale-up size and age and patent filings do not correlate significantly with the top 250. Patent filing correlates significantly with scale-ups in manufacturing whereas trademark filing correlate significantly with firms in the ICT sector and also with firm size. Finally, patent filing by scale-ups also correlates positively with trademark filing.

Table 3.5: Correlation results

		Top 250	manufacturing sector	trade sector	ICT sector	prof., science & tech. services sector	size	age	Northern region	Eastern region	Western region	Southern region	patent filing	trademark filing
Top 250	Pearson Correlation	1												
	Sig. (2-tailed)													
	N	398												
manufacturing sector	Pearson Correlation	-.044	1											
	Sig. (2-tailed)	.378												
	N	398	398											
trade sector	Pearson Correlation	-.079	-,149**	1										
	Sig. (2-tailed)	.117	.003											
	N	398	398	398										
ICT sector	Pearson Correlation	,136**	-,133**	-,253**	1									
	Sig. (2-tailed)	.006	.008	.000										
	N	398	398	398	398									
prof., science & tech. services sector	Pearson Correlation	.062	-,144**	-,273**	-,243**	1								
	Sig. (2-tailed)	.215	.004	.000	.000									
	N	398	398	398	398	398								
size	Pearson Correlation	.054	.015	-.065	.022	-.003	1							
	Sig. (2-tailed)	.281	.766	.194	.663	.952								
	N	398	398	398	398	398	398							
age	Pearson Correlation	-.038	,199**	-.045	-,108*	-.033	,186**	1						
	Sig. (2-tailed)	.455	.000	.370	.032	.518	.000							
	N	398	398	398	398	398	398	398						
Northern region	Pearson Correlation	.076	-.041	.084	.042	-.096	-.044	-.032	1					
	Sig. (2-tailed)	.132	.410	.096	.404	.055	.384	.529						
	N	398	398	398	398	398	398	398	398					
Eastern region	Pearson Correlation	-,100*	.040	-.012	-.060	.069	-.080	.017	-,120*	1				
	Sig. (2-tailed)	.047	.432	.814	.230	.167	.112	.729	.016					
	N	398	398	398	398	398	398	398	398	398				
Western region	Pearson Correlation	.049	-.051	-,127*	,117*	.022	.096	.015	-,347**	-,532**	1			
	Sig. (2-tailed)	.328	.314	.011	.020	.661	.057	.763	.000	.000				
	N	398	398	398	398	398	398	398	398	398	398			
Southern region	Pearson Correlation	-.020	.057	,121*	-,124*	-.029	-.017	-.015	-,125*	-,192**	-,552**	1		
	Sig. (2-tailed)	.685	.257	.016	.013	.560	.729	.768	.013	.000	.000			
	N	398	398	398	398	398	398	398	398	398	398	398		
patent filing	Pearson Correlation	-.004	,107*	.010	.004	.045	.038	.082	.020	.023	-.062	.046	1	
	Sig. (2-tailed)	.930	.033	.848	.932	.372	.444	.100	.686	.653	.214	.362		
	N	398	398	398	398	398	398	398	398	398	398	398	398	
trademark filing	Pearson Correlation	,387**	.040	-.089	,135**	.028	,201**	-.012	-.018	-.041	-.001	.054	,162**	1
	Sig. (2-tailed)	.000	.427	.077	.007	.580	.000	.818	.718	.418	.978	.281	.001	
	N	398	398	398	398	398	398	398	398	398	398	398	398	398

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 3.6 shows the results of the regression analysis for three models where the dependent variable is a dummy indicating whether or not the scale-up belongs to the group of the top 250 fastest growing ("super")-scale-ups:

- one model which includes all scale-ups and their main characteristics (sector, size, age) as independent variables. It also controls for location (NUTS 1-digit level)
- one model which also includes all scale-ups and is similar the first model but were the technological and commercialization capabilities were added as additional independent variables
- one model which includes all scale-ups with trademark filings and includes both the main scale-up characteristics (sector, size, age, location) and the characteristics of their IPR portfolio (firm age at first fling, IPR variety and intensity) as dependent variables. This model has been added because of the significance of commercialization capabilities (as indicated by the high number of scale-ups with trademark filings)

For reasons of redundancy the dummy for the highest firm size class and the dummy indicating that a scale-up resides in the eastern part of the Netherlands was omitted from the analysis. Scale-ups in the other three parts of the Netherlands were therefore compared to scale-ups in the eastern part of the Netherlands which showed a negative correlation with being part of the top 250 scale-ups (table 3.5). We tested for multicollinearity. No evidence for multicollinearity was found for all three models. In the model without capabilities two sector dummies show significant results within the 10% level. Scale-ups in information & communication and professional, scientific and technical activities show a higher tendency for being part of the top 250. Scale-up size is not significant except for the highest size classes. This can be explained by the fast growth of the top 250 scale-ups: they manage to upscale faster and more efficiently than the other scale-ups and therefore are found in the highest size classes more often. Firm age does not show any significance. Not only newly established scale-ups can end up in the top 250. Scale-ups in the northern provinces of the Netherlands (Groningen, Friesland and Drenthe) have a higher tendency for being part of the top 250 as compared to scale-ups in the eastern part of the Netherlands.

Model 2 includes technological and commercialization capabilities as indicated by their patent and trademark filings. Including these capabilities in the model, especially the commercialization capabilities, improves the model resulting in a significantly higher R square value. Commercialization capabilities are found to be more prominent among firms in the top 250 as is indicated by a significant higher tendency for trademark filing. However, technological capabilities do not give significant results. This can be explained by the low number of scale-ups with patent filings.

A third model includes all scale-ups with trademark filings and includes characteristics of their IPR portfolio: a dummy indicating whether these scale-ups have filed their first trademark within the first three years after the start of the firm, a dummy indicating whether they have filed more than one trademark (trademark intensity) and a dummy indicating the use of different types of IPRs (IPR variety, see also chapter 2). Early trademark filing may be an indicator for the importance of commercialization capabilities during the early stages of the lifecycle of a firm. The frequent use of trademarks (IPR intensity) and the use of other types of IPRs may indicate that these firms are frequent innovators or frequently introduce new products and services to the market. IPR variety may indicate that these firms combine different capabilities, for example technological capabilities (patents) and commercialization capabilities (trademarks). All 166 top 250 firms with trademark filings and 39 other scale-ups with trademarks entered the analysis. The results do not reveal significant differences in these characteristics between scale-ups in the top 250 with trademark filings and other scale-ups with trademark filings.

Table 3.6: Regression results: the dependence of top 250 membership of scale-ups on main firm characteristics and capabilities

		Model 1: scale-up characteristics				Model 2: incl capabilties				Model 3: IPR portfolio characteristics			
		Dependent: Top 250				Dependent: Top 250				Dependent: Top 250			
		all scale-ups				all scale-ups				scale-ups with trademark filings			
	Variables	B	std.err.	Wald	Sig.	B	std.err.	Wald	Sig.	B	std.err.	Wald	Sig.
Sector	C - Manufacturing	-.001	.433	.000	.999	-.199	.477	.175	.676	.315	.742	.181	.671
	G - Wholesale & Retail trade	-.086	.290	.087	.768	-.035	.319	.012	.913	.913	.640	2.038	.153
	J - Information & Communication	.895***	.341	6.881	.009	.551	.369	2.227	.136	.430	.535	.646	.422
	M - Professional, scientific and technical activities	.555*	.306	3.295	.070	.495	.333	2.204	.138	.430	.545	.622	.430
Size	Combined score			7.272	.201			7.890	.162			6.776	.238
	10-19 FTE	.717	.630	1.293	.255	.454	.705	.414	.520	19.639	12496.176	.000	.999
	20-49 FTE	.768	.624	1.515	.218	.519	.699	.551	.458	19.829	12496.176	.000	.999
	50-99 FTE	.657	.658	.999	.318	.599	.734	.666	.415	20.083	12496.176	.000	.999
	100-199 FTE	-.014	.698	.000	.984	.252	.776	.106	.745	19.294	12496.176	.000	.999
	200-499 FTE	1.524*	.821	3.450	.063	2.081**	.906	5.275	.022	21.342	12496.176	.000	.999
	≥500 FTE												
Age	Scale-up age (years)	.005	.008	.418	.518	.004	.009	.151	.697	-.001	.014	.005	.946
Location	North	1.129**	.519	4.729	.030	1.151**	.555	4.306	.038	.676	1.212	.311	.577
	West	.457	.300	2.326	.127	.486	.329	2.183	.140	-.488	.630	.599	.439
	South	.448	.373	1.443	.230	.234	.407	.330	.566	-1.285*	.694	3.424	.064
	East												
capabilties	technological (patents)					-.803	.528	2.309	.129				
	commercialization (trademarks)					1.893***	.259	53.468	.000				
IPR portfolio characteristics	entrepreneurship (first trademark within 3 years after start									-.195	.414	.221	.638
	IPR variety (>1 type)									-.122	.420	.084	.771
	tm intensiy (>1 trademark filing)									-.545	.615	.783	.376
Constant	Constant	-3.971**	1.277	9.663	.002	-3.463**	1.455	5.663	.017	-21.803	12496.176	.000	.999
	Nagelkerke R square				.085				.269				.149
	N				398				398				205

*/**/*** significant at the 10/5/1 % level

3.6. Scale-ups and non-scale-ups: IPR filings compared

In the previous sections we studied the distribution of IPR filings across scale-ups in the 2007-2017 period. The results indicated that the top 250 scale-ups have a higher tendency to file trademarks as compared to other scale-ups. The use of different types of IPRs is also more common among top 250 scale-ups. In this section we study whether scale-ups apply for IPRs proportionately more often than other Dutch firms. Next to the top 250 firms and the sample of 150 other scale-ups a third group is added to the analysis as a reference group. Both the top 250 and the sample of other scale-ups were compared to this reference group.

A problem here is that the only data available to serve as a reference group is a dataset with all Dutch firms with IPR filings in the 2006-2010 period. Therefore, there are limitations when comparing the results from the different datasets. The time period considered is different, as is the length of the period. To account for the difference in length of the period time considered, an adjustment therefore has to be made to obtain estimations for the number of firms filing a certain type of IPR within a time period of 10 year. This was done by determining the yearly growth rate of the number of firms filing patents and firms filing trademarks within each firm size class for each consecutive year in the 2006-2010 period and use these growth rates to extrapolate the number of IPR filers to a period of 10 years. Although yearly growth rates for firms filing IPRs may have been different for the period after 2010, previous reports on patent filings in the Netherlands indicated that there was little change in the demographics and numbers of patent filing firms in the Netherlands (van der Poel *et al.*, 2010; Seip and Winnink, 2017). Both the number of firms and the distribution among sectors show little variation. This also holds for the distribution of the size of firms with patent filings. BOIP's annual figures for trademark and design right filings also show little change over the recent years[13]. Therefore, a reliable comparison between the different data sets is still possible.

The results for the different size classes are shown in table 3.7. Especially among the top 250 scale-ups the share of firms filing trademarks is very high as compared to the other scale-ups. In every size class more than 50% of the top 250 scale-ups have filed trademarks. For the other scale-ups, the share of firms filing trademarks is comparable to all other firms. For the firms with patent filings, there is no significant difference between the top 250, the rest of the scale-ups and the estimates for all firms. One reason for this may be the large share of

[13] Available at: https://www.boip.int/en/entrepreneurs/about-boip/previous-annual-reports

firms in services, especially wholesale and retail, among the scale-ups. Firms in services show a smaller tendency to file patents as compared to firms in manufacturing.

Table 3.7: Patent and trademark tendency compared of top 250, other scale-ups and all firms in different size classes

	% of firms with patent filings among all firms within group			% of firms with trademark filings among all firms within group		
FTE	Top 250	Other scale-ups	All firms*	Top 250	Other scale-ups	All firms*
10-19 FTE	5.4%	1,6%	2,3%	60.8%	13,1%	15,5%
20-49 FTE	4.4%	5,2%	5,0%	59.3%	24,2%	27,6%
50-99 FTE	2.9%	11,8%	7,8%	65.7%	41,3%	40,3%
≥100 FTE	8.0%	14,0%	14,5%	88.0%	70,2%	50,0%

* based on an extrapolation of 2006-2010 IPR filing data of Dutch firms

3.7. Discussion and Conclusions

This paper presented an analysis of the IPR filings which signal firm level capabilities which foster the successful development and commercialization of innovation by scale-ups in the Netherlands. Scale-ups are the firms with the highest growth in employees or turnover (at least 20% growth every year) for a period of at least three consecutive years. Insight in these capabilities may inform entrepreneurs and policy makers in developing measures and policies which stimulate firm and employment growth. In this paper the IPR filings by scale-ups were used as a proxy for these capabilities. An important finding was that firms in the top 250 stand out from other scale-ups in their commercialization capabilities. Two thirds (66%) of these firms filed one or more trademarks. Because many scale-ups are found in innovative sectors such as, the consulting, research and technical advisory sectors and information & communication this may indicate that these firms combine innovation with the downstream capabilities needed for the successful commercialization of innovation which enable them to grow. This result is consistent with the findings of a recent study into high growth firms conducted by EPO and EUIPO (EPO/EUIPO, 2019). By comparing the top 250 scale-ups with other scale-ups this paper has provided additional evidence that commercialization capabilities contribute more to the growth of these firms than technological capabilities. Therefore, in order to stimulate growth within firms besides stimulating R&D and innovation governments should consider the introduction of policy measures which stimulate the development of commercialization capabilities across firms.

Additional research with a larger sample of firms, both scale-ups and non-scale-ups, is needed to provide more insight into the contribution to the growth and the upscaling process of the different capabilities. In this paper patent filing was used as proxy for technological capabilities. However, relatively few firms have patent filings. This also applies to the scale-ups with design rights. The lack of patent and design right filings may indicate that relatively few scale-ups excel in these capabilities but it also may indicate that few scale-ups tend to file patents or design rights despite their technological and design related capabilities and innovative activity. This may also inform policy makers whether these firms experience a higher threshold to file patents and design rights.

The combination of different types of IPRs may indicate that these firms combine different capabilities. The study by EPO/EUIPO (2019) found that high-growth firms in manufacturing are more likely to file patents or design rights and combinations of different IPRs. These results could not be replicated in this study. More scale-ups have to be included to be able to study whether scale-ups combine different capabilities more often as compared to other firms.

The timing of IPR filing may also signal the presence of other firm-level capabilities necessary for growth. Early IPR filing may signal capabilities which indicate quality of the entrepreneurship in firms (Castaldi, 2020; Lyalkov *et al.*, 2020). Scale-ups have a tendency to file trademarks already early on during their lifetime as compared to other types of IPRs. On average, scale-ups are younger and smaller when they apply for their first trademark than when they apply for their first patent. For the few cases in our sample where scale-ups have filed both trademarks and patents, the trademarks were filed earlier than the patent. Few firms start off with filing a patent and then follow this up with a trademark. This confirms findings in the literature concerning the timing of trademark filing in innovation processes (de Vries *et al.*, 2017; Seip *et al.*, 2018). Additional research of patent-trademark pairs may provide further insight in the combination of capabilities and the link with the timeliness of their usage in innovation processes.

Additional research is also needed into the motives for filing IPR of scale-ups. These motives may provide more insight into the connection between the different capabilities of scale-ups and their use of IPRs. Study on the motives of firms for filing IPRs reveal that signalling is an important motive for SMEs. This holds especially for trademark filing. They are not only used as a signal to the market but also to other firms and venture capitalists. These motives therefore indicate not only the downstream capabilities of SMEs necessary for the commercialization of new products and services (Block *et al.*, 2015b; Castaldi, 2020).

A final more general conclusion which can be learned from this study is that trademarks mark the success of firms. Research by Sandner (2009), Helmers and Rogers (2010) and EPO/EUIPO (2019) already indicated that trademarks are a useful indicator for determining firm valuations. This is supported by the high tendency of scale-ups, especially firms in the top 250, to file trademarks, which was found in this study.

4. The timing of trademark application in innovation processes

4.1. Introduction

An emerging field of empirical literature is concerned with how trademark statistics might potentially measure innovation (Allegrezza and Guarda-Rauchs, 1999; Greenhalgh and Rogers, 2012; Schautschick and Greenhalgh, 2016; Schmoch, 2003). Because many trademarks are filed to signal the introduction of new products or services (Mendonça *et al.*, 2004) and because they are usually assumed to be filed close to the market introduction of new products (Hipp and Grupp, 2005), they may measure downstream, late-stage innovation that is not adequately captured by patent statistics (Candelin-Palmqvist *et al.*, 2012; Flikkema *et al.*, 2014). Other authors argued that trademarks may be filed earlier in the innovation process and may therefore indicate early stage innovation as well (Lemper, 2012; and Zhou *et al.*, 2016). This paper investigates whether organizations file trademark applications early or late in the innovation process, examining factors influencing the timing of trademark applications.

The current literature provides competing predictions about the timing of trademark applications. However, the empirical evidence is scarce and the results mixed. To enhance our understanding, this paper considers the timing of trademark application during the innovation process. We explore whether trademark application timing can be explained by two factors, around which there are competing views in the literature: the joint use of patents and trademarks, and the micro-level innovation mode. This approach will help us gain insight into whether trademarks can be used to measure innovation at different stages of the innovation process. In Section 4.2, we review the literature about the timing of patent applications to determine whether reasons for early or late filing identified in relation to patents also apply to trademarks. This review provides the background for Section 4.3, in which we consider the competing explanations of why companies apply for trademarks early or late in the innovation process. In Section 4.4, we present the research design and the data collection methods. Section 4.5 is dedicated to the results, while the final section includes the discussion and implications for future research.

4.2. The timing of patent and trademark application

Firms benefit from various intellectual property rights (IPRs) to appropriate returns from innovation (Davis, 2006; Teece, 1986). The actual timing of the engagement of different IPRs requires great precision. Empirical studies into the timing of such applications are limited and most focus on the timing of patenting in particular (Harhoff and Reitzig, 2001; Hipp and Grupp, 2005; Johnson and Popp, 2001). The reason for early patenting is obvious and embedded in the patent system: the first to file a patent which is ultimately granted, gains the monopoly right.

Because of their nature and relatively short handling times at IPR offices, the literature assumes that trademarks are registered close to the market introduction of a new product or service (Hipp and Grupp, 2005; Rujas, 1999). Studying a sample of SMEs, Flikkema *et al.* (2014) showed that this is largely correct for about 60% of the trademarks referring to innovation. The remainder of the trademarks are either registered during early innovation stages or, as occurs in a substantial number of cases, are filed after the market introduction of new products and services. As the literature only partially studies the reasons behind early or late trademark applications, we first review whether the patent literature provides arguments that may apply to trademarks as well.

The main reason for the early application for patents is that they are granted based on a priority principle. This principle may lead companies to apply for a patent as soon as possible in a patent race (Denicolo, 1996). Studies have, however, highlighted at least three reasons why inventors would delay their patent application. The first is to postpone information disclosure. Information disclosure is a prerequisite for patent application, but may also provide competitors with useful information facilitating imitation (Leiponen and Byma, 2009). Second, by postponing patent application, the length of patent protection once a product has ultimately been introduced into the market can be extended in order to better recoup development costs. The third reason is to cut the costs of patent taxes. Patent protection in multiple countries can become very costly (Berrier, 1995; Lanjouw *et al.*, 1998). Firms will therefore delay patent application until they are certain that they will recover all of the costs involved in patent application and renewal. Nevertheless, studies also emphasize that inventors may run the risk of waiting too long. Choosing the right time to file is therefore essential for patent applicants.

Early registration of trademarks may occur for the same reasons as early registration of patents. Companies may want to apply for trademarks early because, like patents, trademarks are based on priority. This implies that the first to apply for a trademark for certain goods or services in a particular country or region, acquires the legal right to prevent others from using similar trademarks in the same markets.

The three reasons mentioned above for postponing patent application, however, do not apply to trademarks. First, information disclosure only partly applies to trademarks, since a trademark only reveals some characteristics of a product and/or the firm's marketing strategy. Unlike patents, when applying for a trademark, the applicant only has to disclose a minimal amount of information about the goods or services covered by the trademark. Second, unlike patents, a trademark can be prolonged indefinitely. This is the reason why trademarks are popular in the pharmaceutical sector (Chudnovsky, 1983), fostering customer loyalty beyond patent expiration. Finally, the costs of maintaining a trademark are much lower than the costs of patent protection. Postponing a trademark application will therefore not lead to considerable cost savings.

We conclude that the arguments for the timing of patent applications shed some light on the mechanisms behind the timing of early trademark registration. The literature also shows that trademarks are used in very diverse circumstances, indicating that trademark-specific arguments may explain early or late trademark applications. In Section 4.3, we explore the consequences of combining patents and trademarks and differences between innovation modes.

4.3. Competing arguments for early and late trademark application

Table 4.1 summarizes competing arguments for early or late trademark application. It remains an open empirical question which of these are valid.

Table 4.1: Competing arguments for early versus late application for trademarks

Antecedents of the timing of trademark application	Arguments for early trademark application	Arguments for late trademark application
1. *Does the* combination with patents *affect the timing of the trademark application?*	Trademark application enables the attraction of venture capital and thus will often be filed earlier than patents.	Trademark application predominantly serves to protect brand names for new products and services, therefore it suffices to apply for a trademark just before the launch of a new product or service. Protection of complementary assets is not needed in upstream stages of the innovation process. Combination with patents reduces the need for early trademark application as a mechanism for protecting IP.
2. *Does the* innovation mode *affect the timing of the trademark application?*	*A. Length of development cycle:* i. Product innovation, new-to-the-world innovation or *B2B* innovation imply longer duration of development cycles and therefore higher probability of trademark application in the early stages to foster a market orientation. ii. For most service innovations, opportunities for patenting or benefiting from other IPRs are limited and the priority principle also applies to trademarks, which results in earlier trademark application. *B. Start-up versus incumbent firms:* Trademarks mark the start of an innovative start-up, entrepreneurs attempt to benefit from trademarks to attract venture capital in upstream stages of the innovation process and, finally, trademarks are possibly used in upstream stages of the innovation process as a substitute for patents.	A. *Length of development cycle:* i. Product innovation, new-to-the-world or *B2B* innovation imply late trademark application for reasons of very long development cycles, which approximate or exceed the period of the use in commerce requirement (five years). ii. Service innovation, *B2C* and incremental innovation have shorter development cycles and new services emerge on the service job. This leads to late trademark application. *B. Start-up versus incumbent firms:* Start-ups prefer secrecy, especially for more radical innovation, because they do not have deep pockets to counter the violation of IPRs as do mature firms.

