KU LEUVEN

FACULTY OF ECONOMICS AND BUSINESS

The Evolving Market for Patent Rights



Dissertation presented to obtain the degree of Doctor in

Business Economics

by

Adrián Kovács

Number 648 2019



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Business

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Yours truly,

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General Introduction

Background

The growing importance of markets for technology

Although historic accounts of markets for technology – markets wherein exchanges between buyers and sellers involve intermediate technological outputs that are disembodied from goods and services – date all the way back to the late 19th century (Lamoreaux & Sokoloff, 1999:2001; Burhop, 2010), there is increasing evidence that these markets have expanded considerably since the beginning of the 1990s. In their pioneering contribution, Arora, Fosfuri and Gambardella (2000) provide aggregate estimates of the size and scope of markets for technology and present preliminary evidence suggesting that the extent of technology trade has grown consistently throughout the 1990s with high-tech industries such as chemicals, electronics and software leading the way. These findings are echoed by Hall and Ziedonis (2001) who find that licensing and cross-licensing deals have become common practice in the US semiconductor industry and attribute this to the strengthening of patent rights during the 1980s.

The growth of technology markets is not only demonstrated by larger volumes of technology trade but also by the greater value in monetary terms that these deals represent. For example, Rivette and Klein (1999) report that IBM's income from royalties and licensing fees has increased from $30 million in 1990 to $1 billion in 1998, which amounts to roughly $750,000 per patent whereas Grindley and Teece (1997) chronicle that in some years during the same time period the licensing income of Texas Instruments exceeded its earnings from regular operations. Not only are firms in high-tech industries generating greater economic rents from the transfer of their own technologies, they are also willing to invest large amounts of financial resources in the acquisition of external technology. Microsoft, for example, recently paid $1.1 billion to acquire

800 patents from AOL, with the average price per patent thus well exceeding the $1m mark[1], whereas Google paid around $12.5 billion to acquire Motorola Mobility mainly to leverage its large patent portfolio.[2]

The relevance of markets for technology for corporate strategy

The expansion of markets for technology largely coincides with the trend of firms opening up their innovation processes as described by Chesbrough (2003a: 2006b). Chesbrough noted that due to the increasingly wide-spread distribution of the knowledge sources for innovation across the economy, the interwovenness of scientific disciplines and technological fields and the cross-sectoral nature of novel technologies, firms are forced to integrate an increasingly wide range of knowledge components into their products. At the same time, he observed that firms face greater competitive pressures due to the globalization of markets, the shortening of product life-cycles and the mobility of knowledge workers. These competitive pressures in combination with the increasing complexity of technology make that even the largest and most technologically advanced firms cannot rely solely on internally developed technology when developing their innovations and, therefore, must tap into knowledge sources that are located outside their boundaries to complement their stock of technologies developed internally (Cassiman and Veugelers, 2006; Laursen and Salter, 2006).

According to the Resource-Based View stream of literature (*i.a.* Penrose, 1959; Wernerfelt, 1984; Barney, 1991), a focal firm's competitive advantage and survival is directly linked to its ability to develop resources that are idiosyncratic and, thus, difficult to imitate by existing competitors as well as new entrants. As accentuated by scholarship on the Knowledge-Based View (*i.a.* Kogut and Zander, 1992; Grant, 1996), the most valuable resources mostly reside in internal knowledge stocks that firms develop via the path-dependent process of organizational learning. This path-dependence may bias firms towards favoring incremental improvements and sub-optimal technological solutions at the expense of exploring unfamiliar, yet potentially more promising technological opportunities (Levinthal and March, 1993; Rosenkopf and Nerkar, 2001). More broadly, core competences can turn into core rigidities in the sense that the routines

[1] https://www.nytimes.com/2012/04/10/technology/microsoft-to-buy-aol-patents-for-more-than-1-billion.html, accessed on January 25th, 2019.

[2] https://www.reuters.com/article/industry-us-media-motorolapatents/behind-googles-12-5-billion-motorola-gamble-patents-idUSTRE77F00O20110816, accessed on January 25th, 2019.

that have enabled a focal firm to become successful in the past may limit its ability to remain successful in the future (Tushman and Anderson, 1986; Leonard-Barton, 1992). Sourcing technologies externally can help firms to overcome such organizational inertia by granting them the flexibility to focus on developing core technological competences whilst relying on external entities for the supply of non-core, yet potentially more promising, technological inputs. As such, external technology sourcing has become a fundamental element of high-tech firms' corporate strategies which is especially manifested by the strategic importance that many of these firms devote to the management of intellectual property (*i.a.* Grindley and Teece, 1997; Arora, Fosfuri and Gambardella, 2000; Chesbrough, 2003b).