4.3.1. Joint use of trademark and patents

In the previous section, we separately reviewed motives for early or late engagement in patent or trademark applications for innovation purposes. However, in many cases, firms apply for both patents and trademarks for reasons of complementarity (Thomä and Bizer, 2013; Zhou *et al.*, 2016; Llerena and Millot, 2020). Trademarks may prolong the time during which an innovation can be exploited in the market (Thomä and Bizer, 2013) or protect assets that are complementary to technological innovation. Block *et al.* (2015) and Zhou *et al.* (2016) emphasize the role of trademarks in attracting venture capital. Zhou *et al.* (2016) found that start-ups applying for both patents and trademarks receive higher amounts of venture capital funding than do start-ups that apply for only one. This suggests the importance of early stage trademark application.

However, there are also reasons why trademarks may be applied for later in the innovation process in cases where they are applied for in tandem with patents. The IPR literature (Hipp and Grupp, 2005) suggests that patents concern early stage innovation, whereas trademarks will be filed later, just before market entry. Trademarks fulfil a specific role in the commercialization stage, by flagging the new product introduction. They seem to protect brand equity rather than intellectual property. This specific role leads companies to apply for trademarks at a later stage. In addition, in the case of the combined use of patents and trademarks, trademarks may be applied for later, since the patent provides better protection than a trademark against the exploitation of new technologies by imitators (Llerena and Millot, 2020). The practical need for a trademark is thus less pressing.

4.3.2. Innovation mode

The literature also points to the micro-level innovation mode as an antecedent of the timing of trademark applications. The literature points to clear differences in innovation processes for Business-to-Business (B2B) and Business-to-Consumer (B2C) products versus services, incremental versus radical types of innovation, and for start-ups versus established firms. Again, theory supports competing arguments regarding whether these modes are associated with early or late application.

4.3.2.1. Length of development cycle

The literature suggests that development cycle characteristics may have an impact on early or late application for trademarks. Innovations with absolutely and relatively long development cycles, such as those in product innovation, new-to-the-world innovation and B2B innovation, have longer R&D phases than service innovations, incremental innovations and B2C innovations (Griffin, 1997, 2002). For the former innovation types, this increases the probability of companies applying in an early phase, because this phase may account for a large part of the entire process. Moreover, to improve new product performance, firms tend to integrate R&D and marketing processes, especially in the case of long and costly new product development processes (Griffin and Hauser, 1996), as in the pharmaceutical sector (Becker and Lillemark, 2006). Notwithstanding, the trademark law requires them to be used within five years of application. This may imply that the longer the development cycle, the later an organization will apply for a trademark, thus limiting the risk of an innovation not being marketed within that five-year period and the trademark lost.

In relation to service innovation, the literature argues that as trademark law is based on the principle of priority, early trademark application is essential to obtain the exclusive rights connected to the trademark (Lemper, 2012). The means of protection available in the case of service innovation is often limited to trademark application, while in the case of product and process innovation, more than one type of IPR is often available, such as patents or design rights. The development of, or control over, co-specialized assets, such as secrecy and complexity of design, are also more frequently relevant in the case of product and process innovation. Service prerequisites are easier to reconstruct, as opposed to the reverse engineering of complex products. In the case of service innovation, keeping things quiet or restricting knowledge flows is not always possible (Hurmelinna-Laukkanen and Ritala, 2010), and interdependence with customers (Xue *et al.*, 2005), which often applies to service innovation, makes relying on secrecy problematic (Hannah, 2005; Martin and Salomon, 2003).

In many cases, the delivery process is quite transparent. This is supported by empirical evidence gathered by Gallié and Legros (2012), who found the use of secrecy and complexity of design to be very limited in service sectors such as real estate and customer services compared to others. Therefore, trademarks are often the only way to protect a new service. Being first, and thus opting for early trademark application, may therefore be essential.

The arguments for the case of the later application for trademarks by service firms centre around the idea that new service development processes differ markedly from product innovation processes (Alam and Perry, 2002; Booz, Allen and Hamilton, 1982; de Brentani, 1989; de Brentani and Cooper, 1992; Sundbo, 1997), although intra-sector heterogeneity is high in the service industry (Hughes and Wood, 2000). Because of its intangible character, service innovation is difficult to capture and therefore its research & development process is also more challenging to describe (Sundbo, 1997; Drejer, 2004; Flikkema *et al.*, 2007).

Alam and Perry (2002) and Sundbo (1997) state that in most cases the generation of new ideas for services is not formalized. It is a creative and fortuitous process, mostly generated from the bottom-up and often in response to specific client needs. Therefore, very often service innovation is not or only partly planned (Flikkema *et al.*, 2007), but triggered by external influences, for example supplier dominance (Pavitt, 1984). Because of the interactive nature of services, customer orientation and interaction is very important in the processing of these new ideas.

Another reason why service innovation may lead to later trademark application is the short duration of service innovation processes. Different stages, which are separated in the product development process, may take place concurrently in the case of service innovation (Alam and Perry, 2002; Sundbo, 1997) or might be bypassed as a consequence of supplier-dominated innovation. Upstream innovation stages may therefore be particularly difficult to discern. A service innovation may often only be recognized as such after proven success in the market.

In summary, the service innovation process is less linear than the product innovation process. Moreover, development cycles are relatively shorter in service innovation (Griffin, 2002) because stages take place concurrently or may be bypassed. IPR protection may occur only when the innovation is already implemented, that is, delivered.

4.3.2.2. Start-ups versus incumbents

In relation to IPRs, the literature clearly finds that large established firms deal differently with their intellectual property compared to start-ups (Mann and Sager, 2007). Research on the use of IPRs by (innovative) start-ups provides three main reasons why they may use trademarks. First, start-ups use trademarks to attract investors. Research by Block *et al.* (2014) and Zhou *et al.* (2016) on the use of trademarks by high-tech start-up firms indicates that early trademark application may enhance their value potential for venture capitalists. Second, start-ups embody innovation, with trade names often filed to mark the start of a new, innovative company. Schneider and Veugelers (2013) found that innovative start-ups that are less than 10 years old, have less than 250 employees and spend at least 10% of their revenues on R&D use significantly more trademarks than other innovators. Finally, as start-ups have limited resources, trademarks may also function as substitutes for patents, especially in consumer-oriented markets (de Vries *et al.*, 2017). This might entail applying for trademarks relatively early in the innovation process. There is, however, also evidence that start-ups may prefer to delay trademark application. Although Schneider and Veugelers (2013) found that innovative start-ups use more trademarks than other innovators, they also found that innovative start-ups are more likely to use secrecy, which might entail the delay of IPR application, especially for radical innovation.

4.4. Survey and variables

The empirical evidence in this paper is based on data collected from a survey of trademark applicants. This survey considers individual trademarks as the units of observation, thereby providing case-level evidence on the relationship between trademarks and innovation. In cooperation with both the BOIP (Benelux Bureau for Intellectual Property) and the EUIPO (European Intellectual Property Office, formerly OHIM), an online questionnaire was distributed among applicants who applied for at least one trademark at one of the offices in 2009, and which had been granted within two years. Novagraaf, a large international IPR agency based in the Netherlands, helped in recovering contact information for large-firm applicants, who typically only report the IPR agency contact in their trademark application.

The survey set out several questions, varying from respondent characteristics, such as firm size and sector, market orientation, branding strategy and maturity of the IPR strategy, to aspects of the trademark registration process, such as motivation, involvement of trademark attorneys, timing of the trademark application and the bundling of trademarks with other IPRs. The initial sample contained responses from 1015 trademark applicants, which also included trademarks that did not refer to an innovation. After removal of these, we had a sample of 677 applicants who had applied for a Benelux Trademark (n = 288) or a

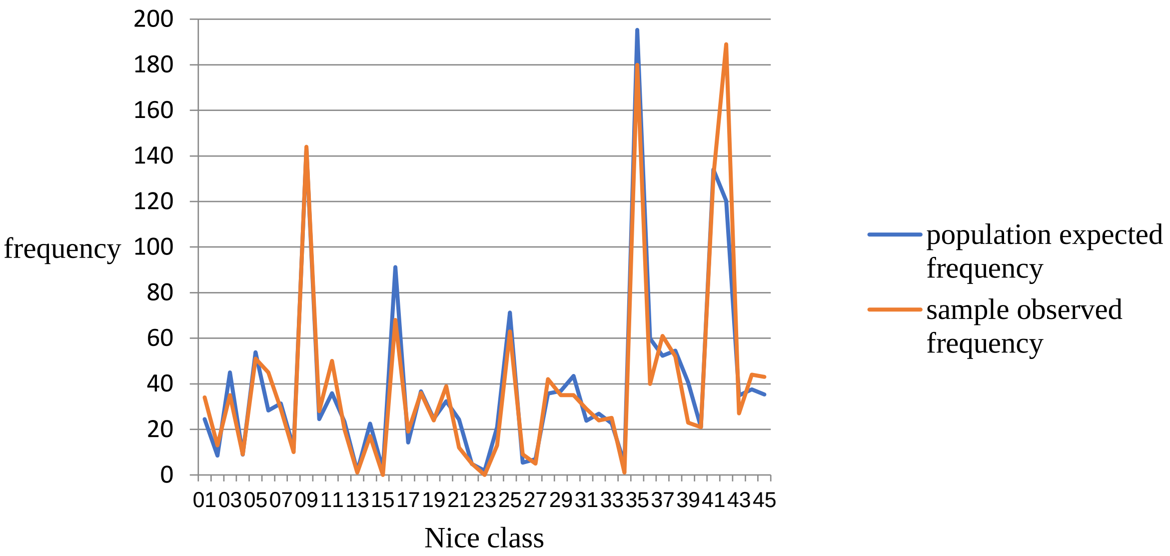
Community Trademark (n = 389) in 2009, and who declared that the trademark referred to something new: a new or improved product, service, process, a significant change in the design, packaging, promotion or pricing of existing products or services, or a significant change in the advertising of existing products or services.

In addition to applicant and trademark characteristics, the survey included questions on the motives of the applicant, the trademark reference to innovation and the use of other IPRs (both formal and informal). If the trademark referred to an innovation, the applicants were asked about the stage of the innovation process in which the trademark application was filed, according to the seven stages defined in Cooper's (1983) new product development (NPD) process.

Of 677 respondents, 585 answered all of the questions required to be used in our final analysis. Cooper's NPD model was also used for trademark applicants referring to service innovation. An advantage of using the same innovation process model for trademarks relating to new products and services is that differences in the timing of a trademark application can be better identified and thus reveal differences in the importance of various stages in the product versus the service innovation processes.

To check whether the responses were a good representation of the whole population, we compared the distribution of the Nice class trademarks in our sample with the whole population. Figure 4.1 shows the trademark volumes in all Nice classes based on the EUIPO and BOIP databases (population expected frequency) and the sample dataset (sample observed frequency). Figure 4.1 shows a similar pattern for the observed sample frequencies and the expected population frequencies. However, a Chi-square test revealed a small but significant difference (χ^2 (45) = 121.90, $p < 0.001$), due to the underrepresentation of Nice class 16 (paper, cardboard and goods made from these materials), class 21 (household or kitchen utensils), class 36 (insurance) and class 39 (transport), and the overrepresentation of class 6 (common metals and their alloys, ores) and class 42 (scientific and technological services).

Figure 4.1: Sample and population distribution over the Nice classes



In addition to applicant sector information and information on the Nice classes of the trademarks in our sample, we had other useful information on the innovation itself. Ideally, we would also like to account for different appropriability regimes that firms might face. Since we did not have survey data at the firm-level on this aspect, we created a proxy for the strength of the appropriability regime by using an innovation-based taxonomy which took into account sectoral differences in appropriability regimes in our robustness checks. Castellacci (2008) integrated innovation-based taxonomies proposed by Pavitt (1984) for sectors in manufacturing and those by Miozzo and Soete (2001) for services, both accounting for specific appropriability strategies used by firms in each group of sectors. In this combined taxonomy, firms are classified into eight groups of sectors: supplier-dominated manufacturing (SD), scale-intensive manufacturing (SI), specialized suppliers (SS), science-based manufacturing (SB), supplier-dominated services (SDS), scale-intensive physical networks (PN), information networks (IN) and knowledge-intensive business services (KIBS). There is an additional category of non-market services, which include non-commercial public and social services. We could assign all trademark applicants in our sample to one of the groups of sectors by relying on the concordance with the 2-digit level NACE industrial classification in Castaldi (2009), also used in Flikkema *et al.* (2014).

Our dependent variable was an ordinal variable corresponding to the seven stages of Cooper's NPD model. Therefore, the application of an ordinal regression model was a logical choice. Ordinal regression models are obtained by modifying the binary regression model to include the ordinal nature of a dependent variable (Norušis, 2012). As a robustness check, we also used a binary regression analysis where the dependent variable was *late* trademark application (trademark application at the marketing stage or later) as opposed to *early* trademark application (trademark application earlier than the marketing stage).

Our independent variables were measured with dummies and categorical variables. A dummy was used to consider the joint use of one or more patents to protect the innovation referred to by the trademark. To test the influence of the differences in innovation mode, we studied three characteristics that are expected to influence the length of development cycles (Griffin, 2002): product versus service innovation; the reference to B2B products/services; and whether the trademark refers to innovation which is new to the world. Dummies were defined for these characteristics. In the case of the dummies representing product and service innovation, the reference category included all other forms of innovation mentioned by the survey question.

A dummy was also introduced to represent the maturity of the firm whose trademark refers to innovation. This dummy was 1, if the respondent indicated it was a start-up or a future start-up. To study the influence of sectoral differences, we used dummies as control variables representing the innovation-based taxonomy defined earlier in this section. Other control variables used were: firm size, whether the trademark referred to both goods and services, whether the applicant had filed a trademark before, and whether the application was done with the help of an attorney.

4.5. Results

4.5.1. Descriptives

Table 4.2 presents the descriptive statistics for the variables used in this study and the dummies created.

Table 4.2: Sample descriptives

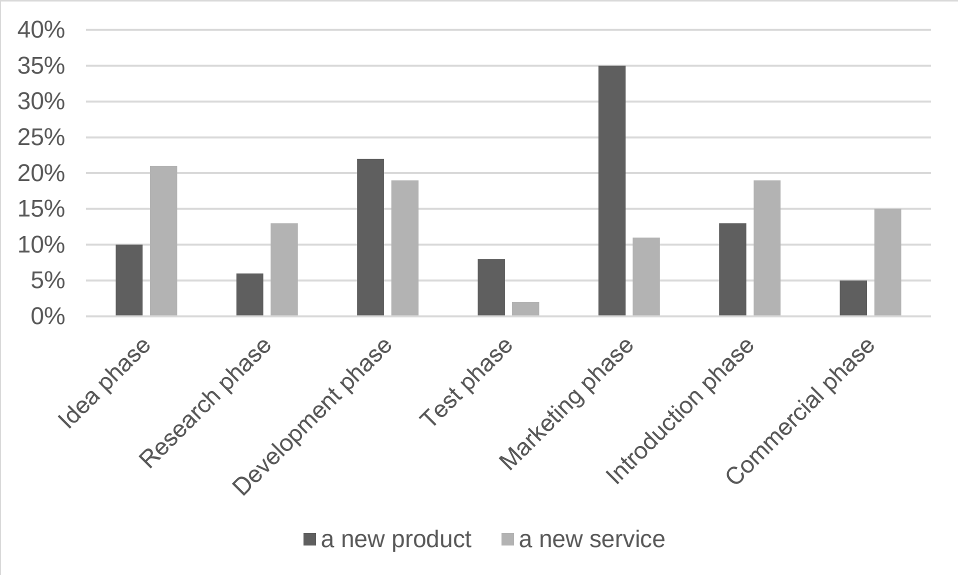
Variable		**Categories**	**n (original sample)**	**Original sample share**	**Operationalization**	**value**	**n (analysis)**	**Final analysis sample share**
Dependent								
1.	Timing (7 phases)	Idea phase	75	11%		1	63	11%
		Research phase	42	6%		1	36	6%
		Development phase	150	22%		1	130	22%
		Test phase	46	7%		1	38	7%
		Marketing phase	142	21%		1	130	22%
		Introduction phase	124	18%		1	104	18%
		Commercial phase	98	15%		1	84	14%
Patents								
2.	Combination with patent(s)	Yes	123	18%	Patent dummy	1	110	19%
		No	554	82%		0	475	81%
Innovation mode								
	Length of development cycle							
3.	Reference to product innov.	Applicable	371	55%	Product innovation reference dummy	1	326	56%
		Not applicable	306	45%		0	259	44%
4.	Reference to service innov.	Applicable	196	29%	Services innov. reference dummy.	1	160	27%
		Not applicable	481	71%		0	425	73%
5.	New-to-the-world innov.	Yes	89	13%	New-to-the-world dummy	1	81	14%
		No	588	87%		0	504	86%
6.	B2B	B2B	463	68%	B2B dummy	1	446	76%
		B2C	301	44%		0	139	24%
		Other	57	8%		0	0	0%

	Start-ups versus incumbents							
7.	Firm maturity	Future start-ups	26	4%	Start-up dummy	1	26	4%
		Start-ups	246	36%		1	246	42%
		Mature firms	313	46%		0	313	54%
		Not applicable	92	14%		0	0	0%
Controls								
	Firm size	1 A one-man business	128	19%		0	116	19%
		2 to 4	154	23%		0	140	24%
		5 to 9	92	14%		0	74	13%
8.		10 to 49	125	18%	Medium firm size dummy	1	111	19%
		50 to 249	66	10%		1	52	9%
9.		250 to 499	14	2%	Large firm size dummy	1	11	2%
		≥ 500	77	11%		1	65	11%
		Not applicable	21	3%		0	16	3%
10.	Firm sector	SD	115	17%	SD dummy	1	108	19%
11.		SI	90	13%	SI dummy	1	82	14%
12.		SS	32	5%	SS dummy	1	29	5%
13.		SB	33	5%	SB dummy	1	32	6%
14.		SDS	84	12%	SDS dummy	1	81	14%
15.		PN	52	8%	PN dummy	1	47	8%
16.		IN	61	9%	IN dummy	1	58	10%
17.		KIBS	70	10%	KIBS dummy	1	69	12%
18.		Non market services	29	4%	Non-market services dummy	1	27	5%
		Other	211	31%		0	52	9%
	Trademark-related controls							
19.	TM ref goods and services	Yes	244	36%	TM ref goods and services dummy	1	212	36%
		No	433	64%		0	373	64%
20.	Trademark experience	First-time applicants	289	43%	Trademark experience dummy	0	256	44%
		Frequent users	388	57%		1	329	56%
21.	Use of IPR agency	Yes	155	23%	Use of IPR agency dummy	1	130	22%
		No	522	77%		0	455	78%

4.5.1.1. Product versus service innovation

In our sample, about 45% of all trademarks were filed before the marketing stage. Clear differences are visible in the timing of trademark application in the case of service innovation as compared to product innovation, as can be seen in Figure 4.2.

Figure 4.2: The timing of trademark applications for product and service innovation

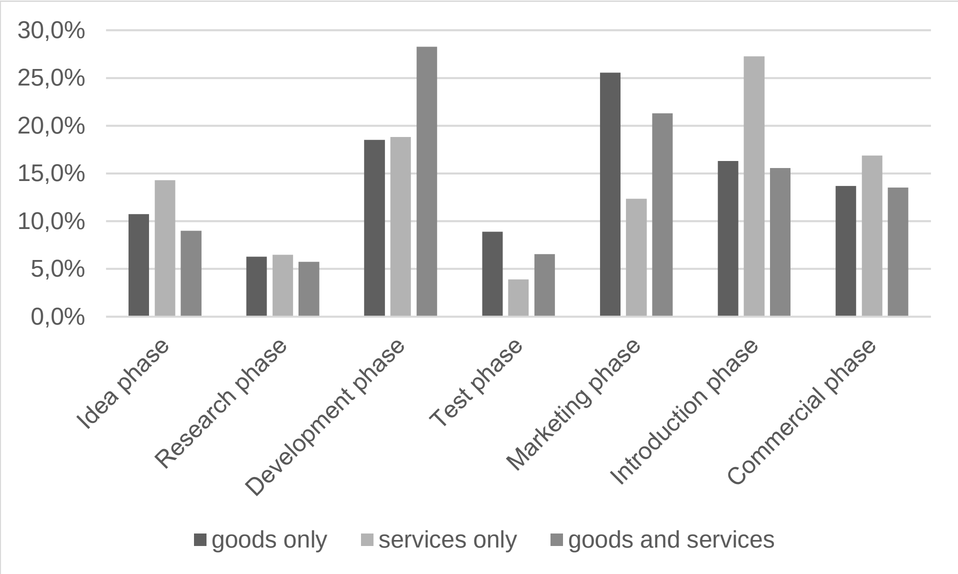


Trademarks referring to new services were registered more frequently in the first two stages of the innovation process or during the last stages (introduction and commercialization stages) compared to product innovations, where trademarks dominate the middle stages of the innovation process. The largest difference was found in the marketing stage: 35% of trademarks referring to product innovation were filed in this stage as compared to 11% for service innovation.

Figure 4.3 shows the differences in the timing of trademark applications between the trademarks referring only to goods, those only to services, and those referring to both goods and services. More than 25% of the trademarks whose Nice classes only refer to goods were filed during the marketing stage. In contrast, for Nice classes only referring to services, more than 25% were filed in the introduction stage, with less than 15% filed during the marketing stage.

Trademarks applied for by organizations that offer a combination of goods and services tend to be filed earlier, especially during the development stage. We therefore included a control dummy in our regression analysis, controlling for trademarks with Nice classes referring to both goods and services. One explanation might be that these trademarks refer to all of the firm's activities and, therefore, mark the start of a firm. A closer look at our data reveals that 32% of the start-ups and future start-ups in our sample declared that the trademark filing referred to all products and/or services of the company. For the mature firms, this was only 13%.