The relevance of markets for technology for policy making

In addition to having implications for corporate strategy, markets for technology are also relevant for policy making because they have the potential to generate positive welfare effects for consumers. At the core, these markets allow for a division of labor between the entities that invent and the entities that commercialize most efficiently (Allain *et. al.*, 2016; De Marco *et. al*, 2017). By providing a viable pathway for invention without commercialization, they enable a level of specialization into inventive activity that renders incentives to inventors who do not possess the downstream resources and capabilities needed to manufacture, market and distribute their inventions (Teece, 1986). Lower entry barriers to inventive activity not only result in a greater supply of technology to be further developed and incorporated into products, but also stimulates a greater level of competition among these technologies (Federal Trade Commission, 2011). Greater competition among technologies is likely to speed up the rate of innovation and result in better and cheaper products for consumers.

A larger supply of and competition among technologies not only creates welfare gains for consumers but also enables gains from trading technology in the sense that specialist providers of technology can often develop technologies faster and cheaper than a focal firm, which makes external technology acquisition a viable alternative to internal technology development (Arora and Nandkumar, 2012). In addition to shaping innovation incentives, efficient markets for technology are also socially desirable because they can limit the duplication of R&D activities and can prevent costly patent litigation cases (Gans and Stern, 2003; Galasso, Schankerman and Serrano, 2013; Chien,

2016).

Patent rights as catalyst of markets for technology?

Whilst the potential social and private benefits of markets for technology are undeniable, there is consensus amongst academics, policy makers and industry representatives that these benefits are not fully realized due to a number of imperfections that define these markets (*i.a.* Arora, Fosfuri and Gambardella, 2001; Federal Trade Commission, 2011). Most notably, technology markets are subject to information asymmetries between buyers and sellers that are attributable to the intangible nature of knowledge assets. Whereas a potential buyer of a technology requires a certain level of detail about the characteristics of that technology in order to make a rational decision to acquire it or not, a seller does not have an incentive to provide such a level of detail because doing so would *de facto* result in the transfer of the technological know-how without any financial compensation. A direct consequence of this 'free-rider' problem is that there is considerable uncertainty about the value of technologies, which may either prevent deals that would result in gains for both buyers and sellers or may induce high transaction costs from negotiating, executing and enforcing contractual agreements between buyers and sellers.

Legal appropriation mechanisms, most notably patents, can remedy this imperfection not only by offering protection from misappropriation by third parties but even more importantly by encouraging inventors to disclose relevant technological information that they would otherwise keep secret. In other words, patent protection can simultaneously enable purposive knowledge flows whilst limiting unintended knowledge spillovers (Chesbrough, 2003b; Chesbrough and Ghafele, 2014). Although patents do not necessarily simplify the valuation of technologies, the codification of technological information in patent documents at least provides a starting point for negotiations between inventors and interested third parties (Arora, 1995: 1996). Patents are thus not only an important mechanism for getting inventions developed but are arguably even more important as a vehicle for getting these inventions put to the right use. This reconceptualization of patents from incentives to tradeable commodities has been institutionalized in multilateral international intellectual property and trade agreements and has resulted in an evolving market for patent monetization (Dreyfuss and Frankel, 2014). The link between technologies and patents in high-tech industries ties the func-

tioning of technology markets to the effectiveness of the disclosure requirements that legislators impose on users of the patent system. It is these requirements that determine the extent to which the information disclosed by users of the patent system informs the public about the technological specifications of claimed inventions as well as the scope of the rights conveyed by them.

Contributions

Patent assignments as indicator of technology transactions

Even though the earliest empirical analyses of markets for technology have generated important insights with respect to the functioning of these markets and the implications thereof for corporate strategy and policy making, these analyses have mostly relied on licensing data and have been limited by the lack of systematic data sets comprising such deals (Arora, Fosfuri and Gambardella, 2000; Serrano, 2010). This void has inspired more recent empirical literature to employ data on patent assignments – transfers of patent ownership rights – in an attempt to better capture the dynamics of exchanges on technology markets. The utilization of patent assignment data in recent scholarship has been motivated by two primary properties of patent assignments.

First, whereas licensing deals essentially involve contractual agreements wherein a conveyor of a technology – the licensee – agrees not to sue the beneficiary of that technology – the licensor – provided that the latter operates within the boundaries specified by the agreement, a patent assignment is a transfer by a party of all or part of her right, title and interest in a patent (application) that includes the entirety of the bundle of rights that is associated with the ownership interest in that patent (application).[3] In other words, patent assignments correspond more with a traditional seller-buyer relationship that is common in commodity markets than do licensing deals.

Second, whereas licensing deals are often kept confidential between the parties involved, regulators provide incentives to record patent assignment deals and patent offices disclose these deals in publicly available registers. To the extent that these incentives are sufficient in motivating parties to record such assignments, these records offer detailed accounts of patent ownership changes that occur throughout the entire

[3] *See* the MANUAL OF PATENT EXAMINING PROCEDURE (MPEP) 301 (8th Ed. Rev. 1, 2003) (incorporating definitions from 37 C.F.R. §3.1.

lifespan of patents on a previously unprecedented scale.

The limitations of patent assignment data

Inspired by the pioneering contribution of Serrano (2006), empirical studies have relied upon publicly available patent assignment records to explore a diverse set of topics that range from the quantification of the size and scope of markets for technology (*i.a.* Chesbrough, 2006a; Serrano, 2010; Gäßler, 2016; Ciaramella, Martinez and Meniere, 2017) and the examination of the determinants of technology transactions (*i.a.* Galasso, Schankerman and Serrano, 2013; Jeong, Lee and Kim, 2013; Caviggioli and Ughetto, 2013) to analyses of the redeployment of patents across organizational units (*i.a.* Arora, Belenzon and Rios, 2014; Ciaramella, 2017), explorations of the use of patent assets to obtain business loans (*i.a.* Hochberg, Serrano and Ziedonis, 2015: 2018) and inquiries into the activities of so-called patent assertion entities (*i.a.* Fisher and Henkel, 2013; Scott Morton and Shapiro, 2014; Haber and Werfel, 2015). Notwithstanding the contributions of these studies, they leave important questions with respect to the application of patent assignment data unanswered.

First, existing scholarship neglects or significantly downplays the concerns expressed in recent studies that federal regulations may not be effective enough to motivate the beneficiaries of patent assignments to publicly disclose these deals (*i.a.* Marco, Myers, Graham, DAgostino and Apple, 2015; Chien, 2012; Ewing and Feldman, 2012). This concern casts serious doubt on the consistency and accuracy of publicly available records of patent ownership changes given that the results of existing studies utilizing such records may be biased to the extent that the characteristics of recorded assignments differ from those that are not recorded.

Second, existing studies neglect a number of methodological advances that are fundamental to realize the full potential of assignment data at the firm-level. Specifically, these studies do not differentiate between transactions that are carried out between entities belonging to the same corporate group and those that happen between entities of different corporate groups. Furthermore, they do not distinguish between patent ownership changes that are standalone and those that occur within the frame of larger M&A deals. As a result, existing studies provide only a limited understanding of the implications of activities on markets for technology at the firm-level. It is the pursuit of developing a better understanding of patent assignment data and applications thereof

in the context of firm's activities on markets for technology that motivates this dissertation.

Objectives of the dissertation

The objectives of this dissertation are twofold as it aims to: (i) systematically examine the reliability and consistency of publicly available records of patent ownership changes and (ii) apply these records to study the performance effects of firms' activities on markets for technology. It bridges economic, managerial and legal scholarship on markets for technology, open innovation and patent monetization in order to contribute to existing debates concerning the functioning of technology markets, the pertinence of patent assignments as indicator of technology transfer and the public notice function of the patent system. To this end the dissertation contains four chapters that are structured as follows: ***Chapter 1*** presents a bibliometric review of the first decade of scholarship on open innovation with the objective of (i) highlighting connections between this scholarship and related scholarships, in particular the scholarship on external technology sourcing and (ii) revealing distinct thematic areas that have been the focus of this scholarship. ***Chapter 2*** presents the results of two empirical exercises designed to verify the reliability of publicly available patent assignment records, both during the pre- and post-issue stages of the patent life-cycle. Specifically, the analyses in Chapter 2 quantify the incidence of not recording patent ownership changes with the United States Patent and Trademark Office (USPTO) and explores distributional differences between recorded and not-recorded assignments. ***Chapter 3*** builds upon the findings of Chapter 2 and presents a comparative analysis of the legal requirements concerning the recording of patent ownership changes of six leading patent offices. This comparative analysis serves as the basis for recommendations geared towards improving the notice function of the patent system. Finally, ***Chapter 4*** presents an application of patent assignment data on the firm-level by analyzing the performance implications of embodied and disembodied technology acquisitions. It describes the construction of a large-scale consolidated dataset that allows to disentangle changes of patent ownership that are standalone from those that are embedded in larger M&A deals and to distinguish between intra- and inter-firm patent assignments. A short summary of each chapter is provided in the next section.

Outline of the Dissertation

Chapter 1 – *A Bibliometric Review of Open Innovation Research*

The concept of open innovation has attracted considerable attention since Henry Chesbrough first coined it in 2003 to capture the increasing reliance of firms on external sources of innovation. Although open innovation has flourished as a topic within innovation management research, it has also triggered debates about the coherence of the research endeavors pursued under this umbrella, including its theoretical foundations. In this chapter, we aim to contribute to these debates by means of a bibliometric review of the first decade of open innovation research. We combine two techniques – bibliographic coupling and co-citation analysis – to (i) visualize the network of publications that explicitly use the label 'open innovation' and (ii) to arrive at distinct clusters of thematically related publications. Our findings illustrate that open innovation research builds principally on four related streams of prior research whilst the bibliographic network of open innovation research reveals that seven thematic clusters have been pursued persistently. While such persistence is undoubtedly useful to arrive at in-depth and robust insights, the observed patterns also signal the absence of new, emerging, themes. As such, open innovation might benefit from applying its own ideas: sourcing concepts and models from a broader range of theoretical perspectives as well as pursuing a broader range of topics might introduce dynamics resulting in more impact and proliferation. Our findings also indicate that only a small part of open innovation research concentrates on external technology sourcing and that large-scale empirical studies on the topic are relatively scarce.