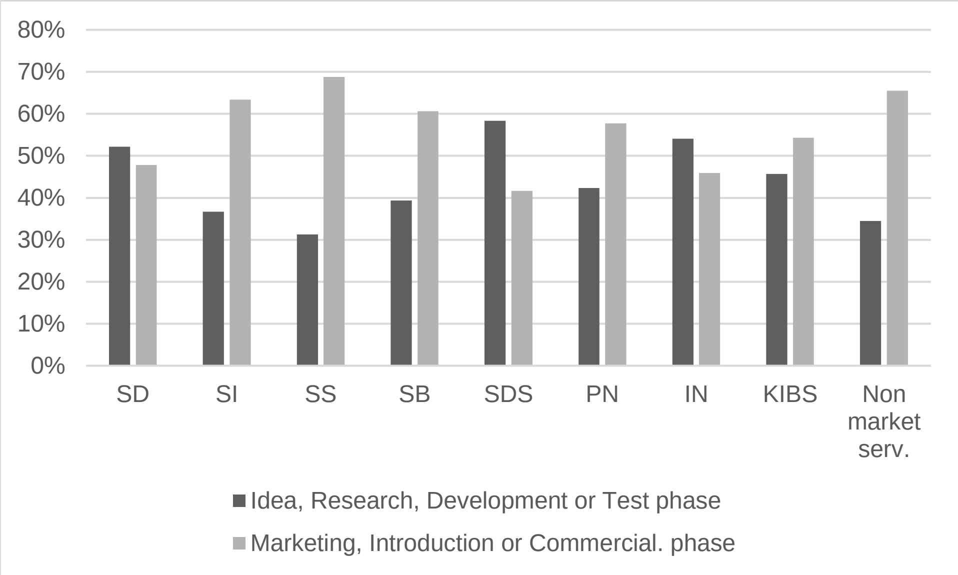
Figure 4.3: Timing of trademark application versus Nice class reference



4.5.1.2. Sectoral patterns

Our survey also provides us with sector information at NACE 2-digit level, which makes it possible to discriminate between low-tech sectors and high-tech sectors. Figure 4.4 shows the breakdown of early and late trademark application for the sectors in our sample, according to the innovation-based taxonomy used in Castaldi (2009).

Figure 4.4: Timing of trademark application versus firm sector



The share of firms with trademark applications in either the marketing, introduction or commercialization stages is higher for specialized suppliers (SS) and for firms in the scale-intensive (SI) and science-based (SB) sectors, compared to low-tech sectors in manufacturing, such as the firms in the supplier-dominated (SD) sector in our sample and most services sectors, but excluding firms belonging to the non-market services group, where the share of late trademark applicants is also high. To control for sectoral heterogeneity that was not already accounted for by the variables capturing innovation mode, we included four dummies for the manufacturing industries and five dummies representing the services sectors as control variables. Three sectors – scale-intensive firms in manufacturing (SI), specialized suppliers (SS) and non-market oriented services firms – showed a significant tendency towards late trademark application.

4.5.1.3 Correlation results

The correlations among our independent variables are presented in Table 4.3. Some correlations are clearly evident. For example, patent protection is linked to product innovation but not to service innovation, which explains the large negative correlation between the combined use of patents and trademarks and service innovation dummies. There is also a significant positive correlation between start-up and service innovation, and a significant negative correlation between start-up and large firm size, indicating that most start-ups are small firms in the service sector. There is a significant positive correlation between the timing of trademark application and the dummies representing firm size. Medium-sized and large firms tend to file trademarks during the marketing stage of the innovation process. For the large firms in our sample, this figure is particularly high, at about 40%.

Table 4.3: Results of correlation analysis

					1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Dependent		1.	Timing of TM application (7 phases)	Pearson Corr.																				
				Sig. (2-tailed)																				
Patent		2.	Combination with patent(s)	Pearson Corr.	-.078*																			
				Sig. (2-tailed)	.041																			
Innovation mode Mode	Length of Development Cycle	3.	Product innovation	Pearson Corr.	-.077*	.251**																		
				Sig. (2-tailed)	.045	.000																		
		4.	Service innovation	Pearson Corr.	-.053	-.166**	-.336**																	
				Sig. (2-tailed)	.165	.000	.000																	
		5.	New-to-the-world innovation	Pearson Corr.	-.130**	.304**	.081*	.002																
				Sig. (2-tailed)	.001	.000	.035	.953																
		6.	B2B	Pearson Corr.	.028	-.029	-.029	.055	-.013															
				Sig. (2-tailed)	.493	.464	.471	.175	.744															
	Start-up	7.	Start-up	Pearson Corr.	-.201**	.007	-.080	.174**	.222**	-.019														
				Sig. (2-tailed)	.000	.856	.054	.000	.000	.645														
Controls	Firm size	8.	Medium firm size	Pearson Corr.	.080*	.037	.081*	-.096*	-.069	.087*	-.297**													
				Sig. (2-tailed)	.036	.342	.034	.012	.073	.029	.000													
		9.	Large firm size	Pearson Corr.	.100**	.129**	.088*	-.070	-.115**	-.005	-.340**	-.247**												
				Sig. (2-tailed)	.009	.001	.022	.068	.003	.894	.000	.000												
	Firm sector	10.	Supplier dominated manuf. (SD)	Pearson Corr.	-.044	.042	.213**	-.219**	.068	-.027	-.055	-.013	-.017											
				Sig. (2-tailed)	.253	.276	.000	.000	.075	.495	.185	.743	.662											
		11.	Scale intensive manuf. (SI)	Pearson Corr.	.076*	.064	.172**	-.154**	-.036	.029	-.149**	.054	.075	-.177**										
				Sig. (2-tailed)	.049	.098	.000	.000	.344	.465	.000	.159	.050	.000										
		12.	Specialized suppliers (SS)	Pearson Corr.	.064	.220**	.090*	-.081*	.078*	.035	-.102*	-.016	.137**	-.101**	-.087*									
				Sig. (2-tailed)	.098	.000	.019	.036	.042	.381	.013	.680	.000	.009	.023									

				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	13.	Science-based manuf. (SB)	Pearson Corr.	.011	.071	.123**	-.084*	.013	-.044	-.013	.041	.092*	-.102**	-.089*	-.050								
			Sig. (2-tailed)	.776	.064	.001	.029	.727	.278	.749	.287	.017	.008	.021	.190								
	14.	Supplier-dominated serv. (SDS)	Pearson Corr.	-.101**	-.096*	-.135**	.115**	-.014	-.051	.172**	-.097*	-.070	-.170**	-.147**	-.084*	-.085*							
			Sig. (2-tailed)	.008	.012	.000	.003	.719	.203	.000	.012	.071	.000	.000	.029	.027							
	15.	Physical networks (PN)	Pearson Corr.	.055	-.064	-.039	-.111**	-.079*	.002	-.061	.041	-.049	-.130**	-.113**	-.064	-.065	-.109**						
			Sig. (2-tailed)	.155	.096	.311	.004	.039	.956	.139	.286	.206	.001	.003	.095	.090	.005						
	16.	Information networks (IN)	Pearson Corr.	-.074	-.068	-.139**	.140**	.030	.018	.104*	.043	-.064	-.142**	-.123**	-.070	-.071	-.118**	-.091*					
			Sig. (2-tailed)	.054	.077	.000	.000	.432	.654	.012	.259	.099	.000	.001	.068	.064	.002	.018					
	17.	Knowledge int. bus. serv. (KIBS)	Pearson Corr.	-.003	-.085*	-.208**	.232**	.011	.102*	.095*	-.073	-.063	-.154**	-.133**	-.076*	-.077*	-.128**	-.098*	-.107**				
			Sig. (2-tailed)	.933	.028	.000	.000	.766	.011	.022	.058	.103	.000	.001	.049	.046	.001	.011	.005				
	18.	Non-market serv.	Pearson Corr.	.036	-.024	-.042	.138**	.026	-.099*	.024	-.035	-.083*	-.096*	-.083*	-.047	-.048	-.080*	-.061	-.067	-.072			
			Sig. (2-tailed)	.350	.533	.271	.000	.505	.013	.569	.358	.030	.013	.031	.221	.213	.038	.113	.083	.062			
Trademark-related Controlsxb	19.	TM refers to both goods + services	Pearson Corr.	-.028	.085*	-.041	.023	.027	.044	.046	.028	.047	-.004	-.140**	.050	.016	-.031	-.043	.118**	-.002	.008		
			Sig. (2-tailed)	.472	.027	.281	.554	.489	.271	.268	.460	.223	.924	.000	.192	.681	.427	.261	.002	.952	.829		
	20.	Previous trademark experience	Pearson Corr.	.016	.066	.062	-.081*	-.088*	.057	-.373**	.203**	.270**	.025	.048	.009	.057	-.083*	.002	-.031	-.060	-.053	.020	
			Sig. (2-tailed)	.681	.087	.106	.035	.021	.156	.000	.000	.000	.523	.215	.809	.141	.031	.954	.423	.119	.165	.610	
	21.	Use of IPR agency	Pearson Corr.	.106**	.035	-.014	-.022	-.066	.051	-.144**	.166**	.125**	.034	.046	-.072	.007	-.077*	.028	-.073	-.012	-.046	.074	.150**
			Sig. (2-tailed)	.006	.363	.722	.563	.085	.206	.000	.000	.001	.372	.237	.062	.850	.045	.473	.057	.758	.234	.054	.000

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4.5.2. Regression analysis

Ordinal regression was used to examine the effect of our variables of theoretical interest on the dependent variables reflecting timing. Model estimations are presented in Table 4.4 for different model specifications. The estimated coefficients represent the log odds of later trademark application in the innovation process.

Innovation mode characteristics, such as product innovation and the applicant being a start-up, show significant negative coefficients, indicating a significant tendency towards early trademark application. The variable reflecting trademarks combined with patents (19% of the cases in our final sample) shows no significant tendency to early application in the innovation process, although more than 30% of the trademarks combined with patents in our sample were applied for during the development stage of the innovation process.

With respect to the determinants used to indicate differences between innovation development cycles, there is a tendency towards early trademark application in the case of determinants which indicate long development cycles. The estimated coefficient for the product innovation dummy (which is associated with long development cycles) is negative and significant, while it is not significant for service innovation. Thus, the evidence indicates that trademarks referring to product innovation are filed earlier than those referring to all other forms of innovation, including service innovation. However, this does not hold for innovation which is new to the world or with reference to B2B products or services, both of which are associated with long development cycles. Start-ups (which made up approximately 50% of our sample) show the most significant tendency towards early trademark application.

Table 4.4: Regression results

Ordinal regression

	Variables	Model 1			Model 2			Model 3		
		B	std.err.	Sig.	B	std.err.	Sig.	B	std.err.	Sig.
Dependent	Timing of TM application (reference = commercial. phase)									
Dependent	Idea	-2.174***	.232	.000	-2.531***	.292	.000	-2.797***	.369	.000
	Research	-1.645***	.221	.000	-1.996***	.283	.000	-2.253***	.360	.000
	Development	-0.455**	.210	.030	-.790***	.273	.004	-1.020***	.349	.003
	Test	-.159	.210	.448	-.490*	.272	.072	-.728**	.348	.036
	Marketing	.750***	.212	.000	.438	.272	.107	.268	.347	.439
	Introduction	1.835***	.225	.000	1.543***	.281	.000	1.367***	.354	.000
Patents	Combination with patents	-.556***	.186	.003	-.379*	.199	.057	-.310	.213	.145
Innovation mode										
Length of development cycle	Product innovation				-.520***	.157	.001	-.549***	.170	.001
	Service innovation				-.326*	.171	.057	-.226	.189	.232
	New-to-the-world innov.				-.413*	.218	.058	-.287	.230	.213
	B2B				.125	.166	.451	.058	.176	.743
Start-up	Start-up							-.545***	.185	.003
Controls										
Firm size	Medium firm	.422**	.168	.012	.399**	.171	.019	.208	.197	.291
	Large firm	.578**	.229	.011	.540**	.232	.020	.190	.274	.487
Firm sector	SD (supplier-dominated manuf.)	-.217	.236	.357	-.130	.244	.596	.088	.303	.772
	SI (scale-intensive manuf.)	.233	.253	.358	.294	.259	.256	.586*	.319	.066
	SS (specialized suppliers)	.484	.366	.186	.548	.368	.137	.701*	.423	.097
	SB (science-based manuf.)	-.034	.351	.923	.069	.357	.847	.357	.401	.373
	SDS (supplier-dominated services)	-.465*	.260	.074	-.499*	.263	.058	-.286	.324	.377
	PN (physical networks)	.412	.299	.168	.329	.303	.277	.592	.361	.101
	IN (information networks)	-.461	.285	.106	-.484*	.288	.093	-.167	.348	.631
	KIBS (knowledge int. business services)	.037	.272	.891	.020	.277	.942	.269	.339	.427
	Non market services	.414	.372	.266	.556	.379	.142	.880**	.432	.042
Trademark-related controls	TM reference to both goods + services	-.076	.145	.599	-.108	.146	.458	-.090	.157	.566
	Previous TM experience	-.212	.150	.156	-.230	.150	.126	-.373**	.167	.026
	Use of IP agency	.312*	.169	.066	.301*	.170	.077	.361*	.187	.053
	N			677			677			585
	Nagelkerke R square			.064			.087			.108
	Goodness of Fit (Pearson significance)			.758			.600			.484
	Chi-square (df)			43.4 (15)			60.4 (19)			64.8 (20)

*: Significant at the 0.1 level. **: Significant at the 0.05 level. ***: Significant at the 0.01 level.

4.5.3. Robustness checks

We checked the robustness of our models by combining different stages and thus reducing the number of categories of our dependent variable to four stages (idea + research stage, development + test stage, marketing stage, introduction + commercialization stage) and also to two stages (up to the test stage and marketing stage or later). Both robustness checks did not influence any of the findings presented in Section 4.2. The results for the controls, however, showed some differences. Large firm size was very significant in the robustness check in which late trademark application was defined as during the marketing stage or later. The basic statistics reveal that a majority of the large firms in our sample applied for trademarks during the marketing stage of the innovation process. The same also holds for the control dummy representing the use of an IPR agency. Most firms using the services of an IPR agency to file their trademark application did this during the marketing stage of the innovation process. Firms with previous trademark experience, however, show a tendency towards early trademark application, although the effect is slightly less strong. The robustness check for the most elaborate model confirmed the tendency towards earlier trademark application in the case of previous experience.

4.6. Discussion

4.6.1. Implications for theory

Because of their nature and relatively short handling times at IPR offices, the majority of the literature assumes that trademarks are registered close to the market introduction of a new product or service and therefore are an indicator of late-stage innovation. Others have argued that early trademark application occurs. Our findings show that the predominant assumption that filing occurs late is not supported by the data. However, we did not find that the opposite was the case. Rather, the timing of filing appears to depend on various firm and innovation mode characteristics. We therefore argue that further theoretical exploration of the determinants of early and late filing is required, including the question of how organizations balance the various reasons for filing late or early. There are various avenues for further research that can be pursued in this respect.

First, consideration of the various motives for trademark application in the analysis may further clarify why some of our findings diverge from some of the predictions. Research by Block *et al.* (2015) showed that trademark applicants may have three distinct motives: protection, marketing and exchange. The strength of these motives may have an impact on the timing of a trademark application.

Second, our data cannot fully capture the appropriability regime of the innovation for which the trademark is applied. We applied Castaldi's taxonomy (2009) as a proxy for appropriability regimes. This proxy, however, is imperfect as it assumes sectoral homogeneity concerning the appropriability regime. There are also other factors which influence appropriability conditions (Hurmelinna-Laukanen and Puumalainen, 2007). Additional research which takes intra-sector heterogeneity into account is therefore needed to enhance our understanding of the relationship between the appropriability regime and the timing of trademark applications.

Third, one limitation of our study is that information about the underlying innovation processes was limited. A direct measure of both the total length of the innovation process and the length of different phases within the process may provide a more definitive answer to the question of how differences between innovation processes influence the timing of trademark applications. One reason for the inconclusive results of our regression analysis on service innovation may be that our survey used Cooper's new product development (NPD) process for the cases involving service innovation. A more general innovation model which accounts for different types of innovation and also accounts for less linear innovation processes, which often occur in relation to service innovation (Alam and Perry, 2002), may improve results.

4.6.2. Implications for practice

Our results suggest that practitioners should think carefully about when to apply for trademarks. To determine the right time, they could at least take their firm type and innovation mode into consideration. A standardized policy for all trademark applications made by all companies does not match with the practices that we observed.

A second observation relevant to practitioners is that, in general, we found a tendency towards earlier trademark application by firms with previous trademark experience. This implies that from their previous experiences, these firms have become more aware of the necessity of timely trademark application. This may indicate that inexperienced firms apply for trademarks too late. These firms may find that advice from an expert or from an experienced company can help them to avoid the potential pitfalls of late trademark application.

4.6.3. Implications for policy

Our study supports the usefulness of trademarks as an innovation indicator, as proposed by Mendonça *et al.* (2004) and Flikkema *et al.* (2014). However, policymakers must take into account that trademarks can refer to early stage invention as well as later stage innovation. Early trademark application is especially relevant in cases of product innovation and innovation by start-ups. The use of trademark statistics for the development and evaluation of innovation policies can take this finding into account. Literature on the motives for trademark application indicates that an important reason why start-ups file trademarks is to signal technological and marketing capabilities and thereby attract venture capital (Zhou *et al.,* 2016). Block *et al.* (2014) and Zhou *et al.* (2016) found that trademarks indeed increase venture capital funding. Entrepreneurship policy should therefore promote the development of these capabilities, including an effective trademark filing strategy by early phase innovating start-ups.

4.7. Conclusions

This is the first empirical study to look at the timing of trademark applications in innovation processes across various industries. Our paper contributes to the innovation literature by testing competing predictions about early versus late application for trademarks. It expands on previous studies into the usefulness of trademarks for measuring innovation (Mendonça *et al.,* 2004; Flikkema *et al.,* 2014) and shows that the relationship between the timing of trademark applications and their combination with patents, as well as the relationship between timing and the applicant's innovation mode are more nuanced than the literature suggests.

Concerning the relationship between the combination of patents and trademarks and the timing of trademark application, our simplest model showed that there is a tendency towards early trademark application in the case of combination with patents. However, our regression analysis showed that this effect disappeared when we take into account the newness of an innovation, which is also a prerequisite for patentability, and for the firm being a start-up. Trademarks are filed later in the innovation process even when they are combined with patents. Moreover, established firms, with incremental innovation, especially showed a tendency towards late trademark application, whether in combination with patents or not.

Concerning the relationship between the applicant's innovation mode and the timing of trademark application, we can draw three conclusions. First, trademarks for service innovation are not primarily applied for in the late stages of the innovation process. Firms apply for trademarks for service innovations in all stages of the innovation process. One possible explanation for this might be that service innovation may follow different innovation patterns (Den Hertog, 2000), also depending on the locus of innovation. In particular, service innovation does not always happen ‘on the job’ within client firms, but might be the outcome of dedicated activities that some service firms develop as internal capabilities (Janssen *et al.*, 2015). Future research that includes the study of more characteristics of the innovation process might aim to determine whether the locus of service innovation predicts the timing of trademark applications.

Second, there is a tendency towards late trademark application by firms in high-tech manufacturing industries, such as scale-intensive manufacturers and specialized suppliers. The development of innovations in these sectors tend to have long cycles (Griffin, 2002). One possible explanation for this might be that the cycles in these sectors approximate or exceed the period defined by the use in commerce requirement in trademark law, forcing them to postpone their trademark application. Late trademark application also holds for non-market services, which can be explained by the non-commercial nature of these firms, typically associated with a disregard for commercial interests.

Third, start-ups show a strong tendency towards early trademark application, especially when the trademark refers to product innovation. This indicates that the assumptions made in the literature on brand management (Klink, 2003) and on the use of trademarks as an innovation indicator (Hipp and Grupp, 2005) – that trademarks are applied for during the later stages of the innovation process and therefore refer to later stage innovation – hold for established firms but not for start-ups. In the case of established firms, trademarks may therefore be a powerful indicator of innovations that make it to the market. This result confirms recent findings in trademark research that start-ups tend to file initial IPRs in the form of trademarks (de Vries *et al.*, 2017), especially when the start-up is backed by venture capital.

One final intriguing finding relates to trademark law. Counter to the expectations of some studies and also counter to the second finding concerning late trademark application in some high-tech sectors, the use in commerce requirement does not seem to lead to later applications on a large scale. Our data, which included trademark applications from sectors with long development cycles, suggest that the priority principle overrides the use in commerce requirement and leads organizations to apply for trademarks in earlier phases. Whether the use in commerce requirement is effective in preventing premature trademark applications may therefore be questioned.

Our general conclusion is that care should be taken when using trademark counts as indicators of late-stage innovation and of service innovation only, as some studies would suggest. We found evidence here that trademarks may also indicate early stage innovation, particularly for radical product innovation in start-ups.

5. Unrelated variety and regional economic resilience
The role of technological and market capabilities

5.1. Introduction

Since the economic crisis which started in 2008 there has been a growing interest among scholars and policy makers in the drivers behind the differential economic resilience of regions as part of the continuing efforts to understand what makes regions navigate periods of crisis and continuously adapt to changing environments (Simmie and Martin, 2010; Groot *et al.*, 2011).

One way to conceptualize regional economic resilience is as ‘a region’s ability to develop new economic activities that fuel economic growth’ (Martin and Sunley, 2006; Boschma, 2015). In this evolutionary interpretation, regional economic resilience is seen as an ongoing process rather than the incidental recovery from economic downturns (Martin and Sunley, 2006; Boschma, 2015). Previous regional studies revealed positive contributions from both regional industrial and technological variety to regional economic resilience (Content and Frenken, 2016; Rocchetta and Mina, 2019). Regional industrial variety can be beneficial for countering demand fluctuations in specific industries, for example through the reallocation of the regional labor force whose jobs have become redundant (Frenken *et al.*, 2007). On the other hand, technological variety can increase the opportunities for technological recombination and innovation. However, some empirical evidence indicated that technological relatedness rather than technological variety correlates positively with regional economic resilience (Rocchetta and Mina, 2019). One may argue that technological relatedness lowers the barriers for technological recombination and its exploitation. In these cases technological opportunities for further innovation are either spotted more easily or budget requirements for subsequent innovation projects are more easily fulfilled.

Less clear are the mechanisms through which different types of industrial and technological variety foster a region's economic resilience and the moderating factors at stake (Martin and Sunley, 2015). Filippetti *et al.* (2020) found evidence that EU regions proved more resilient when having strong profiles in different types of innovation, leveraging technology, market and design capabilities. Their results resonate with an earlier study by Mendonça (2014) who provided a first attempt at measuring both technological and market capabilities of regions. Building on these insights, we propose to research whether these capabilities aside a direct effect on regional economic performance also affect the extent to which regions are able to benefit from industrial and technological variety.