Chapter 2 – *A Validation of Publicly Available Patent Assignment Records*

Recent scholarship attributes patent assignments – transfers of patent ownership rights – distinct properties that allow for a dynamic and detailed analysis of activity on technology markets on a previously unprecedented scale. However, whilst patent regulations provide an incentive for interested parties to record an assignment with designated patent authorities, such recording is by and large voluntary. As a result, questions concerning the reliability and accuracy of assignments recorded at such authorities remain open. In this chapter, we validate assignment records from the USPTO Patent Assignment Dataset (UPAD) in order to examine the variation in recording patterns during

both the pre- and post-issue stages of the patent life-cycle. Our results suggest that a lower-bound estimate of 17% of pre-grant assignments and, conditional on patents being litigated, 54% of post-grant assignments are not recorded. Subsequent analyses reveal that the (non-)recording of assignments is related to characteristics on both the patent and assignee levels that have been associated with greater levels of activity on technology markets by existing empirical studies. This implies that inferences about technology transactions based on patent assignment data may suffer from selection into recording that is non-randomly distributed.

Chapter 3 – *An Analysis of Regulations on Patent Ownership Disclosure*

The most commonly provided economic rationale for the patent system is that it incentivizes inventive effort that may not be carried out in its absence. In addition to this utilitarian rationale, economic and legal scholars often refer to a second rationale that underlies the patent system – the dissemination of technological information to the public. This notice function is thought of as an important mechanism to enable a more efficient investment in innovation by stimulating further (continuous) innovation, reducing wasteful duplicate innovative effort and limiting unnecessary litigation. Consequently, courts have placed a great deal of emphasis on the notice function and have described it as the 'quid pro quo' of granting patent owners the right to exclude. Whereas the notice function is traditionally confined to the adequate disclosure of inventions, we propose that in light of the recent trend towards rapidly growing markets for patent monetization it should also encompass the adequate disclosure of the holders of rights to a patent. Specifically, in this chapter we argue that in addition to knowing in detail the boundaries that define a claimed invention, knowing the identity of the parties that hold rights to this invention is a fundamental prerequisite for any patent transaction to occur. Based on a comparative analysis of the provisions of six of the most proficient patent offices worldwide, we illustrate that although current provisions warrant an adequate disclosure of the identity of the initial patent applicant(s), they provide the public with only limited opportunities to identify and track subsequent changes of ownership. Although most patent authorities require parties to file notice when the rights to a patent are assigned, provisions for strictly enforcing this requirement are absent. This allows for a level of anonymity concerning patent ownership, which may hamper rather than facilitate technology transactions.

Chapter 4 – *A Firm-Level Application of Patent Assignment Data*

This chapter examines the contribution of different technology acquisition strategies to the market value of firms. We exploit a large consolidated dataset on publicly listed US-firms to distinguish between the contributions of patented inventions that these firms acquired via acquisitions of other firms – embodied technology acquisition – and via the outright purchase of standalone technology – disembodied technology acquisition. We develop hypotheses relating firms ability to benefit from both strategies to the size of their internal knowledge stock and their degree of familiarity with the acquired technology. In line with our predictions, we find a positive contribution of embodied technology acquisition on market value, which increases with the size of firms' internal knowledge stock as well as their familiarity with the acquired technology. Contrary to our predictions, we find a negative contribution of disembodied technology acquisition, except for firms having the largest internal knowledge stocks in our sample. Interestingly, our results reveal that firms are most likely te benefit from the acquisition of familiar technology via the embodied mode whilst at the same time indicating that the negative association between market value and the acquisition of standalone technology is most pronounced when this technology is novel to the acquiring firm. Overall, our findings suggest that the benefits associated with acquiring technology from external sources are only realized when firms possess a minimum degree of absorptive capacity, with the minimum needed to benefit from technology acquisition being significantly higher for technology acquired via the disembodied mode.

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Chapter 1

Exploring the Scope of Open Innovation

A Bibliometric Review of a Decade of Research[1]

1.1 Introduction

Within a mere decade of its first appearance in the scientific literature, the concept of open innovation has developed into a flourishing area of innovation management research today (*i.a.* Dahlander and Gann 2010; Huizingh 2011). The increased interest in open innovation is revealed in the fast-growing number of scientific publications referring to the concept as well as the many special issues in management journals devoted entirely to it (*i.a.* R&D Management 36(3): 40(3); Technovation 31; Research Policy 43(5). Open innovation has been broadly defined as *"... the purposive inflows and outflows of knowledge to accelerate internal innovation and to expand the markets for external use of innovation respectively..." (Chesbrough, Vanhaverbeke and West 2006:1)* and has been marked as *"the new imperative for creating and profiting from technology"*

[1] This chapter is based on the published paper: Kovacs A, Van Looy B, Cassiman B. 2015. Exploring the Scope of Open Innovation: A Bibliometric Review of a Decade of Research. *Scientometrics* **104**(3): 951-983. An earlier version of the chapter has been presented at the 2014 Annual Meeting of the Academy of Management in Philadelphia, US.