The literature on firm-level technological and market capabilities provides evidence that these capabilities are both crucial to allow firms to constantly create new opportunities and enable long-term survival (Teece *et al.*, 1997; Duysters and Hagedoorn, 2000; Ortega, 2010). Technological capabilities are the routines and skills to develop new technologies or new configurations of existing technologies and are typically the outcome of dedicated R&D efforts (Cohen and Levinthal, 1990). Market capabilities are the routines and skills to develop and market actual new products or services and capture their economic value. Market capabilities include skills embedded activities such as branding, design, trading and distribution (Morgan *et al.*, 2009; Cacciolatti and Lee, 2016; Tidd and Bessant, 2018).

In this paper, we propose that industrial and technological variety will feed opportunities for spillovers across economic activities and technologies towards recombinant innovation

(Frenken *et al.*, 2007; Janssen and Frenken, 2019), but these opportunities will only create economic value when local firms are able to realize compelling new products, services and/or processes (Flikkema *et al.*, 2007). We expect that the local availability of both technological and market capabilities will be key in this process. Our main research question is therefore: *To what extent do regional technological and market capabilities matter for exploiting opportunities originating from regional industry and technological variety?*

We contribute to the literature on regional economic resilience in three ways. We are the first to study the extent to which different types of regional capabilities moderate the relationship between industrial and technological variety, and economic resilience. This contribution is relevant for policymakers, since there is an increasing consensus on the need of developing regional policies targeting the development of broader capabilities, not just technological ones (Camagni and Capello, 2013). Second, we gauge the role of both industrial and technological variety as complementary sources of opportunities for regional resilience. Finally, we develop new proxies of regional market capabilities by building on and extending insights from an emerging trademark literature (Castaldi *et al.*, 2020).

The remainder of this chapter is structured as follows: in the next section we review the existing literature about sources of economic resilience at the regional level to build and legitimate our conceptual framework followed by the results of our empirical analysis. We exploited economic value added, patent and trademark data covering 40 Dutch regions in a five-year period, including the 2008 economic crisis. We conclude with the scientific and policy implications of our findings and suggestions for future research.

5.2. Theory

5.2.1. Regional industrial variety as a driver of economic resilience

The main argument for a positive relation between industrial variety and regional economic resilience is that it spreads risks and therefore enables a region to accommodate idiosyncratic industry-specific shocks (Dissart, 2003; Essletzbichler, 2007; Davies and Tonts, 2010; Simmie and Martin, 2010; Desrochers and Leppälä, 2011). The negative performance of one industry will only have a mild effect on the total performance in terms of growth and unemployment of a region, especially when there is little interdependency between industries (Attaran, 1986; Haug, 2004). Frenken *et al.* (2007) therefore argued that unrelated industrial variety rather than related variety is instrumental in absorbing industry specific shocks. Unrelated industrial variety may dampen the initial industry specific shock but in order for a region to recover the demand in the industry affected by the shock or in other industries needs to grow (again). Groot *et al.* (2011) showed for the industry-wide economic crisis which started in 2008, that the broad unrelated industries making up European regional economies were characterized by significantly different crisis sensitivity. As such, unrelated industrial variety may also dampen industry-wide shocks.

On the other hand, related variety allows to contain shocks to employment since industries share common skills and knowledge (Content *et al.*, 2019). Diodato and Weterings (2014) showed that employees who lost their job due to a shock will be better able to find a new one when other industries in the region require similar kinds of skills as the industry where they used to work, that is, when industries within the region are more related. However, related variety can only be beneficial if there are job vacancies in related industries which can be filled by the employees who lost their job in the industry which suffered the shock. In this context, Simmie and Martin (2010, p. 31) stated that “resilience is considered as an ongoing process rather than a recovery to a (pre-existing or new) stable equilibrium state …”. Part of this ongoing process is the search for and creation of new growth paths or the extension of existing ones which enable the creation of new business opportunities and new jobs. Frenken *et al.* (2007) also argued that opportunities originating from variety between firms within the same industry (related industrial variety) rather than between firms in totally different industries (unrelated industrial variety) are more likely to be exploited because of the relatedness of their knowledge base. Related industrial variety is more likely to enable opportunities which can lead to the extension of existing growth paths whereas opportunities from unrelated industrial variety can lead to the creation of new growth paths (Boschma, 2015). Because opportunities from related variety are more likely to happen and to be exploited, a common argument is that related industrial variety benefits regional economic resilience more significantly than unrelated industrial variety (Frenken *et al.*, 2007).

5.2.2. Regional economic resilience: the role of technological variety

Boschma and Frenken (2011) suggested that a key mechanism behind the positive relation between related variety and regional economic growth is that recombinant innovations arising from knowledge spillovers are more likely to happen in regions hosting technologically related industries. Breschi *et al.* (2003) found that firms extend their innovative activities across knowledge-related technological fields. Therefore, regions where firms can share a common (technological) knowledge base, may have an advantage when they develop activities where existing local technological expertise is recombined (Boschma *et al.*, 2014, Castaldi *et al.*, 2015). These recombinations of related technologies are more likely to lead to incremental innovation whereas combinations of unrelated technologies are more likely to spur radical innovation (Frenken *et al.*, 2007; Castaldi *et al.*, 2015; Miguelez and Moreno, 2018). Incremental innovation is associated with the extension of existing growth paths whereas radical innovation is associated with the creation of new ones. Both are essential for regional economic resilience (Boschma, 2015). Castaldi *et al.* (2015) also pointed out that unrelated technological recombinations are more likely to fail and thus new growth paths are more difficult to create. Rocchetta and Mina (2019) found that regional technological relatedness rather than technological diversity benefits regional economic resilience. Their main argument is that the process of knowledge recombination is more effective when there is a high degree of technological proximity between the technologies involved. Hence, current research found evidence for a positive role on resilience for both related and unrelated technological variety.

Table 5.1 gives a summary of the arguments on how the different types of variety can benefit regional economic resilience. While industrial variety benefits regional economic resilience through mitigation across unrelated or related industries the main arguments for technological variety involve its potential to make new technological recombinations.

Table 5.1: Regional variety and economic resilience: mechanisms promoting regional resilience.

	Unrelated	Related
Industrial variety	Allows risk spreading in response to shocks in the demand of products and services.	Facilitating transition of labor force to related industries and new job creation
Technological variety	Increasing the potential for more radical recombinations	Leveraging less risky recombination of related technologies

5.2.3. The moderating role of technological and market capabilities

While the above discussion suggests that regional variety provides opportunities for a region to continuously renew its economic activities, regions are expected to differ in the extent to which they are able to exploit these opportunities. The translation of knowledge spillovers to new valuable economic activities is a complex and uncertain process, particularly so in case of spillovers originating from unrelated variety. The downstream activities connected with the market introduction and successful commercialization of products and services require different capabilities than the ones needed for upstream activities which are connected with research and development (Datta *et al.*, 2015; Janssen *et al.*, 2016). Management research focusing on how firms are able to navigate changing environmental conditions and thrive in the long run through constant adaptation and renewal indicated that both technological and market capabilities matter (Kogut and Zander, 1992, Teece *et al.*, 1997, Arora and Nandkumar, 2012). At the regional level, regional capabilities can be viewed as micro-founded in the capabilities of locally active firms. We argue that both regional technological and market capabilities are needed to *exploit* the opportunities generated by spillovers across industries and technologies.

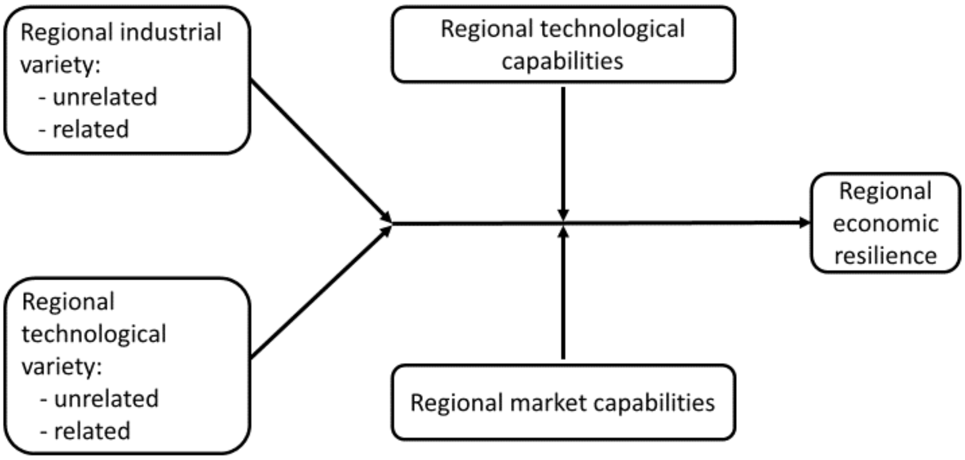
Technological capabilities are the routines and skills to develop new technologies or new configurations of existing technologies and are typically the outcome of dedicated R&D efforts (Cohen and Levinthal, 1990). They involve the capabilities of sensing and seizing technological opportunities, in interaction with the external environment (Iammarino *et al.*, 2012; Leten *et al.*, 2016). These capabilities can be used to improve existing products, processes or services or, more difficult, to generate new ones. Leten *et al.* (2016, p. 1261) stated that these capabilities can be considered as dynamic capabilities: “In technology-based industries, the discovery and exploitation of technological opportunities and emerging trajectories can be considered a ‘dynamic’ capability underlying sustainable competitive advantage.” Firms have to update and renew these skills continuously in order to sustain their competitive advantage.

This also applies to regions. A region hosting firms with stronger technological capabilities would therefore benefit more from related and unrelated variety. Filippetti *et al.* (2020) showed that resilient regions are strong in technological innovation. Fritsch and Kublina (2018) found evidence for the moderating role of regional R&D capabilities in fostering knowledge spillovers which contribute to regional economic growth.

On the other hand, *market capabilities* cover market activities such as market exploration, the development of a market strategy and marketing activities. A crucial part of market capabilities is the capability to sense and seize new market opportunities from knowledge spillovers and the ability to respond to changing circumstances (Teece *et al.*, 1997, Janssen *et al.*, 2016). These capabilities are different from technological capabilities. While some firms may be particularly skilled in adapting and recombining new technologies in order to develop technical inventions, they may have weaker capabilities when it comes to turning those inventions into new offers in the market (Castaldi and Dosso, 2018). Like technological capabilities, market capabilities can also be considered to be dynamic capabilities, in particular the ones related to seizing opportunities for entry in new markets (King and Tucci, 2002; Teece, 2007). These capabilities may reside in incumbent firms (Kogut and Zander, 1992) or in entrepreneurial ventures laying the grounds for new markets (Noseleit, 2013). The aggregation of these firm-level capabilities at the regional level can be seen as regional market capabilities. (Mendonça, 2014). Regions hosting firms with stronger market capabilities, including specialized business service firms which can assist all other firms with developing these capabilities, would be in a better position to seize opportunities originating from industrial and technological variety.

Figure 5.1 summarizes our conceptual framework. Testing this model can provide a better understanding of the mechanisms which make a region resilient. In this model, based on insights from the literature discussed in this section, regional industrial and technological variety act as the sources for opportunities whereas technological and market capabilities act as moderators of these opportunities.

Figure 5.1.: Varieties, capabilities and their relation to regional economic resilience



5.2.4. Variety, capabilities and regional resilience: a conceptual framework.

The previous sections provided arguments for the relation of related and unrelated industrial and technological variety to economic resilience. Both industrial and technological related variety can benefit economic resilience through mitigation of industry specific shocks and skill relatedness of the regional labor force. Both industrial and technological variety can be a source for new market and technological opportunities leading to the extension or creation of growth paths (Boschma, 2015). While opportunities from related forms of variety might more easily emerge and contribute to short-term economic growth, those from unrelated forms of variety might bear a higher potential for contributing to regional resilience in the longer term.

Opportunities from spillovers between industries or technologies with a small cognitive distance can be implemented more easily (Nooteboom *et al.*, 2007; Bar and Leiponen, 2012; Content and Frenken, 2016). In these cases, the extent of technological or market capabilities necessary for successful commercialization can be limited. In case of opportunities stemming from unrelated varieties these capabilities can be expected to be of greater importance because opportunities stemming from unrelated spillovers and technological recombination are more difficult to realize. Fritsch and Kublina (2018) found evidence that technological capabilities moderate the relation between the capability of a region to turn opportunities from unrelated industrial variety into economic growth. With the model we have in mind we can investigate the overall relation between related and unrelated industrial and technological variety, technological capabilities, market capabilities and regional economic resilience.

5.3. Empirical analysis

5.3.1. Data sources

We combined three different data sources to construct our regional dataset for 40 Dutch regions at NUTS-3 level, the so called *Corop* regions. These regions are constructed in such a way that most regions are characterized by some degree of clustering of economic activity and intraregional business linkages (Oosterhaven *et al.*, 2001). Each region has a strongly urbanized central place, a large town or a city serving as its socio-economic center, and rural surroundings. Furthermore, the scale of *Corop* regions is such that personal contacts between regions are likely to occur less frequently than personal contacts within regions (van Stel and Nieuwenhuijsen, 2004). Therefore, it can be expected that intra-regional knowledge spillovers at this level are more likely to occur.

A first data source is an exhaustive dataset of patents and trademarks owned by applicants in 40 Dutch regions (NUTS-3 level) for the years 2006-2010, a period which includes the global economic crisis. They include data on approximately 35,000 patent families applied at national and international patent offices (Netherlands Patent Office, European Patent Office and World Intellectual Property Organization). Including national patent and trademark filings has the advantage that our analysis is not biased towards large firms only. Research based on linked IPR and firm data showed that SME's tend to prefer national offices to file their IPRs (Filitz and Tether, 2015). Data on more than 65,000 trademarks include Community Trademarks issued by EUIPO and trademarks issued by BOIP (Benelux Office for Intellectual Property) between 2006 and 2010. Patent and trademark data have been aggregated at NUTS-3 regional level.

A second data source is the Dutch LISA employment register (www.lisa.nl) which is used to construct industrial varieties at NUTS-3 regional level for each year from 2006 to 2010. LISA is a firm register compiled by the LISA foundation which represents 21 regional Dutch employment registers and also combines their data. It contains information about all local establishments for each firm in the Netherlands where paid work is being done. The key data have a spatial component (address data) and socio-economic components (employment in full-time equivalent FTE and economic activity).

Finally, we exploited data on value added and number of firms from Statistics Netherlands published for each NUTS-3 region using the Statistical Classification of Economic Activities in the European Community, commonly referred to as NACE, at one-digit level for each year from 2006 up to 2015. The data on value added is used to construct regional economic resilience for different time-lags. The data on the number of firms in combination with the patent and trademark data are used to calculate patent and trademark intensities for each year in the 2006-2010 period.

5.3.2. Model specification

We assumed that regional varieties in combination with technological and market capabilities in year t generate spillovers and recombinant innovations leading to increased regional economic resilience in year $t+T$. The model we tested therefore takes the form

$$resilience_{i,t+T} = \gamma_0 + \gamma_{1,i} Region_i + \sum_{n=1}^{N} \gamma_{s,m,i} Varieties_{m,i,t} + \sum_{p=1}^{P} \gamma_{2,m,i} Capabilities_{p,i,t}$$

$$+ \sum_{n=1}^{N} \sum_{p=1}^{P} \gamma_{3,n,p,,i} \quad Capabilities_{n,i,t} \times Varieties_{p,i,t}$$

where γ_0 is a constant, T ranges between 1 and 5, and $Region_i$ represent the regional fixed-effect dummies introduced to capture the time-independent idiosyncratic effects of region *i* which are not taken into account by the controls, which will be introduced later on in this section, and the explanatory variables.

We considered both the direct effect of the varieties and capabilities and their indirect effect when technological and market capabilities facilitate the opportunities originating from the different varieties. This indirect effect is represented by the interaction-term in the equation above.

Indicators

Economic resilience

We defined regional economic resilience in a region *i* as the change in regional value added in the year *t+T* with respect to year *t* as the growth rate in regional value added with respect to the average growth rate of the Netherlands, in line with the sensitivity index for regional economic resilience introduced by Martin (2011) and which is also used by Filippetti *et al.* (2020):

$$resilience_{i,t+T} = \left(\frac{value\ added_{i,t+T}}{value\ added_{i,t}}\right) / \left(\frac{value\ added_{NL,t+T}}{value\ added_{NL,t}}\right)$$

We pooled years which means that we calculated all independent variables for each year *t* in the period 2006-2010 and calculated the difference in value added for each year within this period and the resilience by calculating the difference in value added *T* years later.

We used regional value-added growth instead of regional employment in our definition because within the EU the annual change in value added was much larger compared to the annual change in employment growth especially in the manufacturing industries, i.e. valued-added growth showed much more sensitivity to economic crises than employment growth, especially in the years of the global economic crisis which started in 2008 (Groot *et al.*, 2011; Veugelers and Batsaikhan, 2017). For the regional value added in the Netherlands we relied on regional accounts data published at NUTS-3 level by Statistics Netherlands.

Variety

Unrelated and related variety are often defined using the concept of entropy (Frenken *et al.*, 2007; Castaldi *et al.*, 2015). Entropy has the main advantage that total variety can be decomposed into a related and an unrelated one given a hierarchical classification system. Unrelated variety (URV) is measured as the entropy of the distribution of either the contribution of different industries (NACE classification) to the total value added of a region *i* or the distribution of patents across different technologies designated by the International Patent Classification (IPC) or classifications derived from the IPC like the World Intellectual Property Organization (WIPO) classification (Schmoch, 2008)

$$URV_i = \sum_{k=1}^{N} s_{k,i} \ln(\frac{1}{s_{k,i}})$$

where N is the number of main (one-digit level) categories which depend on the classification used (NACE or WIPO) and $s_{k,i}$ represents the share of a industry or IPC class in the total value added or patent filings in a region.

Related variety (RV) is defined as the weighted sum of entropies of the more fine-grained classes in each main category (Castaldi *et al.*, 2015):

$$RV_i = \sum_{l=1}^{n} s_{l,i} \ln(\frac{1}{s_{l,i}}) - \sum_{k=1}^{N} s_{k,i} \ln(\frac{1}{s_{k,i}})$$

where n is the number of fine-grained classes and N the number of main categories.

In line with Frenken *et al.* (2007) we defined related industrial variety for the NACE classification as the difference between the five-digit entropy and two-digit entropy. To calculate industrial unrelated and related variety we used data from the LISA employment database with information about all firms in the Netherlands where paid work is performed. Employment numbers in LISA were obtained for every Dutch region at five-digit sectoral level. From these numbers we calculated the different industrial varieties (related and unrelated) at NUTS 3-level for each year in the period 2006-2010. For unrelated industrial variety we considered the variety of employment numbers (full time equivalent) at NACE two-digit level and constructed related industrial variety by looking at the variety of employment at NACE five-digit level within each two-digit sector.

We measured technological variety by using patent classes. Here we relied on the WIPO classification, a classification derived from all classes making up the IPC classification, consisting of 5 main fields of technology and 35 subclasses. This classification has been introduced by Schmoch (2008) to accommodate the use of patent data for country comparisons in economic studies. He developed a systematic technology classification based on the codes of the International Patent Classification (IPC) which is more in line with the different industries than the IPC. Also, the size of the main fields which make up this classification strikes a better trade-off between having enough patents in each field while limiting the heterogeneity within fields. More information about the decomposition of the different types of variety is given in appendix A.

Capabilities

Patent intensity, defined as the average number of patent filings per firm within a year within a region, is generally considered to be a good proxy for technological capabilities and is often used as a measure of regional technological portfolios (Quatraro, 2009). We constructed patent intensity by dividing the total number of patent filings within a year (based on year of filing) assigned to a region (based on applicant address) by the total number of firm establishments within that region. Known limitations of patent indicators are that not all new technologies get patented and that patenting propensity differs by sector. Despite these limitations, patent intensity correlates highly with R&D intensity and patents can be assigned systematically to locations and to technological fields.

To measure market capabilities, we exploited trademark-based indicators. Castaldi (2020) provided an overview of the firm level trademark literature indicating that trademarks can be used to signal downstream capabilities needed for the successful commercialization of new products and services. New trademarks can only be registered by proving use in market, hence a firm filing a trademark has reached the commercialization stage of the innovation process and has figured out the right positioning in the market (Semadeni and Anderson, 2010). Trademarks may capture both incremental new-to-firm innovation and radical new-to-the market one (Flikkema *et al.*, 2019). Other arguments for using trademarks as indicators for market related activities are: they capture the activities of both startups and incumbents (Seip *et al.*, 2018), they may specifically capture the activities of 'high-quality'-startups (EPO/EUIPO, 2019, Castaldi *et al.*, 2019) and they capture activities in service industries as well, in particular the innovation activities of knowledge-intensive business services (KIBS) (Schmoch and Gauch, 2009). This specific category of services plays an important role in regional innovation systems and is found to boost the regional ability to develop specialization in new industries (Janssen *et al.*, 2018, Content, 2019). At regional level, trademark intensity, constructed by dividing the number of trademarks registered within a year by firms located within a region by the total number of firms within that region, can be used as a proxy for the ability to bring new products and services to the market (Mendonça *et al.*, 2004; Mendonça, 2014).

Controls

We controlled for the time-independent idiosyncratic effects of each region which are not captured by the other dependent variables by including 12 time-independent regional dummies at provincial level (NUTS 2-level).

5.4. Results

Table 5.2 presents the descriptives of the key variables for the 40 NUTS-3 regions of the Netherlands. The largest region in its peak year has almost 85,000 firms while the smallest region has little more than 2,000 firms. Additional information about the distribution of the patent and trademark intensities, unrelated and related varieties across the 40 regions can be found in the table in Appendix B which shows the five-year average for these variables. The top 5 values for each variable are highlighted.

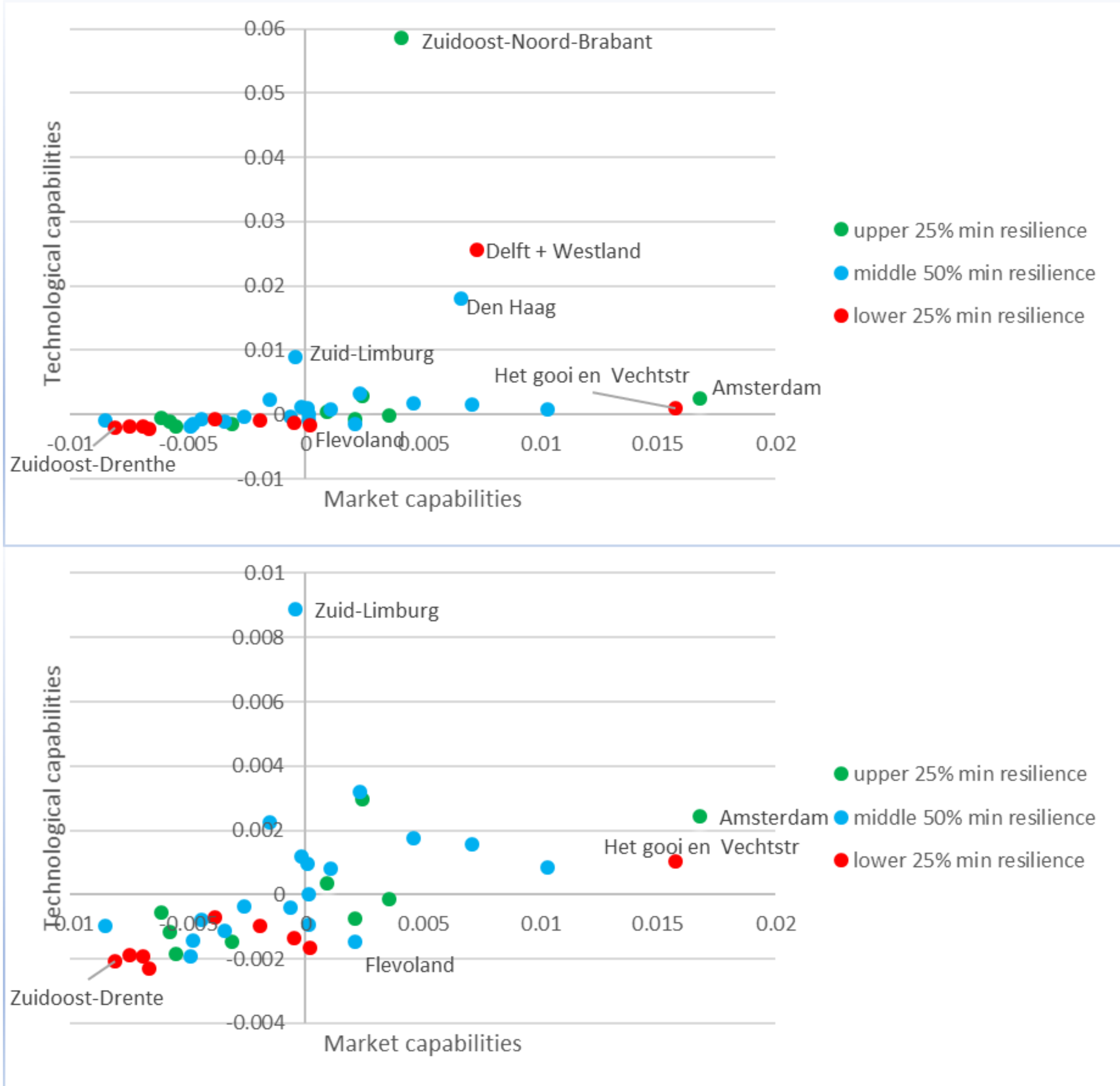
Table 5.2: Descriptives of key variables.

concept	variable	Minimum	Maximum	Mean	Std. Dev..
economic resilience					
	resilience (value added) t+1	0.84	1.10	1.00	0.03
	resilience (value added) t+2	0.80	1.18	0.99	0.04
	resilience (value added) t+5	0.78	1.16	0.98	0.06
industrial variety					
unrelated	unrelated variety employment	3.42	3.73	3.57	0.07
related	related variety employment	1.16	1.88	1.66	0.14
technological variety					
unrelated	unrelated patent variety	0.00	1.60	1.29	0.23
related	related patent variety	0.00	1.90	1.24	0.38
capabilities					
technological	patent intensity	0.0%	7.9%	0.6%	1.1%
market	trademark intensity	0.2%	4.0%	1.2%	0.6%

Correlation results for the different variables entering our analysis can be found in appendix C. Significant positive correlations exist between resilience for different time-lags and between resilience and industrial variety. No significant correlation is visible between resilience and technological variety although industrial and technological variety do correlate. Significant positive correlations also can be found between market capabilities and all varieties. Finally, technological and market capabilities are also strongly correlated. This also is visible in the scatterplot which shows the five-year average for the technological and market capabilities for each region for the period 2006-2010 as compared to the average value for these capabilities for the Netherlands (Figure 5.2). Values below zero indicate regional capabilities which lie below the Dutch average whereas values above zero indicate above average regional technological or market capabilities. The minimum score for regional economic resilience is also displayed in figure 5.2. This score corresponds to the year 2009 when regions had to absorb the initial shock of the crisis. The top 25% resilient regions capable of absorbing this initial shock are displayed in green, whereas the lowest 25% are displayed in red. The middle 50% are displayed in blue.

The top plot shows all regions including the outlier regions for technological capabilities. For reasons of clarity a second plot (bottom) is included which zooms in on the top plot where these three outlier regions for technological capabilities have been excluded. Regions which score below average on technological capabilities, also tend to score below average on market capabilities. Examples are more peripheral regions like Zuidoost-Drenthe. A noticeable exception is Flevoland, a region with a more diversified structure which included an above average contribution of the agriculture sector to its economy, which scores below average in technological capabilities but above average in market capabilities. Only three out of forty regions score above average in technological capabilities but below average in market capabilities. The most resilient regions (Amsterdam and Zuidoost-Noord-Brabant) score significantly above average in both technological and market capabilities. Yet, the region "Delft + Westland" also scores high on both capabilities but belongs to the 25% least resilient regions. A possible explanation can be found in the dominant role of the horticulture sector in this region, whose exports have been seriously affected by the global economic crisis (Berkhout and van Bruchem, 2010). However, most of the least resilient regions score also below average in both technological and market capabilities.

Figure 5.2**:** Regional technological vs. market capabilities (patent vs. trademark intensity) and their relation to categories of economic resilience.



In line with Frenken *et al*. (2007) and Fritsch and Kublina (2018) we estimated OLS regressions for a time-lag of five years. We removed two small outlier-regions (*Oost-Groningen* and *Delfzijl en omgeving*) from the analysis based on their Cook's-distances, calculated using all the independent variables in the OLS regressions: this distance is an estimate of the influence of a data point when performing OLS (Cook, 1977). Table 5.3 presents the results of the regression analysis (N=192) for T=5 years. Robustness checks for shorter time-lags *T* were also performed[14]. The results for the robustness checks for T=1 and T=2 years replicated the significant positive relation between related industrial variety and regional economic resilience which have been found in other studies (summarized in Content and Frenken, 2016), albeit at a 10% significance level.

Table 5.3 reports estimates of different models: first, a baseline model without interactions, then models with interactions for industrial and technological variety and technological capabilities and market capabilities respectively, and finally a full model with both interactions included. The results indicated that unrelated industrial variety was significantly positively related to regional economic resilience. Unrelated industrial variety remained significant and relates even more strongly positively to resilience in models where we accounted for the moderating role of technological and market capabilities. As for technological variety, the results showed no evidence for a direct relation between related technological variety and regional economic resilience, while unrelated technological variety did appear to matter.

Concerning the moderating role of capabilities, both types of regional capabilities mattered for regional resilience. The results indicated that these capabilities were particularly relevant in conjunction with unrelated variety. Interestingly, technological capabilities had a moderating role for both industrial and technological unrelated variety, while market capabilities mattered most for unrelated technological variety. We even found a negative relation of the interaction term between market capabilities and related industrial variety. This result could point to detrimental effects of further specializing in exploiting related market opportunities such as lock-in effects, at the expense of more risky investment in seizing opportunities from unrelated industrial variety (Nooteboom, 2000; Coenen *et al.*, 2015).

[14] *available upon request*

The regions with the highest five-year average scores on the interaction between unrelated technological variety and *market capabilities* were Amsterdam and the province of Utrecht, both also among the most resilient regions in the Netherlands within the period considered in this research.

Finally, it should be noted that the results for the baseline model showed that both technological and market capabilities correlated with regional economic resilience. However, their significance vanished when they were also included in the regressions in interaction with industrial or technological varieties. Because their significance as moderators exceeded their main effect this is evidence that they matter most as enablers of opportunities from industrial and technological variety rather than as a source for opportunities. The sole presence of these capabilities was not enough for a region to become resilient, as they mostly played a facilitating role in translating opportunities into new economic activities.

Table 5.3: Regression results for T=5 years

Dependent: regional economic resilience (value added growth)

	Variables	model 1			model 2			model 3			model 4		
5 year time-lag		**without interaction**			**interaction with techn capabilities included**			**interaction with market capabilities included**			**full model**		
		B	std.err.	Sig.	B	std.err.	Sig.	B	std.err.	Sig.	B	std.err.	Sig.
industry	unrelated variety (Nace 2 digits)	.114	.085	.178	.200*	.090	.028	.151	.087	.085	0.191*	.092	.038
	related variety (Nace 5 within 2 digits)	.093	.052	.077	.103	.064	.109	.098	.058	.092	.084	.068	.222
technology	unrelated variety	.026	.019	.189	.047*	.023	.043	.051*	.021	.014	0.062*	.025	.012
	related variety	-.003	.016	.868	-.008	.020	.676	-.013	.016	.409	-.013	.020	.513
capabilities	technological	1.150**	.438	.009	1.327	1.466	.367	1.342**	.435	.002	1.235	1.734	.478
	market	2.023*	.834	.016	1.830*	.857	.034	1.438	.985	.146	1.660	1.143	.148
interaction - techn. capabilities	unrelated ind. variety * technological cap.				25.431*	12.055	.036				17.882	13.892	.200
	related ind. variety * technological cap.				-15.857	9.519	.098				-9.929	11.449	.387
	unrelated techn. variety * techn. cap.				11.555**	3.971	.004				6.742	4.425	.130
	related techn. variety * techn. cap.				-2.571	3.860	.506				-1.775	4.573	.698
interaction - market capabilities	unrelated ind. variety * market cap.							14.772	11.520	.202	9.801	14.433	.498
	related ind. variety * market cap.							-15.983*	8.048	.049	-10.954	9.963	.273
	unrelated techn. variety * market cap.							12.317**	3.649	.001	10.469*	4.220	.014
	related techn. variety * market cap.							-3.544	3.063	.249	-3.309	3.537	.351
Controls	regional fixed effects	included			included			included			included		
	Constant	.957**	.009	.000	.941**	.014	.000	.957**	.009	.000	.946**	.015	.000
	R square			.276			.320			.340			.352
	N[1]			192			192			192			192

*/** significant at 5/1 percent level

[1] after removal of two regions based on their Cook's distances

5.5. Discussion

This study makes several contributions to the existing literature on regional economic resilience.

Our primary contribution is to highlight how regional technological and market capabilities moderate the relation between industrial and technological variety and economic resilience. We found this for unrelated industrial and technological variety. Our results are in line with results from Fritsch and Kublina (2018) for unrelated industrial variety in conjunction with R&D capabilities, for the case of West-Germany. Our interpretation is that unrelated variety generates more opportunities for the creation of new economic pathways, which are essential for the continuous adaptation of a region across periods of adverse economic conditions, provided that the technological capabilities necessary for the exploitation of these new pathways are available. There is also significant evidence for the positive influence of unrelated technological variety provided that it is fostered by available technological and market capabilities. Technological breakthroughs can lead to new pathways but because of their radical nature the outcome of these innovation processes is more uncertain than in the case of incremental technological improvements (Castaldi *et al.*, 2015). Both technological and market capabilities help local firms making sense and seizing these riskier but often more rewarding opportunities.

A second contribution is that we found a difference between the effects of related technological and industrial variety. We replicated findings of earlier studies which found evidence for the beneficiary effect of related industrial variety on regional economic resilience (see Content and Frenken, 2016, for an overview). However, we found no such effect for related technological variety. A possible interpretation of this result is that related technological variety may also lead to technological lock-in because too much similarity may result in cognitive lock-in (Nooteboom, 2000). Cognitive lock-in can inhibit innovation and the creation of new economic pathways. This can impede regional economic resilience. Further research may be dedicated to studying the effect of cognitive lock-in on the economic resilience of regions.

A final contribution of our study is of a methodological nature. We showed that next to economic and patent data, trademark data can be used in the study of regional economic resilience. Whereas patents can be a good indicator for more upstream innovation activities, trademarks can be an indicator for the more downstream activities necessary to realize new market opportunities. Trademark-based indicators also allow capturing entrepreneurial dynamism in a region. Further research may distinguish between types of trademark owners. For example, trademark intensity by startups may provide specific information about the entrepreneurial dynamism within a region, which can be a source of resilience and economic growth in general (Fritsch and Kublina, 2018). A qualitative analysis of regional trademark portfolios may also provide an interesting avenue for further research. The breadth of the market classes covered by the regional trademark filings may for example provide information about the diversity of the new growth paths developed within a region. One could even differentiate between trademarks in knowledge-intensive classes vs other classes, like Mendonça *et al.* (2019).

Our analysis is not without limitations. Our primary goal was to study the influence of technological and market capabilities in fostering opportunities from industrial and technological variety. Both patent and trademark indicators are only able to capture a share of all available expertise and capabilities. This limitation is valid also for our study, but slightly less so since the Netherlands are a highly IPR intensive country[15]. However, these IPR-based

[15] *https://www.wipo.int/publications/en/details.jsp?id=4369*

indicators of capabilities might be more problematic for other countries, with lower IPR filing rates. An additional weakness of our study was that we could not rely on extensive time-series and as such we could not use stocks, i.e. accumulated portfolios of IPRs indicating systematic instead of incidental activities as measures of capabilities (Castaldi, 2020).

The available data allowed us only to consider a period of five years including the global economic crisis which started in 2008. A longer period, including the more recent (and also smaller more industry specific) economic downturns could have allowed a further test of some of the factors considered. Frenken at al. (2007) argued that unrelated industrial variety can be beneficial in mitigating the effect of industry specific shocks. However, the global economic crisis which started in 2008 was felt in all industries, although the crisis sensitivity differed between sectors (Groot *et al.*, 2011). Possibilities for mitigation to other industries were therefore limited during this particular crisis. Also, based on regional employment data for a period of more than 25 years Essletzbichler (2007) found evidence that unrelated industrial variety stabilizes regional economies on the longer run. Apparently, unrelated variety can benefit regional economic resilience, but only in the very long run. We studied the relation between unrelated industrial and technological variety and regional economic resilience for up to five years. Although evidence for a positive relation has been found the results found by Essletzbichler (2007) suggest that even longer time-lags should be considered.

Finally, our study was limited to the 40 NUTS-3 regions making up the Netherlands and a period of only five years. A larger dataset, including more countries and more years, could allow a stronger test for different countries and at different regional levels. For example, a robustness check could indicate if the conclusions still hold at different levels of regional aggregation, like the NUTS-2 level, because we found that in NUTS-3 regions with large firms the related technological variety often originated from related activities within the same firms. However, other problems may arise when other countries are included. IPR filing rates and therefore their appropriateness as a proxy for technological and market capabilities may vary across countries.

5.6. Conclusions

This study has proposed a novel take on regional economic resilience by suggesting that the contribution of regional varieties is moderated by specific regional capabilities. The existing literature mainly focuses on the study of the varieties as possible sources for opportunities which, if realized, may contribute to regional economic resilience. In this sense, this paper extends existing frameworks by explicitly accounting for the role of regional capabilities for seizing opportunities. While this study replicated the findings of earlier studies which showed that regional related industrial variety has a beneficiary effect on regional economic resilience on the short run, it also showed that both unrelated industrial and technological variety can be beneficial on the long run, especially when they are moderated by the presence of regional technological and market capabilities. Our interpretation is that in the long run it is the ability to transfer opportunities from spillovers and recombinant innovations into economic output which makes a region resilient.

In terms of policy implications, our findings indicated that although related industrial variety matters for regional economic resilience in the short run, it is unrelated industrial variety which benefits regional economic resilience in the long run. In this interpretation, our results support policy efforts directed at stimulating the creation of linkages between strong but unrelated industries (Janssen and Frenken, 2019). The cooperation between firms from different unrelated industries who share a common ground can also be a source for unrelated knowledge spillovers (Puranam *et al.*, 2009). This could induce specific knowledge flows driving economic diversification and the creation of new growth paths. Regional policies could therefore also include efforts to connect firms which share a common ground, for example by creating networks of firms sharing similar goals and visions, like in the case of the dissemination of cleaner technologies to SMEs through social networks surrounding these SMEs (Verheul, 1999).

However, our results also indicated that the availability of technological and market capabilities is necessary for exploiting the spillovers from unrelated activities. Local innovation policy could therefore also include measures to stimulate the availability of these capabilities. This supports Camagni and Capello (2013) and others who argued that innovation policies should include all capabilities besides R&D related ones, in particular entrepreneurial orientation and market orientation. Examples of these policies include programs to assist entrepreneurs in the different phases of their journey, but also programs supporting incumbent firms in their efforts to diversify into new markets, for instance within trajectories of servitization (Janssen and Castaldi, 2018): financial support, access to networks and personal advice to firms to find new export markets. This can differ between regions depending on the capabilities available. For example, peripheral regions in the Netherlands tend to score below average in market capabilities. Regional policies for these regions could therefore include measures to promote further development of these downstream capabilities.

Appendices

Appendix A: Unrelated and related variety composition

	N	n
Industrial variety (NACE)	NACE 2 digit employment rates (FTE)	NACE 5 digit employment rates (FTE)
Technological variety (WIPO)	5 main fields of technologies (WIPO, 2008):	35 technologies derived from IPC (WIPO, 2008):
	I. Electrical engineering	**I. Electrical engineering**
	II. Instruments	1 Electrical machinery, apparatus, energy
	III. Chemistry, Pharmaceuticals	2 Audio-visual technology
	IV. Mechanical engineering	3 Telecommunications
	V. Other fields	4 Digital communication
		5 Basic communication processes
		6 Computer technology
		7 IT methods for management
		8 Semiconductors
		II. Instruments
		9 Optics
		10 Measurement
		11 Analysis of biological materials
		12 Control
		13 Medical technology
		III. Chemistry
		14 Organic fine chemistry
		15 Biotechnology
		16 Pharmaceuticals
		17 Macromolecular chemistry, polymers
		18 Food chemistry
		19 Basic materials chemistry
		20 Materials, metallurgy
		21 Surface technology, coating
		22 Micro-structure and nano-technology
		23 Chemical engineering
		24 Environmental technology
		IV. Mechanical engineering
		25 Handling
		26 Machine tools
		27 Engines, pumps, turbines
		28 Textile and paper machines
		29 Other special machines
		30 Thermal processes and apparatus
		31 Mechanical elements
		32 Transport
		V. Other fields
		33 Furniture, games
		34 Other consumer goods
		35 Civil engineering

* no data was available for these industries at 1- digit level

Appendix B

Five year average values for different explanatory variables: intensities and related varieties (top 5 of each variable are highlighted).