(Chesbrough 2003a) and even as *"the new paradigm for understanding industrial innovation"* (Chesbrough, Vanhaverbeke and West 2006). Whilst this broad definition has undoubtedly contributed to the concept's proliferation, it also lies at the heart of the criticism to which it has become increasingly subject.

This criticism relates either to the lack of coherence in the body of research surrounding the concept of open innovation or a lack of distinctiveness from related fields of research. The first critique is exemplified by Dahlander and Gann (2010) who note that, although *"…a variety of definitions and focal points are used [in existing open innovation research],… these do not yet cohere into a usable analytical frame" (Dahlander and Gann 2010:699)*. They stress that the absence of such a coherent analytical frame makes it difficult to compare and validate the findings of studies on the effects of firms' openness. Groen and Linton (2010) go one step further in explicitly questioning whether open innovation is a field of study or a communication barrier to theory development. The second critique is exemplified most notably by Trott and Hartmann (2009), who suggest that open innovation is simply the *"…repackaging and representation of concepts and findings presented over the past forty years within the literature on innovation management…" (Trott and Hartmann 2009:715)*. They argue that open innovation research draws especially upon insights from the literature on R&D collaboration. This view is supported by Mowery (2009) who, based on a survey of the development of industrial R&D in the United States in the postwar period, concludes that *"…many of the elements of the "Open Innovation" model … are apparent in the early development of US industrial R&D…" (Mowery, 2009:5)*.

Existing qualitative reviews of open innovation research (Gassmann, Sandmeier and Wecht 2006; Elmquist, Fredberg and Ollila 2009; Dahlander and Gann 2010; Gassmann, Enkel and Chesbrough 2010; Van De Vrande, Vanhaverbeke and Gassmann 2010; Huizingh 2011; Lichtenthaler 2011; West and Bogers 2013) predominantly focus on the first critique whilst providing useful insights regarding current themes, definitions, key empirical findings, and avenues for future research. This is illustrated in Table 1.1, which provides an overview of the themes and the avenues for future research advanced by the most recent reviews of open innovation research. Although the table reveals some coherence in terms of identified themes, it also highlights differing views on how to delineate and characterize the body of open innovation research. This is illustrative of both the lack of conceptual clarity surrounding open innovation as well as the key

weakness of qualitative reviews, which, by their very nature, are characterized by a certain degree of subjectivity and bias, since they rely on the idiosyncratic views and perspectives of the reviewers involved (Vogel and Güttel 2013).

In this chapter we aim to address both critiques simultaneously by creating a more systematic and comprehensive picture of the 'open innovation' research agenda. We engage in a quantitative review of the existing literature on open innovation to complement and cross-validate the insights from qualitative literature reviews. In particular, we aim to (i) identify the foundations of open innovation research, (ii) identify themes within open innovation research, (iii) benchmark open innovation research to related fields and (iv) identify fertile areas for future research based on (i), (ii) and (iii). To this end, we apply two bibliometric techniques – bibliographic coupling and co-citation analysis – that enable us to assess the thematic similarity between scientific publications based on overlaps in their referencing patterns. Whereas co-citation analysis implies an assessment of the similarity of cited documents, bibliographic coupling is an assessment of the similarity of citing documents. Consequently, the former technique is well-suited to identifying the foundations of a field of research, whereas the second technique is compatible with identifying current themes and future trends within a field of research. Therefore, combining these techniques enables us to obtain relevant insights into both the past traditions and the current trends that characterize open innovation research.

Based on our bibliometric approach, we clearly illustrate that open innovation is primarily rooted in technology- and innovation management streams but also selectively builds on frameworks and concepts from the strategic management literature. It is primarily the integration of insights from the user-centric perspective that distinguishes the open innovation literature from the broader literature on R&D collaboration. In addition, we also show that the first decade of open innovation research is illustrated by a relatively coherent network of seven distinct yet closely interconnected thematic clusters. An analysis of the publication output per cluster over time highlights that the identified themes have been pursued consistently over time. We interpret this as an indication that open innovation has matured into an established field of research that resides mainly in the literature on innovation management. At the same time it can be noted that 'open innovation' as a field, might benefit by applying the principles it advocates: more 'openness' – both in terms of contributing theoretical frameworks as well as pursued themes – might lead to an enriched development of the theme during

Table 1.1: An overview of existing qualitative reviews of open innovation research.