COROP (Nuts 3 region)	unrelated industrial variety	*Std. Deviation*	related industrial variety	*Std. Deviation*	unrelated techn variety	*Std. Deviation*	related techn variety	*Std. Deviation*	techn capabilities	*Std. Deviation*	market capabilities	*Std. Deviation*
01 Oost-Groningen	3.471	*0.003*	1.493	*0.033*	1.26	*0.17*	0.94	*0.23*	0.23%	*0.05%*	0.37%	*0.09%*
02 Delfzijl en omgeving	3.471	*0.032*	1.187	*0.018*	0.65	*0.46*	0.38	*0.38*	0.13%	*0.08%*	0.54%	*0.30%*
03 Overig Groningen	3.585	*0.012*	1.671	*0.017*	1.39	*0.06*	1.10	*0.10*	0.21%	*0.06%*	0.88%	*0.08%*
04 Noord-Friesland	3.561	*0.007*	1.632	*0.011*	1.26	*0.24*	1.22	*0.23*	0.19%	*0.11%*	0.75%	*0.06%*
05 Zuidwest-Friesland	3.581	*0.004*	1.448	*0.010*	1.29	*0.12*	0.74	*0.21*	0.14%	*0.04%*	0.48%	*0.12%*
06 Zuidoost-Friesland	3.577	*0.008*	1.561	*0.017*	1.28	*0.16*	0.93	*0.19*	0.23%	*0.07%*	1.04%	*0.13%*
07 Noord-Drenthe	3.489	*0.007*	1.635	*0.012*	1.28	*0.10*	0.88	*0.32*	0.14%	*0.06%*	0.74%	*0.16%*
08 Zuidoost-Drenthe	3.617	*0.008*	1.541	*0.037*	1.11	*0.21*	0.79	*0.12*	0.12%	*0.04%*	0.42%	*0.07%*
09 Zuidwest-Drenthe	3.579	*0.008*	1.549	*0.015*	1.26	*0.13*	1.01	*0.08*	0.27%	*0.07%*	0.62%	*0.11%*
10 Noord-Overijssel	3.596	*0.008*	1.623	*0.016*	1.19	*0.16*	1.20	*0.16*	0.18%	*0.02%*	0.91%	*0.08%*
11 Zuidwest-Overijssel	3.567	*0.007*	1.531	*0.008*	1.01	*0.21*	0.94	*0.31*	0.41%	*0.15%*	1.34%	*0.30%*
12 Twente	3.589	*0.004*	1.762	*0.011*	**1.56**	***0.05***	1.42	*0.10*	0.45%	*0.09%*	1.21%	*0.21%*
13 Veluwe	3.597	*0.002*	1.794	*0.007*	1.41	*0.07*	1.43	*0.12*	0.36%	*0.03%*	1.32%	*0.15%*
14 Achterhoek	3.595	*0.008*	1.758	*0.016*	1.43	*0.07*	1.50	*0.12*	0.29%	*0.06%*	0.97%	*0.15%*
15 Arnhem/Nijmegen	3.618	*0.014*	1.789	*0.010*	1.24	*0.07*	**1.86**	***0.04***	**0.65%**	***0.09%***	1.46%	*0.21%*
16 Zuidwest-Gelderland	3.619	*0.009*	1.687	*0.012*	1.22	*0.20*	1.28	*0.19*	0.24%	*0.05%*	1.24%	*0.28%*
17 Utrecht	3.571	*0.007*	**1.862**	***0.006***	**1.50**	***0.03***	1.62	*0.03*	0.41%	*0.05%*	**2.26%**	***0.27%***
18 Kop van Noord-Holland	3.500	*0.013*	1.598	*0.021*	1.38	*0.09*	1.43	*0.16*	0.25%	*0.08%*	0.79%	*0.07%*
19 Alkmaar en omgeving	3.521	*0.014*	1.789	*0.003*	1.40	*0.09*	1.16	*0.09*	0.31%	*0.05%*	1.58%	*0.25%*
20 IJmond	3.473	*0.007*	1.514	*0.006*	1.19	*0.18*	0.98	*0.24*	0.26%	*0.10%*	0.84%	*0.18%*
21 Agglomeratie Haarlem	3.534	*0.030*	1.680	*0.007*	1.39	*0.11*	1.07	*0.16*	0.16%	*0.02%*	1.25%	*0.19%*
22 Zaanstreek	3.600	*0.013*	1.726	*0.020*	1.18	*0.27*	0.83	*0.26*	0.29%	*0.15%*	1.17%	*0.16%*
23 Groot-Amsterdam	**3.670**	***0.006***	1.672	*0.011*	**1.52**	***0.03***	**1.73**	***0.03***	0.57%	*0.06%*	**2.90%**	***0.44%***
24 Het Gooi en Vechtstreek	3.590	*0.007*	1.669	*0.013*	1.29	*0.12*	1.50	*0.15*	0.43%	*0.11%*	**2.80%**	***0.63%***
25 Agg. Leiden en Bollenstreek	3.473	*0.005*	1.783	*0.018*	1.28	*0.08*	1.35	*0.12*	0.42%	*0.07%*	1.24%	*0.20%*
26 Agglomeratie 's-Gravenhage	3.475	*0.010*	1.672	*0.004*	**1.48**	***0.05***	1.33	*0.15*	**2.13%**	***0.44%***	**1.89%**	***0.32%***
27 Delft en Westland	3.436	*0.013*	1.412	*0.016*	**1.49**	***0.02***	**1.73**	***0.04***	**2.89%**	***0.44%***	**1.96%**	***0.37%***
28 Oost-Zuid-Holland	3.550	*0.008*	**1.853**	***0.014***	1.25	*0.19*	1.37	*0.10*	0.19%	*0.04%*	1.18%	*0.15%*

29 Groot-Rijnmond	**3.656**	***0.005***	**1.868**	***0.008***	1.39	*0.05*	1.56	*0.06*	0.50%	*0.13%*	1.69%	*0.24%*
30 Zuidoost-Zuid-Holland	3.588	*0.003*	**1.805**	***0.013***	1.43	*0.11*	1.34	*0.17*	0.33%	*0.06%*	1.24%	*0.13%*
31 Zeeuws-Vlaanderen	3.470	*0.003*	1.444	*0.009*	1.00	*0.58*	0.46	*0.34*	0.10%	*0.07%*	0.56%	*0.31%*
32 Overig Zeeland	3.641	*0.006*	1.596	*0.012*	1.37	*0.12*	1.09	*0.24*	0.14%	*0.03%*	0.68%	*0.07%*
33 West-Noord-Brabant	**3.682**	***0.012***	1.801	*0.015*	1.35	*0.05*	1.30	*0.14*	0.62%	*0.19%*	1.47%	*0.07%*
34 Midden-Noord-Brabant	**3.646**	***0.013***	**1.820**	***0.022***	1.41	*0.08*	1.51	*0.07*	0.25%	*0.02%*	1.44%	*0.19%*
35 Noordoost-Noord-Brabant	3.642	*0.018*	1.771	*0.009*	1.43	*0.03*	1.51	*0.02*	0.48%	*0.07%*	1.94%	*1.17%*
36 Zuidoost-Noord-Brabant	**3.714**	***0.013***	1.739	*0.009*	1.20	*0.08*	**1.71**	***0.06***	**6.19%**	***1.01%***	1.64%	*0.15%*
37 Noord-Limburg	3.544	*0.005*	1.624	*0.004*	1.26	*0.11*	1.44	*0.05*	0.55%	*0.12%*	1.07%	*0.10%*
38 Midden-Limburg	3.620	*0.006*	1.700	*0.010*	1.33	*0.24*	1.20	*0.16*	0.21%	*0.04%*	0.65%	*0.09%*
39 Zuid-Limburg	3.623	*0.009*	1.740	*0.020*	0.93	*0.15*	**1.86**	***0.05***	**1.21%**	***0.15%***	1.18%	*0.13%*
40 Flevoland	3.602	*0.006*	1.774	*0.024*	1.39	*0.08*	1.11	*0.24*	0.18%	*0.03%*	1.44%	*0.24%*

Appendix C

Correlations results

		resilience (5 yr)	resilience (2 yr)	resilience (1 yr)	unrelated ind. variety	related ind. variety	unrelated tech. variety	related tech. variety	techn capabilities	market capabilities
resilience (5 yr)	Pearson Corr.	1								
	Sig. (2-tailed)									
resilience (2 yr)	Pearson Corr.	.705**	1							
	Sig. (2-tailed)	.000								
resilience (1 yr)	Pearson Corr.	.421**	.627**	1						
	Sig. (2-tailed)	.000	.000							
unrelated ind. variety	Pearson Corr.	.141*	.223**	.313**	1					
	Sig. (2-tailed)	.046	.002	.000						
related ind. variety	Pearson Corr.	.072	.156*	.089	.513**	1				
	Sig. (2-tailed)	.311	.027	.211	.000					
unrelated tech. variety	Pearson Corr.	-.020	.015	.037	.124	.418**	1			
	Sig. (2-tailed)	.778	.838	.599	.080	.000				
related tech. variety	Pearson Corr.	-.008	.041	.102	.346**	.579**	.354**	1		
	Sig. (2-tailed)	.909	.563	.151	.000	.000	.000			
technological capabilities	Pearson Corr.	.020	.040	.192**	.171*	.041	.025	.380**	1	
	Sig. (2-tailed)	.779	.570	.007	.016	.568	.721	.000		
market capabilities	Pearson Corr.	-.004	.059	.105	.255**	.403**	.299**	.543**	.290**	1
	Sig. (2-tailed)	.961	.405	.138	.000	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

6. Conclusions

6.1. Summary of results and conclusions

Recent IPR literature indicated that there is a large heterogeneity among firms in the use of IPRs. (Hall *et al.*, 2014). This thesis has focused on the use of types of IPRs that can be officially registered: patents, trademarks, design rights and breeders' rights. The central research question addressed in this thesis is:

How do firms employ different IPRs for innovation and growth purposes?

To answer this question, it was decomposed into four sub-questions:

1. *Who is filing IPRs?*
2. *Which IPRs do firms file?*
3. *When are IPRs filed?*
4. *Where are IPR filers located?*

The results of the research presented in the previous chapters provide answers to these sub-questions. Figure 6.1 presents a summary of the results for these sub-questions.

Table 6.1: Summarized results for the sub-questions: Who? Which IPRs? When? Where?

Chapter	**Who?**	**Which IPRs?**	**When?**	**Where?**
Ch. 2.	IPR strategists, IPR specialists, IPR generalists, patent and trademark rookies	Foremost trademark filings; then patents, design and breeders' right filings		
Ch. 3.	Scale-ups in the Netherlands	Increased fling of IPRs by top 250 scale-ups, especially for trademarks.	Scale-ups tend to file trademarks already at a young age. This holds especially for scale-ups in the top 250. Patents tend to be filed more widespread throughout the lifetime of scale-ups.	Scale-ups, especially those in the northern part of the Netherlands are more likely to file trademarks
Ch. 4.	Innovating firms	Trademarks (related to innovation)	Trademarks are not only filed during later phases of the innovation process such as the marketing phase but also during the early (R&D) phases of the innovation process, especially in case of start-ups or in combination with patents	
Ch. 5.		Patents and trademarks representing technological and non-technological capabilities		Resilient regions (NL, NUTS-3)

1. *Who is filing IPRs?*

Chapter 2 presented results on the distribution of IPR filings across firms. A taxonomy of firms filing IPRs in terms of IPR variety and intensity revealed the most common filing practices across firms. This taxonomy distinguishes between five categories of firms: patent rookies, trademark rookies, IPR strategists, IPR specialists and IPR generalists. Another conclusion is that IPR filing strongly depends on both sector and firm size. The share of firms which file IPRs increases intensively with firm size. Also, this share is higher for firms in high-tech sectors. This observation not only holds for patents, but also for trademarks although the intensive use of trademarks also applies to firms in non-technological (services) sectors.

IPRs are also filed by firms having capabilities necessary for successful innovation. Research indicated that different types of IPRs can be used as an indicator for the technological and commercialization capabilities present within a firm, region or country (Kogut and Zander, 1992; Teece *et al.*, 1997; Iammarino *et al.*, 2012; Mendonça, 2014; Castaldi, 2020). These capabilities foster growth. Chapter 3 presented an analysis of the IPRs of scale-ups. The results indicated a higher use of IPRs by scale-ups, particularly trademarks, as compared to non-scale-ups. An important finding was that the tendency to file trademarks is even higher for the top 250 fastest growing firms. Two thirds of these firms filed one or more trademarks. The share of firms filing trademarks was much higher for scale-ups in the top 250 than for other firms with similar sizes. Building on the literature on IPRs it can be argued that these trademark filings indicate that these firms stand out in their commercialization capabilities (Guzman and Stern, 2016; Castaldi *et al.*, 2020; Lyalkov *et al.*, 2020).

2. *Which IPRs do firms file ?*

The results based on Dutch IPR filers presented in chapter 2 clearly confirmed statistics on IPRs which indicate that trademarks are by far the most widespread type of IPR filed by firms (Dinlersoz *et al.*, 2018; WIPO, 2019). About six times as many firms file trademarks as opposed to firms filing patents. Patents are filed by more firms than design and breeders' rights.

3. *When are IPRs filed?*

The results in chapter 3 indicated that scale-ups tend to file trademarks already at a young age. This holds especially by firms in the top 250 scale-ups. Because IPR literature indicated that trademarks also signal commercialization capabilities, this result may indicate that commercialization capabilities within these firms are already present in the start-up phase. Instead, patents tend to be filed throughout the lifetime of scale-ups.

In IPR literature trademarks are generally associated with downstream activities of the innovation process, such as the market introduction and successful commercialization of products and services. Chapter 4 presented evidence that, contrary to this assumption, trademarks are often filed during the early phases of the innovation process. There is a higher tendency towards early trademark filing by start-ups, for the purpose of radical innovation and when trademark filings are combined with patents. This tendency is even higher when these factors are combined. Medium-sized and large firms, especially in high-tech manufacturing industries, with incremental innovation, show a tendency towards late trademark filing, irrespective the combination of trademarks with patents.

4. *Where are IPRs filers located?*

The analysis of the IPR filings of scale-ups presented in chapter 3 also included the location of these firms. Scale-ups in the Netherlands, especially the top 250 fastest growing scale-ups and especially those in the Northern three provinces (Groningen, Friesland and Drenthe) are more likely to file trademarks as compared to other firms.

An analysis of the differences in the intensity of patent and trademark filings, done by firms across regions at NUTS 3-level in the Netherlands was presented in chapter 5. We interpreted these differences as a result of differences in the presence of specific capabilities within regions. Patent intensity signals the presence of technological capabilities whereas trademark intensity signals the presence of capabilities connected with commercialization activities (Mendonça, 2014, Castaldi, 2020). Not surprisingly, urbanized regions, where many firms with these capabilities are concentrated, tend to show higher patent and trademark filing intensities and therefore score higher on these capabilities than rural regions. These capabilities moderate the successful exploitation of opportunities for new economic pathways which foster regional economic resilience during economic crises.

6.2. Implications for research and policy

The results presented in the previous section provide an answer to the central question on how firms employ the range of IPRs for innovation and growth purposes. The results also have implications for research on IPRs and for IPR policy.

6.2.1. Implications for research

First, the distribution of IPR filings across firms is very skewed for all types of IPRs. Few firms are responsible for a majority of all IPR filings. Most of these “frequent filers” are large multinational firms in (high-tech) manufacturing and services. This seems to be in accordance with IPR research which states that SMEs tend to file IPRs less frequently, also after controlling for firm size (Lanjouw and Shankerman, 2004; Leiponen and Byma, 2009; Thomä and Bizer, 2013). Innovating SMEs are less likely to file patents or trademarks than innovating large firms, even when they consider IPRs as an important tool for protecting their innovations (Hanel, 2008; Robson and Kenchatt, 2010). These filing patterns are similar for the different types of IPRs considered in this thesis. This may indicate that similar causes for these differences in filing practices apply to the whole IPR system. Future studies may reveal these causes. Do SMEs experience limited access to the IPR system? If so, does this impede their ability to profit from innovation? Possible causes for limited access include a lack of resources and knowledge (Castaldi, 2018) or strategic practices by competitors (Reitzig, 2004; Germeraad, 2010), while some other causes are related to alternative strategies, such as opting for secrecy (Arundel, 2001; Hussinger, 2006) or lack of belief in IPR systems (Berland, 2013). The costs of keeping technological advances secret might be lower for SMEs and therefore SMEs might relatively more frequently decide to prefer secrecy over patent filing.

Second, the taxonomy of IPR filing practices presented in chapter 2 confirmed earlier findings in the IPR literature (Neuhäusler, 2012) and the legal literature on litigation, in particular the Apple versus Samsung battle (Carani, 2012). Firms that use IPRs strategically rely on the whole range of available IPRs. Therefore, instead of focusing on one type of IPR more insight will be gained from research into the combination of IPRs which addresses the following research questions:

- What are the main reasons for firms to use the whole range of IPRs?
- How do firms benefit from the combination of IPRs? How do firms use the different IPRs to leverage their competitive advantage?
- Does the combination of IPRs lead to significant market foreclosure and even distort competition in such a way that antitrust laws are violated as suggested by Todino (2014)?

Further research into the combination of IPRs should also focus on characteristics of the innovation process such as the length of the innovation process and the costs involved. Are firms more likely to use multiple IPRs to protect innovation in case of long and costly innovation processes? Research in the pharmaceutical and electronic industries indicated that this is the case (Bekkers *et al.*, 2002; Schnichels and Sule, 2010; Nasirov, 2020).

The research presented in Chapter 4 of this thesis indicated that the combination of trademarks with patents covaries with filing early on in the innovation process. The combination of IPRs could indicate the presence of different capabilities within a firm: patent filing signals the presence of technological capabilities while trademark filing signals commercialization capabilities. Another reason for combining IPRs is that complex innovations require the use of different IPRs for the protection of the different features of an innovation which make it unique and different from similar products or services in the market.

Third, regarding the filing of IPRs in innovation processes this thesis confirmed earlier research that besides patents, trademarks also indicate innovation and therefore are useful as an indicator for innovation. Contrary to the general assumption in IPR literature, trademarks not only refer to downstream innovation activities connected with the market introduction and successful commercialization of products and services but can also refer to innovation which is still in the early phases in the innovation process connected to research and development. Especially in case of startups trademarks often refer to upstream innovation activities. Trademarks are more widely filed by firms than patents because trademarks can also be used in case of incremental innovation, in case of the non-technological innovation by service firms, for the non-innovative development of products, services or processes or to support brand strategies (Flikkema *et al.*, 2014; Flikkema *et al.*, 2019; Castaldi, 2020; Castaldi *et al.*, 2020). Further sector-specific research into trademarks and their reference to innovation can provide an overview of sectors for which they are a better alternative to patents as an indicator for innovation. One might argue that patent statistics should be preferred in high-tech sectors whereas trademarks should be preferred in sectors where innovation is dominated by SMEs or where most innovation is of a non-technological nature like the services sectors (Mendonça *et al.*, 2004; Flikkema *et al.*, 2014).

Finally, patent and trademark filings have been used as an indicator for technological and commercialization capabilities. Both at the firm and at the regional level, results stress the importance of commercialization capabilities in moderating growth and resilience. However, until now the role of these capabilities and their connection with IPRs is still underexplored. Therefore, a more detailed study on the contribution of these different capabilities in firm and regional growth at sector-level or for different types of innovation (product, services and process innovation) would be a good avenue for future research. This also holds for a study on the validity of patent and trademark filings as indicators for these capabilities.

6.2.2. Implications for policy

Insights about the actual use of IPRs reported in this thesis may have implications for policy makers.

First, we found large differences in filing practices between firms which may indicate limitations in the access to the IPR system, especially in case of SMEs. Results indicated that the distribution of IPRs over firms is highly skewed for all types of IPRs, implying that a few firms are responsible for a large share of all filings. In most cases they are large firms in high-tech sectors. The taxonomy which was built from this data also stresses the differences between these few firms which frequently use IPRs and combine the different types and the vast majority of firms, especially SMEs, which consider IPRs only marginally. This observation holds for patents and trademarks and to a lesser degree also for design and breeders' rights. Further research has to reveal the causes of these differences. Possible reasons include limited access perceived by firms, especially when firms lack the necessary resources, or have limited familiarity with the IPR system. The question whether this has an impact on innovation by SMEs also needs to be answered. If so, then policy measures which remove these barriers have to be developed and implemented. Measures taken in some countries, such as Austria[16] and Finland[17] include patent vouchers which support innovating SMEs by enabling them to use the services of patent attorneys or IPR consultants in general to protect their innovation. Another example is the foreign market entry voucher introduced by the Dutch government to help Dutch SMEs to start business abroad and which can also be used by Dutch SMEs to file trademarks in foreign countries[18]. Improving the access to IPR systems may foster innovation activities by SMEs..

Second, we want to explore the policy consequences of the role IPRs play in stimulating the growth of firms and regions. The goal of most innovation policy measures is to stimulate R&D and innovation across firms and to foster public-private partnerships for knowledge exchange purposes. An example of these measure is the innovation vouchers which are awarded by many regional and national governments (Veugelers, 2015, Lemmers *et al.*, 2019). Besides stimulating R&D and innovation governments should consider the introduction of policy measures which stimulate the development of commercialization capabilities across firms or stimulate knowledge exchange with firms and organizations who stand out in these capabilities. The results presented in chapter 3 and 5 of this thesis indicated that these capabilities play an important role in the downstream activities in the innovation process and, thus enabling successful market introduction and commercialization,

[16] *https://www.patentamt.at/en/patentvoucher/*
[17] *https://www.businessfinland.fi/en/for-finnish-customers/services/funding/research-and-development/innovation-voucher/*
[18] *https://english.rvo.nl/subsidies-programmes/sib/sib-market-entry-voucher*

Finally, the results of this thesis indicated that next to patent filings policy makers should resort to other IPRs as well in order to monitor the innovation activities within countries. In economies such as the Netherlands which is moving from an economy dominated by the manufacturing sectors towards a service economy, the significance of patents as an indicator of innovation is decreasing. The importance of other IPRs, in particular trademarks, which also account for other forms of innovation, including service innovation, is increasing. Yet, the focus in many international innovation scoreboards is still on international patent filings although only a few large multinationals in manufacturing are responsible for most of these filings. However, these multinationals contribute less than 50% to the gross domestic products (GDPs) of the economies in most countries[19]. The results in this thesis provided further evidence for the importance of going ‘beyond patents’ to monitor innovation and the capabilities within firms, regions or countries which foster innovation and growth.

[19] *In the Netherlands they account for 30 procent of the economy. See also https://www.cbs.nl/en-gb/news/2018/41/multinationals-account-for-30-percent-of-economy*

References

Agostini, L., Filippini, R., & Nosella, A. (2016). Protecting intellectual property to enhance firm performance: does it work for SMEs?. *Knowledge Management Research & Practice*, *14*(1), 96-105.

Alam, I., & Perry, C. (2002). A customer-oriented new service development process. *Journal of Services Marketing*, *16*(6), 515-534.

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

Allegrezza, S., & Guarda-Rauchs, A. (1999). The determinants of trademarks deposits: An econometric investigation. *Economie Appliquée*, *52*(2), 51-68.

Almus, M. (2002). What characterizes a fast-growing firm? *Applied Economics*, *34*(12), 1497-1508.

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

Arora, A., & Nandkumar, A. (2012). Insecure advantage? Markets for technology and the value of resources for entrepreneurial ventures. *Strategic Management Journal*, *33*(3), 231-251.

Arundel, A. (2001). The relative effectiveness of patents and secrecy for appropriation. *Research Policy*, *30*(4), 611-624.

Attaran, M. (1986). Industrial diversity and economic performance in US areas. *The Annals of Regional Science*, *20*(2), 44-54.

Bar, T., & Leiponen, A. (2012). A measure of technological distance. *Economics Letters*, *116*(3), 457-459.

Barbero, J. L., Casillas, J. C., & Feldman, H. D. (2011). Managerial capabilities and paths to growth as determinants of high-growth small and medium-sized enterprises. *International Small Business Journal*, *29*(6), 671-694.

Becker, M. C., & Lillemark, M. (2006). Marketing/R&D integration in the pharmaceutical industry. *Research Policy*, *35*(1), 105-120.

Bekkers, R., & West, J. (2009). The limits to IPR standardization policies as evidenced by strategic patenting in UMTS. *Telecommunications Policy*, *33*(1-2), 80-97.

Bekkers, R., Duysters, G., & Verspagen, B. (2002). Intellectual property rights, strategic technology agreements and market structure: The case of GSM. *Research Policy*, *31*(7), 1141-1161.

Berkhout, P., & van Bruchem, C. (2010). *Agricultural Economic Report 2010 of the Netherlands: Summary* (No. 2010-054). LEI WUR.

Berland, E. (2013). European citizens and intellectual property: Perception, Awareness and Behaviour. *Office for Harmonization in The Internal Market. Alicante, Spain*.

Berrier Jr, E. F. (1995). Global patent costs must be reduced. *Idea*, *36*, 473.

Bessen, J. E., Bessen, J., & Meurer, M. J. (2008). *Patent failure: How judges, bureaucrats, and lawyers put innovators at risk*. Princeton University Press.

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

Block, J. H., De Vries, G., Schumann, J. H., & Sandner, P. (2014). Trademarks and venture capital valuation. *Journal of Business Venturing*, *29*(4), 525-542.