Authors	Identified Themes	Avenues for Future Research
Gassman (2006)	Identifies four literature streams on which open innovation research builds: (1) the internationalization of innovation stream, (2) the early supplier integration stream, (3) the user innovation stream and (4) the external commercialization of technology stream.	• Developing a contingency approach with respect to the management of open innovation.
Elmquist, Fredberg and Ollila (2009)	Identify seven common themes within open innovation research: (1) the notion of open innovation, (2) business models, (3) organizational design and boundaries of the firm, (4) leadership and culture, (5) tools and technology, (6) intellectual property, patenting and appropriation and (7) industrial dynamics and manufacturing.	• Re-conceptualizing open innovation research, thereby highlighting strengths, weaknesses, underlying theoretical models and contributions to managerial practice. • More focus on the 'human side' and 'organizational side' of open innovation.
Gassman, Enkel and Chesbrough (2010)	Identify nine perspectives that are represented by open innovation research: (1) the spatial perspective, (2) the structural perspective, (3) the user perspective, (4) the supplier perspective, (5) the leveraging perspective, (6) the process perspective, (7) the tool perspective, (8) the institutional perspective and (9) the cultural perspective.	• Developing a 'holistic' model of open innovation that simultaneously takes into account the determinants of the process and industry specifics, as well as the limits to opening up. • More focus on intellectual property issues, small- and medium sized enterprises (SMEs) and the 'spatial aspect' of open innovation.
Lichtenthaler (2011)	Identifies four tentative streams of open innovation research: (1) the technology transactions stream, (2) the users stream, (3) the business models stream and (4) the innovation markets stream.	• Developing a clearer understanding of the characteristics of open innovation as well as the practices and tools for managing it. • Addressing the link between approaches to open innovation and firms' corporate strategy and organizational culture. • More attention for the determinants of successful open innovation. • Developing a better theoretical foundation for open innovation research. • More rigor in academic studies that employ an empirical research design.

Table 1.1: An overview of existing qualitative reviews of open innovation research (continued).

Authors	Identified Themes	Avenues for Future Research
Dahlander and Gann (2010)	Distinguish four streams of open innovation research based on two dimensions – inbound vs. outbound and pecuniary vs. non-pecuniary open innovation: (1) the revealing stream, (2) the selling stream, (3) the sourcing stream and (4) the acquiring stream.	• Explaining the contingencies under which openness is a fruitful strategy. • More focus on the decision processes underlying different forms of openness. • Elaborating on the conceptual frame of open innovation from the perspective of product/technology life cycles. • Exploring combinations of different forms of openness and studying the conditions under which these different forms are complements or substitutes.
Van De Vrande, Vanhaverbeke and Gassmann (2010)	Does not identify themes but addresses trends in open innovation based on three characteristics of the research performed: (1) focus (large multinationals, SMEs, user communities), (2) type of research (theoretical, qualitative, quantitative) and (3) level of analysis (firms, individuals, dyads, projects, industries, regions).	• Explaining how open innovation strategies enable firms to create a competitive advantage. • Integrating open innovation research into the existing literature about external technology acquisition and cooperation. • Incorporating different levels of analysis. • Connecting open innovation to other disciplines or management areas. • More focus on SMEs.
Huizingh (2011)	Distinguishes four streams of open innovation research based on the level of openness of two artifacts – the process and/or outcome of open innovation: (1) closed innovation, (2) private open innovation, (3) public innovation, (4) open source innovation.	• More attention for cases in which open innovation initiatives have failed. • Developing an integrated framework that helps managers to decide when and how to deploy particular open innovation practices. • More large-scale quantitative studies in various industries and countries. • Incorporating the concept into integrated management theories and existing management toolkits.
Bogers and West (2014)	Identify four related streams of open innovation research: (1) obtaining external innovations stream, (2) integrating external innovations stream, (3) commercializing external innovations stream, (4) interaction between the focal firm and its collaborators stream.	• More focus on the role of the business model in open innovation. • More attention for the entire process of obtaining, integrating and commercializing innovations. • Moving beyond depictions of innovation as a linear process. • Exploring the moderators and limits of external sourcing, by focusing more on the potential risks and costs associated with external sourcing. • More focus on the failures of open innovation.

the next decade.

The remainder of this chapter is structured as follows. In the next section, we elaborate on the data that we use and the methods we apply. We discuss the procedures that we adhered to in order to construct the dataset, and we describe the application of bibliographic coupling and co-citation analysis in detail. In the third section, we present the bibliographic network of the references that are cited by our set of open innovation publications, based on co-citation analysis. We analyze this network in order to highlight the foundations of open innovation research. In the fourth section, we present the bibliographic network of our set of publications, based on bibliographic coupling. This network serves as the basis for our subsequent discussion of clusters that represent thematic areas in open innovation research. In the fifth section, we discuss the implications of our findings and relate them to the findings of existing reviews in order to identify fertile areas for future research.

1.2 Data and Methods

1.2.1 Data

We used the 'topic search option' in the Thomson Reuters Web of Science database in order to search for scientific publications that contain the terms 'open' and 'innovation' in either the title, keywords or abstract fields of the database. Although Rigby and Zook (2002) have introduced the arguably similar concept of 'open-market innovation' already in the year 2002, Chesbrough (2003a) is generally credited with coining the term 'open innovation'. Therefore, we limited our search to publications published between 2003 and 2013 and included only publications of the document type 'article'[2]. However, the topic search option in the Web of Science is conducive to 'false positives' as it not only captures publications that contain the term 'open innovation' but also publications that simply contain the terms 'open' and 'innovation' separately from each other (Dahlander and Gann 2010). Rather than making ex-ante normative judgments with regard to whether publications address the concept of open innovation or not, we decided to limit our sample to only those publications that contain the combination term 'open innovation' in either the title, keywords or abstract fields of the Web of

[2] In rare cases publications are assigned to multiple document-type categories, e.g. 'article/editorial'. We only selected publications that are assigned solely to the document type 'article'.