Block, J. H., Fisch, C. O., Hahn, A., & Sandner, P. G. (2015a). Why do SMEs file trademarks? Insights from firms in innovative industries. *Research Policy*, *44*(10), 1915-1930.

Block, J. H., Kohn, K., Miller, D., & Ullrich, K. (2015b). Necessity entrepreneurship and competitive strategy. *Small Business Economics*, *44*(1), 37-54.

Bogas, P., & Barbosa, N. (2015). High-growth firms: what is the impact of region-specific characteristics? In *Entrepreneurship, human capital, and regional development* (pp. 295-308). Springer, Cham.

Boldrin, M., & Levine, D. (2002). The case against intellectual property. *American Economic Review*, *92*(2), 209-212.

Boldrin, M., & Levine, D. K. (2013). The case against patents. *Journal of Economic Perspectives*, *27*(1), 3-22.

Booz, & Allen & Hamilton. (1982). *New products management for the 1980s*. Booz, Allen & Hamilton.

Boschma, R. (2015). Towards an evolutionary perspective on regional resilience. *Regional Studies*, *49*(5), 733-751.

Boschma, R., Balland, P. A., & Kogler, D. F. (2014). Relatedness and technological change in cities: the rise and fall of technological knowledge in US metropolitan areas from 1981 to 2010. *Industrial and Corporate Change*, *24*(1), 223-250.

Boschma, R., & Frenken, K. (2011). 14 Technological relatedness, related variety and economic geography. *Handbook of regional innovation and growth*, 187, Edward Elgar Publishing.

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

Breschi, S., Lissoni, F., & Malerba, F. (2003). Knowledge-relatedness in firm technological diversification. *Research Policy*, *32*(1), 69-87.

Breschi, S., & Malerba, F. (2001). The geography of innovation and economic clustering: some introductory notes. *Industrial and Corporate Change*, *10*(4), 817-833.

Brown, R., & Mawson, S. (2013). Trigger points and high-growth firms: A conceptualisation and review of public policy implications. *Journal of Small Business and Enterprise Development*, *20*(2), 279-295.

Brown, R., & Mawson, S. (2016). The geography of job creation in high growth firms: the implications of 'growing abroad'. *Environment and Planning C: Government and Policy*, *34*(2), 207-227.

Burrone, E. (2005). Intellectual property rights and innovation in SMEs in OECD countries. *Journal of Intellectual Property Rights*, *10(1)*, 34-43

Cacciolatti, L., & Lee, S. H. (2016). Revisiting the relationship between marketing capabilities and firm performance: The moderating role of market orientation, marketing strategy and organisational power. *Journal of Business Research*, *69*(12), 5597-5610.

Camagni, R., & Capello, R. (2013). Regional innovation patterns and the EU regional policy reform: Toward smart innovation policies. *Growth and Change*, *44*(2), 355-389.

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

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

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

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

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

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

Castaldi, C. (2020). All the great things you can do with trademark data: Taking stock and looking ahead. *Strategic Organization*, *18*(3), 472-484.

Castaldi, C., Block, J., & Flikkema, M. J. (2020). Why and when do firms trademark? Bridging perspectives from industrial organisation, innovation and entrepreneurship. *Industry and Innovation*, *27*(1-2), 1-10.

Castaldi, C., & Dosso, M. (2018). *From R&D to market: using trademarks to capture the market capability of top R&D investors* (No. 2018-01). Joint Research Centre (Seville site).

Castaldi, C., Frenken, K., & Los, B. (2015). Related variety, unrelated variety and technological breakthroughs: an analysis of US state-level patenting. *Regional Studies*, *49*(5), 767-781.

Castellacci, F. (2008). Technological paradigms, regimes and trajectories: Manufacturing and service industries in a new taxonomy of sectoral patterns of innovation. *Research Policy*, *37*(6), 978-994.

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

Ceccagnoli, M., & Jiang, L. I. N. (2013). The cost of integrating external technologies: Supply and demand drivers of value creation in the markets for technology. *Strategic Management Journal*, *34*(4), 404-425.

Chudnovsky, D. (1983). Patents and trademarks in pharmaceuticals, *World Development*, *11*(3), 187-193.

Coad, A., & Rao, R. (2008). Innovation and firm growth in high-tech sectors: A quantile regression approach. *Research Policy*, *37*(4), 633-648.

Cobbenhagen, J. (2000). *Successful innovation: towards a new theory for the management of small and medium sized enterprises*. Edward Elgar Publishing.

Coenen, L., Moodysson, J., & Martin, H. (2015). Path renewal in old industrial regions: Possibilities and limitations for regional innovation policy. *Regional Studies*, *49*(5), 850-865.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, *35*(1), 128-152.

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

Content, J. (2019). *The role of relatedness and entrepreneurship in regional economic development* Doctoral dissertation, Utrecht University.

Content, J. and Frenken, K., 2016. Related variety and economic development: a literature review. *European Planning Studies*, *24* (12), 2097-2112.

Content, J., Frenken, K., & Jordaan, J. A. (2019). Does related variety foster regional entrepreneurship? Evidence from European regions. *Regional Studies*, *53* (11), 1531-1543.

Cook, R. D. (1977). Detection of influential observation in linear regression. *Technometrics*, *19*(1), 15-18.

Cooper, R. G. (1983). A process model for industrial new product development. *IEEE Transactions on Engineering Management*, (1), 2-11.

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

Datta, A., Mukherjee, D., & Jessup, L. (2015). Understanding commercialization of technological innovation: taking stock and moving forward. *R&D Management*, *45*(3), 215-249.

Daunfeldt, S. O., Elert, N., & Johansson, D. (2016). Are high-growth firms overrepresented in high-tech industries? *Industrial and Corporate Change*, *25*(1), 1-21.

Davies, A., & Tonts, M. (2010). Economic diversity and regional socioeconomic performance: An empirical analysis of the Western Australian grain belt. *Geographical Research*, *48*(3), 223-234.

Davis, L. (Draft 2006), “How do trademarks affect firms’ incentives to innovate?”, presented to the DIME IPR Conference, electronic version available at http://www.dime-eu.org/files/active/0/Davis.pdf

De Brentani, U. (1989). Success and failure in new industrial services. *Journal of Product Innovation Management*, *6*(4), 239-258.

De Brentani, U., & Cooper, R. G. (1992). Developing successful new financial services for businesses. *Industrial Marketing Management*, *21*(3), 231-241.

De Vries, G., Pennings, E., Block, J. H., & Fisch, C. (2017). Trademark or patent? The effects of market concentration, customer type and venture capital financing on start-ups’ initial IP applications. *Industry and Innovation*, *24*(4), 325-345.

Dedrick, J., & Kraemer, K. L. (2017). *Intangible assets and value capture in global value chains: The smartphone industry* (Vol. 41). WIPO.

Den Hertog, P. (2000). Knowledge-intensive business services as co-producers of innovation. *International Journal of Innovation Management*, *4*(04), 491-528.

Denicolo, V. (1996). Patent races and optimal patent breadth and length. *The Journal of Industrial Economics*, *44*(3), 249-265

Deschryvere, M. (2008). *High growth firms and job creation in Finland* (No. 1144). ETLA Discussion Papers.

Desrochers, P., & Leppälä, S. (2011). Creative cities and regions: The case for local economic diversity. *Creativity and Innovation Management*, *20*(1), 59-69.

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

Di Benedetto, C. A., DeSarbo, W. S., & Song, M. (2008). Strategic capabilities and radical innovation: an empirical study in three countries. *IEEE Transactions on Engineering Management*, *55*(3), 420-433.

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

Diodato, D., & Weterings, A. B. (2014). The resilience of regional labour markets to economic shocks: Exploring the role of interactions among firms and workers. *Journal of Economic Geography*, *15*(4), 723-742.

Dissart, J. C. (2003). Regional economic diversity and regional economic stability: research results and agenda. *International Regional Science Review*, *26*(4), 423-446.

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

Drejer, I. (2004). Identifying innovation in surveys of services: a Schumpeterian perspective. *Research Policy*, *33*(3), 551-562.

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

Duysters, G., & Hagedoorn, J. (2000). Core competences and company performance in the world-wide computer industry. *The Journal of High Technology Management Research*, *11*(1), 75-91.

Edler, J., & Fagerberg, J. (2017). Innovation policy: what, why, and how. *Oxford Review of Economic Policy*, *33*(1), 2-23.

Engel, D. (2002). The impact of venture capital on firm growth: an empirical investigation. *ZEW Discussion Paper No. 02-02.*

EPO/EUIPO (2019). *High-growth Firms and Intellectual Property Rights: IPR Profile of High-potential SMEs in Europe.* May 2019. Available at: http://documents.epo.org/projects/babylon/eponet.nsf/0/F59459A1E64B62F3C12583FC002FBD93/$FILE/high_growth_firms_study_en.pdf

Essletzbichler, J. (2007). 10. Diversity, stability and regional growth in the United States, 1975–2002. *Applied evolutionary economics and economic geography*, 203, Edward Elgar

EUIPO, EPO, (2016). *Intellectual property rights intensive industries and economic performance in the European Union. Industry-Level Analysis Report.*Available at https://www.epo.org/service-support/publications.html?pubid=122#tab3

Eurostat, OECD (2007). *Eurostat-OECD Manual on Business Demography Statistics.* OECD publishing

Falkenhall, B., & Junkka, F. (2009). High-growth firms in Sweden 1997-2007. *Characteristics and development patterns. The Swedish Agency for Growth Policy Analysis*, *Stockholm*.

Feldman, M. P. (1994). *The geography of innovation (Vol. 2).* Springer Science & Business Media.

Feng, H., Morgan, N. A., & Rego, L. L. (2017). Firm capabilities and growth: the moderating role of market conditions. *Journal of the Academy of Marketing Science, 45*(1), 76-92.

Filatotchev, I., Su, Z., & Bruton, G. D. (2017). Market orientation, growth strategy, and firm performance: the moderating effects of external connections. *Management and Organization Review*, *13*(3), 575-601.

Filippetti, A., Gkotsis, P., Vezzani, A., & Zinilli, A. (2020). Are innovative regions more resilient? Evidence from Europe in 2008–2016. *Economia Politica*, *37*(3), 807-832.

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

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

Flikkema, M., Castaldi, C., de Man, A. P., & Seip, M. (2019). Trademarks' relatedness to product and service innovation: A branding strategy approach. *Research Policy, 48*(6), 1340-1353.

Flikkema, M., De Man, A. P., & Castaldi, C. (2014). Are trademark counts a valid indicator of innovation? Results of an in-depth study of new Benelux trademarks filed by SMEs. *Industry and Innovation*, *21*(4), 310-331.

Flikkema, M., Jansen, P., & Van Der Sluis, L. (2007). Identifying neo-Schumpeterian innovation in service firms: A conceptual essay with a novel classification. *Economics of Innovation and New Technology*, *16*(7), 541-558.

Florida, R., Adler, P., & Mellander, C. (2017). The city as innovation machine. *Regional Studies, 51*(1), 86-96.

Frenken, K., Van Oort, F., & Verburg, T. (2007). Related variety, unrelated variety and regional economic growth. *Regional Studies*, *41*(5), 685-697.

Fritsch, M., & Kublina, S. (2018). Related variety, unrelated variety and regional growth: the role of absorptive capacity and entrepreneurship. *Regional Studies, 52*(10), 1360-1371.

Furlan, A., & Grandinetti, R. (2011). Size, relationships and capabilities: a new approach to the growth of the firm. *Human Systems Management*, *30*(4), 195-213.

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

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

Germeraad, P. (2010). Integration of intellectual property strategy with innovation strategy. *Research-Technology Management*, *53*(3), 10-18.

Gotsch, M., & Hipp, C. (2012). Measurement of innovation activities in the knowledge-intensive services industry: a trademark approach. *The Service Industries Journal*, *32*(13), 2167-2184.

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

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

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

Griffin, A. (1997). PDMA research on new product development practices: Updating trends and benchmarking best practices. *Journal of Product Innovation Management*, *14*(6), 429-458.

Griffin, A. (2002). Product development cycle time for business-to-business products. *Industrial Marketing Management*, *31*(4), 291-304.

Griffin, A., & Hauser, J. R. (1996). Integrating R&D and marketing: a review and analysis of the literature. *Journal of Product Innovation Management*, *13*(3), 191-215.

Griliches, Z., Pakes, A., & Hall, B. H. (1986). *The value of patents as indicators of inventive activity.* (No. w2083). National Bureau of Economic Research.

Groot, S. P., Möhlmann, J. L., Garretsen, J. H., & de Groot, H. L. (2011). The crisis sensitivity of European countries and regions: stylized facts and spatial heterogeneity. *Cambridge Journal of Regions, Economy and Society*, *4*(3), 437-456.

Guzman, J., & Stern, S. (2016). *The State of American Entrepreneurship: New Estimates of the Quality and Quantity of Entrepreneurship for 32 US States, 1988-2014.* (No. w22095). National Bureau of Economic Research.

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

Hanel, P. (2006). Intellectual property rights business management practices: A survey of the literature. *Technovation*, *26*(8), 895-931.

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

Hannah, D. R. (2005). Should I keep a secret? The effects of trade secret protection procedures on employees' obligations to protect trade secrets. *Organization Science*, *16*(1), 71-84.

Harhoff, D., & Reitzig, M. (2001). Strategien zur Gewinnmaximierung bei der Anmeldung von Patenten. *Zeitschrift für Betriebswirtschaft*, *71*(5), 509-529.

Haskel, J., & Westlake, S. (2018). *Capitalism without capital: The rise of the intangible economy*. Princeton University Press.

Haug, P. (2004). Diversifikation und regionale Wirtschafts-und Beschäftigungsentwicklung. Eine empirische Analyse für ausgewählte deutsche Gebiete. *Review of Regional Research*, *24*(2), 177-195.

Heller, M. (2010). *The Gridlock Economy: How Too Much Ownership Wrecks Markets Stops Innovation, and Costs Lives.* ReadHowYouWant.com.

Helmers, C., & Rogers, M. (2010). Trademarks and performance in UK firms. In *Trademarks, brands, and competitiveness* (pp. 73-94). Routledge.

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

Henrekson, M., & Johansson, D. (2010). Gazelles as job creators: a survey and interpretation of the evidence. *Small Business Economics*, *35*(2), 227-244.

Hipp, C., & Grupp, H. (2005). Innovation in the service sector: The demand for service-specific innovation measurement concepts and typologies. *Research Policy*, *34*(4), 517-535.

Hitt, M. A., Ireland, R. D., & Lee, H. U. (2000). Technological learning, knowledge management, firm growth and performance: an introductory essay. *Journal of Engineering and Technology management*, *17*(3-4), 231-246.

Hölzl, W. (2009). Is the R&D behaviour of fast-growing SMEs different? Evidence from CIS III data for 16 countries. *Small Business Economics*, *33*(1), 59-75.

Hughes, A., & Wood, E. (2000). Rethinking innovation comparisons between manufacturing and services: the experience of the CBR SME surveys in the UK. In *Innovation systems in the service economy* (pp. 105-124). Springer US.

Hurmelinna-Laukkanen, P., & Puumalainen, K. (2007). Nature and dynamics of appropriability: strategies for appropriating returns on innovation. *R&D Management, 37(2),* 95-112.

Hurmelinna-Laukkanen, P., & Ritala, P. (2010). Protection for profiting from collaborative service innovation. *Journal of Service Management*, *21*(1), 6-24.

Hussinger, K. (2006). Is silence golden? Patents versus secrecy at the firm level. *Economics of Innovation and New Technology*, *15*(8), 735-752.

Iammarino, S., Piva, M., Vivarelli, M., & Von Tunzelmann, N. (2012). Technological capabilities and patterns of innovative cooperation of firms in the UK regions. *Regional Studies, 46*(10), 1283-1301.

Jaffe, A. B., & Lerner, J. (2011). *Innovation and its discontents: How our broken patent system is endangering innovation and progress, and what to do about it.* Princeton University Press.

James, S. D., Leiblein, M. J., & Lu, S. (2013). How firms capture value from their innovations. *Journal of Management, 39*(5), 1123-1155.

Janssen, M. J., & Castaldi, C. (2018). Services, innovation, capabilities, and policy: Toward a synthesis and beyond. *Science and Public Policy, 45*(6), 863-874.

Janssen, M. J., Castaldi, C., & Alexiev, A. (2016). Dynamic capabilities for service innovation: conceptualization and measurement. *R&D Management*, *46*(4), 797-811.

Janssen, M. J., Castaldi, C., & Alexiev, A. S. (2018). In the vanguard of openness: which dynamic capabilities are essential for innovative KIBS firms to develop? *Industry and Innovation*, *25*(4), 432-457.

Janssen, M. J., & Frenken, K. (2019). Cross-specialisation policy: rationales and options for linking unrelated industries. *Cambridge Journal of Regions, Economy and Society*, *12*(2), 195-212.

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

Johnson, D. K., & Popp, D. (2001). Forced out of the closet: The impact of the American inventors protection act on the timing of patent disclosure (No. w8374). *National Bureau of Economic Research.*

King, A. A., & Tucci, C. L. (2002). Incumbent entry into new market niches: The role of experience and managerial choice in the creation of dynamic capabilities. *Management Science*, *48*(2), 171-186.

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

Klink, R. R. (2003). Creating Meaningful Brands: The Relationship between Brand Name and Brand Mark. *Marketing Letters* 14(3), 143-157.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science, 3*(3), 383-397.

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

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

Lanjouw, J. O., Pakes, A., & Putnam, J. (1998). How to count patents and value intellectual property: The uses of patent renewal and application data. *The Journal of Industrial Economics, 46*(4), 405-432.

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

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

Lemper, T. A. (2012). The critical role of timing in managing intellectual property. *Business Horizons*, *55*(4), 339-347.

Lemmers, O., Roelandt, T., Seip, M. & van der Wiel, H. (2019). Innovatievouchers zorgen structureel voor meer innovatieactiviteiten. *Economisch Statistische Berichten*, *104*(4779), 527-529.

Leten, B., Belderbos, R., & Looy, B. V. (2016). Entry and technological performance in new technology domains: Technological opportunities, technology competition and technological relatedness. *Journal of Management Studies*, *53*(8), 1257-1291.

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

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

Llerena, P., & Millot, V. (2020). Are two better than one? Modelling the complementarity between patents and trademarks across industries. *Industry and Innovation*, *27*(1-2), 52-79.

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

Lyalkov, S., Carmona, M., Congregado, E., Millán, A., & Millán, J. M. (2020). Trademarks and their association with Kirznerian entrepreneurs. *Industry and Innovation*, *27*(1-2), 155-183.

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

Mann, R. J., & Sager, T. W. (2007). Patents, venture capital, and software start-ups. *Research Policy*, *36*(2), 193-208.

Mansfield, E. (1986). Patents and innovation: an empirical study. *Management science*, *32*(2), 173-181.

Martin, R. (2011). Regional economic resilience, hysteresis and recessionary shocks. *Journal of Economic Geography*, *12*(1), 1-32.

Martin, R., & Sunley, P. (2006). Path dependence and regional economic evolution. *Journal of Economic Eeography*, *6*(4), 395-437.

Martin, R., & Sunley, P. (2015). On the notion of regional economic resilience: conceptualization and explanation. *Journal of Economic Geography*, *15*(1), 1-42.

Martin, X., & Salomon, R. (2003). Tacitness, learning, and international expansion: A study of foreign direct investment in a knowledge-intensive industry. *Organization Science, 14*(3), 297-311.

Martínez, C. (2011). Patent families: When do different definitions really matter?. *Scientometrics*, *86*(1), 39-63.

Maskus, K. E. (2000). *Intellectual property rights in the global economy*. Peterson Institute.

Mason, C., & Brown, R. (2013). Creating good public policy to support high-growth firms. *Small Business Economics, 40*(2), 211-225.

Menapace, L., & Moschini, G. (2012). Quality certification by geographical indications, trademarks and firm reputation. *European Review of Agricultural Economics*, *39*(4), 539-566.

Mendonça, S. (2014). National adaptive advantages: Soft innovation and marketing capabilities in periods of crisis and change. In *Structural Change, Competitiveness and Industrial Policy* (pp. 149-166). Routledge.

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

Mendonça, S., Schmoch, U., & Neuhäusler, P. (2019). *Interplay of Patents and Trademarks as Tools in Economic Competition.* In Springer Handbook of Science and Technology Indicators (pp. 1023-1035). Springer, Cham.

Miguelez, E., & Moreno, R. (2018). Relatedness, external linkages and regional innovation in Europe. *Regional Studies*, *52*(5), 688-701.

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

Milesi, D., Petelski, N., & Verre, V. (2013). Innovation and appropriation mechanisms: Evidence from Argentine microdata. *Technovation, 33*(2-3), 78-87.

Millot, V. (2011). Firms' intangible assets: Who relies on trademarks? Analysis of French and German firms' trademarking behaviour. In *DRUID Society Conference', Copenhagen, Denmark.*

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

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

Moir, H. V. (2009). Who benefits? An empirical analysis of Australian and US patent ownership. *Politics of Intellectual Property: Contestation over the Ownership, Use, and Control of Knowledge and Information, Edward Elgar*, *Cheltenham, UK*, 182-210.

Monteiro, G. F. A. (2019). High-growth firms and scale-ups: a review and research agenda. *RAUSP Management Journal*, *54*(1), 96-111.

Morgan, N. A., Vorhies, D. W., & Mason, C. H. (2009). Market orientation, marketing capabilities, and firm performance. *Strategic Management Journal*, *30*(8), 909-920.

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

Murray, J. Y., Gao, G. Y., & Kotabe, M. (2011). Market orientation and performance of export ventures: the process through marketing capabilities and competitive advantages. *Journal of the Academy of Marketing Science*, *39*(2), 252-269.

Narin, F., Noma, E., & Perry, R. (1987). Patents as indicators of corporate technological strength. *Research Policy*, *16*(2-4), 143-155.

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

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

Nooteboom, B. (2000). *Learning and innovation in organizations and economies*. OUP Oxford.

Nooteboom, B., Van Haverbeke, W., Duysters, G., Gilsing, V., & Van den Oord, A. (2007). Optimal cognitive distance and absorptive capacity. *Research Policy*, *36*(7), 1016-1034.

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

Noseleit, F. (2013). Entrepreneurship, structural change, and economic growth. *Journal of Evolutionary Economics*, *23*(4), 735-766.