Science database. Hence, authors who seek to contribute to open innovation research at the highest level of development are likely to refer to the term 'open innovation' in at least one of these fields. Although our approach may involve missing out on a number of 'false negatives', it ensures that no 'false positives' are captured.

Our search effort using the 'topic search option' resulted in a set of 2,013 publications for which we downloaded Web of Science records[3]. These standardized records comprise information about the title, abstract and keywords fields; they also contain basic information about authors, sources, publishers and, most relevant to our study, the cited references. In order to remove false positives, we subsequently read through the title, abstract and keywords fields of each of these 2,013 publications and identified all records that contain the term 'open innovation' in at least one of these fields. Based on this effort, we identified 358 publications, which constitute the dataset that we used for further analysis. These publications refer to 11,873 publications and are referred to in 2,372 publications.

Figure 1.1 below visualizes the distribution of our set of publications over time.To put this distribution into perspective, the figure also visualizes the distribution of publications on R&D collaboration over the same time period. This data is derived from the Web of Science entering stemmed synonyms of R&D collaboration, using the same set of parameters. It can be observed from the figure that although the first publication containing the term 'open innovation' was published in 2003, the number of publications only started to flourish from 2006 onwards. Furthermore, the figure clearly shows that the literature on open innovation has developed separately from the broader literature on R&D collaboration. Publications that refer to the term 'open innovation' do not tend to refer to terms that can be associated with R&D collaboration and vice versa. This provides a first indication that open innovation is a field of research that develops relatively independent from research focusing on R&D collaboration.

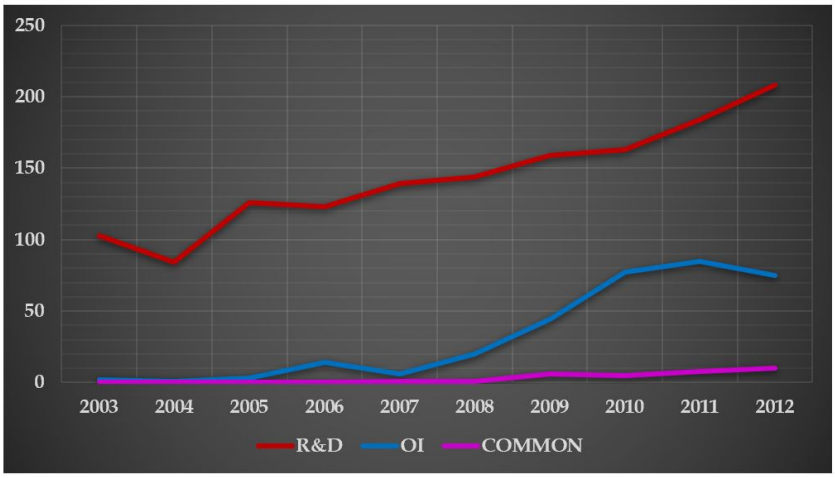
1.2.2 Methods

Bibliographic coupling and co-citation analysis

As mentioned previously, we combine two bibliometric techniques that build on the analysis of authors' referencing behavior – bibliographic coupling and co-citation analysis. Accordingly, these techniques rely on the fundamental assumption that, to the

[3] We downloaded the Web-of-Science records on October 1st, 2013.

Figure 1.1: The distribution of WoS-publications on open innovation and R&D collaboration over time.



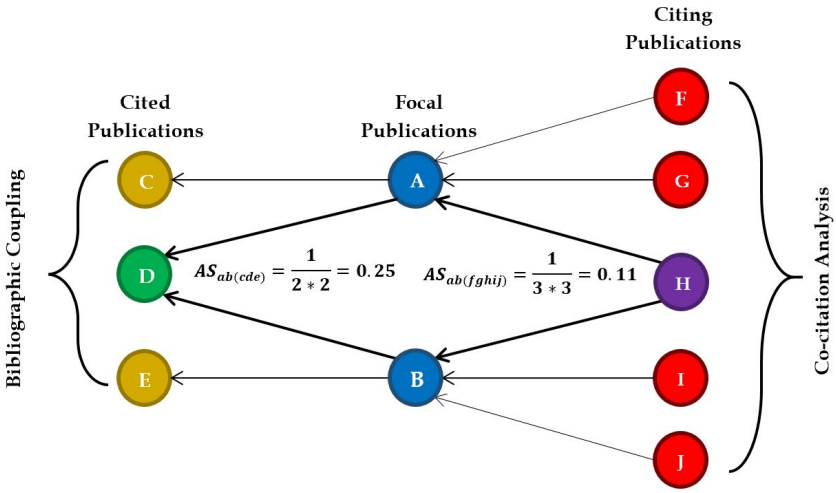
extent that the cited references of a focal publication provide a background for this publication, they denote at least some degree of relatedness between the focal publication and the publication(s) to which it refers. Based on this assumption, citation-based indicators have been widely applied in the field of bibliometrics as a means of mapping the flow of science and the development of fields and communities (see for instance Kessler 1963; Weinberg 1974; Vladutz and Cook 1984). More recently, citation-based bibliometric methods have also found their way into management research (e.g. Chen, Huang and Chen 2012; Vogel and Güttel 2013)[4]. The basic assumption underlying both bibliographic coupling and co-citation analysis is that the greater the degree of overlap in the referencing patterns of a pair of focal publications, the greater the relatedness between both publications.