OECD. Publishing. (2010). *OECD Studies on SMEs and Entrepreneurship High-Growth Enterprises: What Governments Can Do to Make a Difference*. Organisation for Economic Co-operation and Development.

Oosterhaven, J., Eding, G. J., & Stelder, D. (2001). Clusters, linkages and interregional spillovers: methodology and policy implications for the two Dutch mainports and the rural north. *Regional Studies*, *35*(9), 809-822.

Ortega, M. J. R. (2010). Competitive strategies and firm performance: Technological capabilities' moderating roles. *Journal of Business Research*, *63*(12), 1273-1281.

Pakes, A., & Griliches, Z. (1980). Patents and R&D at the firm level: A first report. *Economics letters*, *5*(4), 377-381.

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

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

Puranam, P., Singh, H., & Chaudhuri, S. (2009). Integrating acquired capabilities: When structural integration is (un) necessary. *Organization Science*, *20*(2), 313-328.

Quatraro, F. (2009). Diffusion of regional innovation capabilities: evidence from Italian patent data. *Regional Studies*, *43*(10), 1333-1348.

Rammer, C. (2002), Patente und Marken als Schutzmechanismen für Innovationen, ZEW Mannheim, *Studien zum Deutschen Innovationssystem*, 11-2003

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

Reitzig, M. (2004). Strategic management of intellectual property. *MIT Sloan Management Review*, *45*(3), 35.

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

Robson, S., & Kenchatt, M. (2010). First findings from the UK Innovation Survey 2009. *Economic & Labour Market Review*, *4*(3), 28-35.

Rocchetta, S., & Mina, A. (2019). Technological coherence and the adaptive resilience of regional economies. *Regional Studies, 53* (10), 1421-1434.

Rujas, J. (1999). Trade marks: complementary to patents. *World Patent Information, 21*(1), 35-39.

Saardchom, N. (2014). Design patent war: Apple versus Samsung. *South Asian Journal of Business and Management Cases*, *3*(2), 221-228.

Salminen, V., Halme, K., & Härmälä, V. (2019). Mini-evaluation of the Nordic Scalers programme. *Nordic Innovation* Available at: https://www.diva-portal.org/smash/get/diva2:1372693/FULLTEXT01.pdf

Sandner, P. (2009). The market value of R&D, patents, and trademarks. In *The Valuation of Intangible Assets* (pp. 35-72). Gabler.

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

Schaufeld, J. (2015). Commercializing Innovation. *Turning Technology Breakthroughs into Products. New York: Apress*.

Schautschick, P., & Greenhalgh, C. (2016). Empirical studies of trade marks–the existing economic literature. *Economics of Innovation and New Technology*, *25*(4), 358-390.

Schneider, C., & Veugelers, R. (2013). *Which IP strategies do young highly innovative firms choose?.* Available at www.ssrn.com/abstract=2382516

Schmoch, U. (2003). Service marks as novel innovation indicator. *Research Evaluation*, 12(2), 149-156.

Schmoch, U. (2008). Concept of a technology classification for country comparisons. Final report to the world intellectual property organisation (wipo), WIPO.

Schmoch, U., & Gauch, S. (2009). Service Marks as Indicators for Innovation in Knowledge-Based Services. *Research Evaluation, 18*(4): 323–335.

Schnichels, D., & Sule, S. (2010). The pharmaceutical sector inquiry and its impact on competition law enforcement. *Journal of European Competition Law & Practice, 1*(2), 93-111.

Schreyer, P. (2000). High-growth firms and employment. *OECD Science, Technology and Industry Working Papers 2000/03*

Seip, M., & Winnink, J.J. (2017). *Octrooien in Nederland 2008-2012*. Rijksdienst voor Ondernemend Nederland. Available at https://www.rvo.nl/sites/default/files/octrooiportal/2017/03/Octrooien_in_Nederland_2008-2012.pdf

Seip, M., Castaldi, C., Flikkema, M., & De Man, A. P. (2018). The timing of trademark application in innovation processes. *Technovation*, *72*, 34-45.

Semadeni, M., & Anderson, B. S. (2010). The follower's dilemma: Innovation and imitation in the professional services industry. *Academy of Management Journal*, *53*(5), 1175-1193.

Simmie, J., & Martin, R. (2010). The economic resilience of regions: towards an evolutionary approach. *Cambridge Journal of Regions, Economy and Society*, *3*(1), 27-43.

Smallbone, D., Leig, R., & North, D. (1995). The characteristics and strategies of high growth SMEs. *International Journal of Entrepreneurial Behavior & Research*.

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

Stam, E., & Wennberg, K. (2009). The roles of R&D in new firm growth. *Small Business Economics*, *33*(1), 77-89.

Statline, CBS (2013). Statistics Netherlands. *Patentaanvragers en -aanvragen; bedrijfstakken/branches (SBI'93) 2000-2008*
http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=80826ned&D1=0-3&D2=a&D3=a&VW=T
ondernemingsgrootte aanvrager, 2000-2010
http://statline.cbs.nl/StatWeb/publication/?VW=T&DM=SLNL&PA=80813NED

Sundbo, J. (1997). Management of innovation in services. *Service Industries Journal*, *17*(3), 432-455.

Talvela, J., Karvonen, M., & Kässi, T. (2018). Patents: The Case of Exploitation of the Patent System among SMEs and Private Inventors in Finland. *Series on Technology Management*, *30*, 45-68.

Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy*, *15*(6), 285-305.

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, *28*(13), 1319-1350.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, *18*(7), 509-533.

Testa, G., Szkuta, K., & Cunningham, P. N. (2019). Improving access to finance for young innovative enterprises with growth potential: Evidence of impact of R&D grant schemes on firms' outputs. *Research Evaluation*, *28*(4), 355-369.

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

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

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

Tidd, J., & Bessant, J. R. (2018). *Managing innovation: integrating technological, market and organizational change*. John Wiley & Sons.

Todino, M. (2014). Antitrust rules and Intellectual Property Rights in the EU and the US–Towards convergence?. *Antitrust & Public Policies*, *1*(2).

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

Van der Poel, R., Seip, M., & Snoei, J. (2010). *Octrooien in Nederland.* Panteia/EIM 201004. Available at http://ondernemerschap.panteia.nl/main/publication/bestelnummer/a201004

Van Stel, A. J., & Nieuwenhuijsen, H. R. (2004). Knowledge spillovers and economic growth: an analysis using data of Dutch regions in the period 1987–1995. *Regional Studies*, *38*(4), 393-407.

Verheul, H. (1999). How social networks influence the dissemination of cleaner technologies to SMEs. *Journal of Cleaner Production*, *7*(3), 213-219

Veugelers, R., & Batsaikhan, U. (2017), Remaking Europe: the new manufacturing as an engine for growth. *Bruegel Blueprints*, 26 Available at: http://bruegel.org/wp-content/uploads/2017/09/Remaking_Europe_blueprint.pdf

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

Watson, D. S., & Holman, M. A. (1970). The concentration of patent ownership in corporations. *The Journal of Industrial Economics*, *18*(2), 112-117.

WIPO (2019), *World Intellectual Property Indicators 2019*, WIPO. Available at www.wipo.int/edocs/pubdocs/en/wipo_pub_941_2019.pdf

Xue, M., Hein, G. R., & Harker, P. T. (2005). Consumer and co-producer roles in e-service: analysing efficiency and effectiveness of e-service designs. *International Journal of Electronic Business*, *3*(2), 174-197.

Zhou, H., Sandner, P. G., Martinelli, S. L., & Block, J. H. (2016). Patents, trademarks, and their complementarity in venture capital funding. *Technovation*, *47*, 14-22.

Ziedonis, R. H. (2008). On the apparent failure of patents: A response to Bessen and Meurer. *Academy of Management Perspectives*, *22*(4), 21-29.

Zingales, L. (2000). In search of new foundations. *The Journal of Finance*, *55*(4), 1623-1653.

Zobel, A. K., Lokshin, B., & Hagedoorn, J. (2017). Formal and informal appropriation mechanisms: The role of openness and innovativeness. *Technovation*, *59*, 44-54.

Samenvatting (Summary in Dutch)

Om winstgevend te kunnen zijn, proberen bedrijven zich te onderscheiden van andere bedrijven door middel van de producten en diensten die ze aanbieden. Innovatie leidt tot de totstandkoming van nieuwe of verbeterde producten en diensten of tot efficiëntere productieprocessen waardoor de productie sneller, efficiënter en goedkoper plaatsvinden. Deze nieuwe of verbeterde producten en diensten en efficiëntere processen hebben over het algemeen een hogere toegevoegde waarde[20]. Het succes van nieuwe en verbeterde producten en diensten kan vanwege een groeiende vraag leiden tot groei van deze bedrijven.

Bedrijven moeten investeren om te kunnen innoveren. Ze vragen intellectuele eigendomsrechten (IE-rechten) aan om deze investering te kunnen terugverdienen en ervoor te zorgen dat innovatie winstgevend is. IE-rechten zijn de formele juridische instrumenten om rechten op intellectueel eigendom zoals uitgewerkte ideeën en creatieve concepten en innovatie, te beschermen. Indien toegekend, verschaffen deze rechten hen de exclusieve rechten om hun intellectueel eigendom economisch te exploiteren door hen te beschermen tegen het kopiëren en commercieel toepassen van hun intellectueel eigendom door concurrenten. Op deze manier dragen ze bij aan de winstgevendheid en groei van bedrijven. Onder meer technologische uitvindingen (octrooien), reputatie en goodwill (handelsmerken), onderscheidend ontwerp (modelrechten) of karakteristieke kenmerken van specifieke producten zoals plantenrassen (kwekersrecht) kunnen door middel van IE-rechten worden beschermd.

Dit proefschrift richt zich op IE-rechten als een indicator voor innovatie en van de vaardigheden van bedrijven die essentieel zijn voor innovatie en het succesvol realiseren van

[20] *www.bedrijvenbeleidinbeeld.nl*

nieuwe economische kansen. Het onderzoek in deze dissertatie richt zich dan ook op het beantwoorden van de volgende vraag:

Hoe gebruiken bedrijven verschillende IE-rechten voor innovatie- en groeidoeleinden?

Om deze vraag te kunnen beantwoorden is onderzocht *wie, wat, wanneer* en *waar* aanvraagt:

1. *Wie?* Welke bedrijven vragen IE-rechten aan? Wat zijn de eigenschappen van deze bedrijven?

2. *Wat?* Welke IE-rechten worden aangevraagd?

3. *Wanneer?* Wanneer in de levenscyclus van een bedrijf en tijdens innovatieprocessen worden IE-rechten aangevraagd?

4. *Waar?* In welke regio's worden IE-rechten aangevraagd? Wat zegt de aanvraag van verschillende IE-rechten over de vaardigheden van lokale bedrijven die nodig zijn voor innovatie en het ontwikkelen en benutten van nieuwe economische kansen door bedrijven. Wat dragen deze vaardigheden bij aan de regionale economische veerkracht van regio's tijdens een economische crisis?

In de verschillende hoofdstukken van dit proefschrift worden deze vragen beantwoord aan de hand van verschillende onderzoeken die zijn uitgevoerd met behulp van gekoppelde data uit verschillende registers, zowel van Nederlandse bedrijven als registers van vier verschillende IE-rechten (octrooi-, merk-, model- en kwekersrechtregistraties) en aan de hand van een enquête onder zowel Benelux- als Europese merk-aanvragers uit verschillende Europese landen.

1. Wie? Welke bedrijven vragen IE-rechten aan?

Hoofdstuk 2 behandelt de resultaten zien van een onderzoek waarin een zo compleet mogelijk overzicht te krijgen van Nederlandse bedrijven die IE-rechten aanvragen in een periode van vijf jaar voor vier verschillende IE-rechten. De resultaten laten zien dat het gebruik van IE-rechten sterk afhankelijk is van bedrijfsgrootte en de sector waarin bedrijven actief zijn. Een cluster-analyse van bijna 23.000 Nederlandse bedrijven die in de periode tenminste één IE-aanvraag hebben ingediend laat zien dat vijf archetypen kunnen worden onderscheiden onder IE-aanvragende bedrijven op basis van de aantallen aanvragen die ze indienen en de verschillende vormen van IE die ze gebruiken. Verreweg de meeste bedrijven (meer dan 80% van de IE aanvragende bedrijven) vragen incidenteel IE-rechten aan. Deze bedrijven zijn gelabeld als “rookies”. Het betreft hier met name kleine bedrijven in de dienstensector die meestal slechts één merk aanvragen in een periode van vijf jaar tijd. Daarnaast is er een kleine groep bedrijven, meestal ook kleine bedrijven en zelfstandigen in de handel of kennisintensieve bedrijven in de dienstensector, die één keer (in een periode van tenminste vijf jaar) een octrooi aanvragen.

In tegenstelling tot deze “rookies” die incidenteel aanvragen, is er een kleine groep bedrijven (ongeveer 6% van de IE aanvragende bedrijven), gelabeld als IE-strategen, die veelvuldig IE-rechten aanvragen. Meestal worden door deze bedrijven meerdere vormen van IE aangevraagd, vaak zowel merken als octrooien. Dit zijn voornamelijk grotere hightech bedrijven in de industrie of dienstensector.

De twee kleinste groepen onder de archetypes zijn de IE specialisten en de IE gerneralisten. IE specialisten zijn bedrijven die een vorm van IE-recht gebruiken waarmee specifieke producten kunnen worden beschermd (model- of kwekersrecht). Vaak gebruiken ze dit type IE-recht vaker. De IE generalisten zijn bedrijven die incidenteel aanvragen, maar hun product wel met verschillende vormen van IE beschermen. Deze bedrijven combineren bijvoorbeeld een octrooi met een merk of een merk met modelrecht. In beide gevallen zijn de aanvragers vaak kleine bedrijven in de handel of, in het geval kwekersrechten, meestal kwekers.

Het aanvragen van IE-rechten kan ook een indicator zijn voor de verschillende vaardigheden aanwezig binnen bedrijven die noodzakelijk zijn voor succesvolle innovatie en marktintroductie van nieuwe producten en diensten door bedrijven.

Hoofdstuk 3 bevat een analyse van de IE-aanvragen door Nederlandse scale-ups, de snelst groeiende bedrijven in Nederland. Scale-ups zijn bedrijven die gedurende een periode van drie jaar een groei van meer dan 20% per jaar gerealiseerd hebben in werknemers en/of omzet. Daarnaast moet een bedrijf aan het begin van de periode 10 of meer medewerkers hebben en/of een omzet van minstens €5 miljoen genereren. De resultaten laten zien dat scale-ups met name vaker merken aanvragen in vergelijking met niet-scale-ups. Dit laatste geldt met name voor de top 250 scale-ups. Twee derde van deze bedrijven heeft één of meer merken aangevraagd. Wanneer deze bedrijven worden vergelijken met andere bedrijven van vergelijkbare omvang dan is het aantal bedrijven met merkaanvragen veel hoger voor de top 250. Dit kan erop duiden dat deze bedrijven met name uitblinken in hun commercialiseringsvaardigheden.

2. *Wat? Welke IE-rechten vragen bedrijven aan?*

De resultaten voor Nederlandse IE-aanvragende bedrijven in hoofdstuk 2 (figuur 2.1) laten zien dat merken verreweg de meest voorkomende vorm van IE zijn die door bedrijven worden ingediend. Er zijn ongeveer zes keer zoveel bedrijven die merken aanvragen dan bedrijven die octrooien aanvragen. Daarna volgen de model- en kwekersrechten die door minder dan 10% van alle IE-aanvragende bedrijven worden aangevraagd. Voor alle IE-rechten die in hoofdstuk 2 zijn onderzocht geldt dat een zeer klein deel van de IE aanvragende bedrijven verantwoordelijk zijn voor een meerderheid van de aanvragen.

3. *Wanneer? In welke fase in de levenscyclus van een bedrijf of innovatieproces worden IE-rechten aangevraagd?*

De resultaten in hoofdstuk 3 laten zien dat de merkaanvragen van scale-ups meestal al vroeg worden aangevraagd, vaak al in het eerste jaar na de oprichting van het bedrijf (figuur 3.1). Dit geldt met name voor de top 250 scale-ups. Dit kan een aanwijzing zijn dat vaardigheden die betrekking hebben op de commercialisering van producten en diensten al tijdens de startup-fase in deze bedrijven aanwezig zijn. Scale-ups met octrooiaanvragen bestaan meestal al een aantal jaren voordat ze hun eerste octrooi aanvragen.

Hoofdstuk 4 kijkt naar het gebruik van merken als indicator voor innovatie. In de wetenschappelijke literatuur wordt algemeen aangenomen dat merken pas tijdens de latere fases in een innovatieproces worden aangevraagd, vlak voor of tijdens de marktintroductie van een nieuw of verbeterd product of dienst. De resultaten van een enquête onder bedrijven die een merk hebben aangevraagd bij het Benelux Bureau voor Intellectueel Eigendom (BBIE) of het Bureau voor intellectuele eigendom van de Europese Unie (EUIPO) laat echter zien dat merken die verwijzen naar innovatie vaak al worden aangevraagd tijdens de vroege fases van het innovatieproces, dat wil zeggen de fases die gewijd zijn aan onderzoek en ontwikkeling van nieuwe producten en diensten. Dit geldt met name voor startups, wanneer een merk verwijst naar radicale innovatie en wanneer merkaanvragen worden gecombineerd met octrooien. In tegenstelling tot kleine startups vragen middelgrote en grote bedrijven merken vaak pas aan in de latere fases van het innovatieproces. Dit zijn de fases die gewijd zijn aan marketing en marktintroductie. Dit geldt met name wanneer er sprake is van incrementele innovaties, dat wil zeggen licht verbeterde producten en diensten. Voor de octrooiaanvragen van deze bedrijven geldt dit niet. Zij worden vaak al eerder aangevraagd. Er kan dan ook worden geconcludeerd dat merken niet alleen verwijzen naar innovatie die (bijna) op de markt geïntroduceerd is, maar ook een vroege indicator zijn van innovatie door bedrijven. Dit hangt af van de kenmerken van het bedrijf dat een merk aanvraagt en de innovatie waarop het merk betrekking heeft.

4. *Waar? In welke regio's worden IE-rechten aangevraagd?*

Het onderzoek naar scale-ups in hoofdstuk 3 omvat ook de locatie van deze bedrijven. Scale-ups in Nederland, vooral de top 250 snelst groeiende scale-ups en vooral die in de drie noordelijke provincies (Groningen, Friesland en Drenthe), vragen vaker merken aan dan andere bedrijven.

Hoofdstuk 5 bestudeert de verschillen tussen 40 regio's in Nederland wat betreft de octrooi- en merkaanvragen door bedrijven in de periode 2006-2010, een periode die ook de economische crisis, die begon in 2008, omvat. Gebaseerd op bevindingen in de wetenschappelijke literatuur worden octrooiaanvragen gebruikt als een indicator voor de aanwezige technologische vaardigheden in verschillende technologiegebieden binnen een regio. Daarnaast worden merkaanvragen gebruikt als een indicator voor de vaardigheden die betrekking hebben op de commercialisering van producten en diensten binnen een regio. Diversificatie kan leiden tot kennis-spillovers tussen sectoren en technologiegebieden en kan een mitigerend effect hebben bij een economische crisis. Bij de analyse van de economische veerkracht van deze regio's zijn derhalve ook industriële en technologische diversificatie binnen regio's in beschouwing genomen. De resultaten laten zien dat met name de aanwezigheid van vaardigheden die betrekking hebben op commercialisering in combinatie met de mate van industriële diversificatie regionale economische veerkracht bevorderen. Een verklaring hiervoor is dat de aanwezigheid van commerciële vaardigheden de succesvolle benutting van nieuwe kansen voortkomend uit kennis-spillovers bevordert. De succesvolle implementatie van innovatie en andere nieuwe activiteiten heeft een positieve invloed op de economische veerkracht van regio's in tijden van een economische crisis.

Implicaties

Het onderzoek, beschreven in dit proefschrift, heeft implicaties voor zowel onderzoek als beleid. Het onderzoek heeft aangetoond dat een overgrote meerderheid van de bedrijven die IE-rechten aanvragen dit slechts incidenteel doen Deze bedrijven staan in schril contrast met het kleine aantal bedrijven (minder dan 5% van de aanvragers) die verantwoordelijk zijn voor een meerderheid van de aanvragen. Meer onderzoek die gericht is op de grote groep incidentele gebruikers kan beleidsmakers informeren over de oorzaken van dit contrast in en wat bedrijven, met name MKB-ers, er mogelijk van weerhoudt om IE-rechten aan te vragen.

Andere implicaties betreft het gebruik van IE-rechten als indicator voor innovatie voor de vaardigheden binnen bedrijven of regio's die nodig zijn voor de totstandbrenging en succesvolle commercialisatie van innovatie en andere nieuwe kansen die bijdragen aan de groei en veerkracht van bedrijven en regio's.

Het onderzoek in dit proefschrift bevestigt dat naast octrooien ook merken verwijzen naar activiteiten die betrekking hebben op innovatie, met name als het gaat om radicale innovatie en innovatie door startups. Daarnaast zijn er andere redenen waarom merkaanvragen een belangrijke toevoeging zijn voor de monitoring van innovatie door beleidsmakers. Eerder is al genoemd dat er veel meer bedrijven zijn die merken aanvragen dan er bedrijven zijn die octrooien aanvragen. Daarnaast zijn merken ook bruikbaar voor de monitoring van innovatie in de dienstensectoren.

Er zijn aanwijzingen gevonden dat niet alleen technologische vaardigheden, maar ook vaardigheden gericht op de commercialisering van nieuwe producten en diensten bijdragen tot de groei van bedrijven en de economische veerkracht van regio's. Aanvullend onderzoek bij bedrijven in verschillende sectoren is nodig om dit te kunnen bevestigen. Dit zou het belang kunnen onderstrepen van overheidsmaatregelen die niet alleen gericht moeten op het stimuleren van (technologische) R&D, maar ook gericht zijn op de ontwikkeling van vaardigheden die betrekking hebben op commercialisering.

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Per astra ad aspera.
Per aspera ad astra.

Promoveren naast een volledige baan en een gezin verreist vooral doorzettingsvermogen. Echter doorzettingsvermogen alleen is niet voldoende. Het lukt niet zonder de hulp en steun van andere mensen.

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