Bibliographic coupling and co-citation analysis are complements in the sense that, whilst the former approach is suitable for capturing current trends within a field, the latter approach is appropriate when capturing the origins of that field (Sharabchiev

[4] *See* Vogel and Güttel (2013) for a more elaborate overview of management research that draws upon citation-based bibliometric methods.

1988; Boyack and Klavans 2010). Hence, bibliographic coupling associates focal publications on the basis of their references to publications, which are by definition older than the focal publications themselves. On the other hand, co-citation analysis associates focal publications on the basis of their future appraisal by publications, which are by definition more recent than the focal publications themselves (see Figure 1.2 for an illustration of bibliographic coupling and co-citation analysis). In line with the unique properties of both techniques, we apply co-citation analysis in order to identify the foundations of existing open innovation research and bibliographic coupling to identify themes within open innovation research itself.

Figure 1.2: An illustration of bibliographic coupling and co-citation analysis.



The figure depicts the citation network of two focal publications *A* and *B* that both cite two publications (*A* cites *C* and *D* whilst *B* cites *D* and *E*) and are cited by three publications (*A* is cited by *F*, *G* and *H* whilst *B* is cited by *H*, *I* and *J*). *A* and *B* have one common backward citation *D* that links them via bibliographic coupling and one common forward citation *H* that links them via co-citation analysis.

Relatedness measures

Several measures have been developed to calculate the relatedness between pairs of bibliographic objects. We apply a measure – known as the *association strength* – that determines the relatedness between a pair of focal publications by normalizing the co-occurrence frequency of the references they make (in case of bibliographic coupling) or the references they receive (in case of co-citation analysis). This measure has been developed by Van Eck and Waltman (2009), who illustrate that it is more suited to normalizing co-occurrence data than the more conventional cosine and Jaccard index-based measures, which are widely applied in the field of bibliometrics[5]. We calculate the association strength between pairs of focal publications by means of the following formula:

$$AS_{ab} = \frac{C_{ab}}{C_a C_b}$$

In case of bibliographic coupling, C_{ab} relates to the references made that a pair of focal publications A and B have in common, C_a relates to the total number of references made by publication A and C_b relates to the total number of references made by publication B. This means that the association strength of publications A and B is proportional to the ratio between the observed number of overlapping references made, on the one hand, and the expected number of references made by publications A and B, on the other hand. The measure is analogous in case of co-citation analysis, with the only difference being that it pertains to references received instead of references made by publications A and B respectively.

Hence, the higher the value for AS for a given pair of focal publications, the greater the relatedness between these publications. In the example of Figure 1.2, the association strength between focal publications A and B equals 0.25 (1/(2*2)) based on bibliographic coupling and 0.11 (1/(3*3)) based on co-citation analysis. We calculated the association strength for all possible pairs of references cited by the publications in our dataset based on co-citation analysis. The matrix that resulted from this exercise served as an input to visualize and identify the foundations of the concept of open innovation. We also calculated the association strength for all possible pairs of publications that are contained in our dataset based on bibliographic coupling. The resulting association matrix served as the input for the visualization and identification of thematic clusters

[5] *See* Van Eck and Waltman (2009) for a more elaborate overview of the most widely applied measures of similarity in bibliometric studies.

of open innovation research itself.

Visualization and clustering

We rely on the Visualization of Similarities (VOS) approach as described by Van Eck and Waltman (2010) in order to identify and visualize thematic clusters based on the relatedness between publications in our set. Essentially, VOS is a unified approach for mapping and clustering bibliometric networks that combines an optimization algorithm with a clustering algorithm in one software package; VOSviewer[6]. VOSviewer has been used to develop bibliographic mappings in a variety of studies (*i.a.* Rafols, Leydesdorff, O'Hare, Nightingale and Steling 2012; Wuehrer and Smejkal 2013; Mamtora, Wolstenholme and Haddow 2014; Rafols *et. al.* 2014). The VOS optimization algorithm ensures that *"...publications are located in a low-dimensional space in such a way that the distance between any two items is a reflection of the relatedness of the items as accurately as possible..." (Van Eck, Waltman, Dekker and Van Den Berg 2010:2407).* More specifically, the algorithm minimizes the weighted sum of the squared distances between all pairs of publications and weighs these by the relatedness of these publications. Accordingly, the greater the association strength between a pair of publications, the smaller the distance between these publications in the low-dimensional space. Furthermore, the optimization algorithm ensures that the most connected publications will be located near the center of the low-dimensional space whilst the less-connected publications will be located in its periphery.

Publications are grouped into clusters on the basis of the VOS clustering algorithm, which is based on a weighted version of Newman and Girvan's (2004) modularity function. In this function, modularity is a measure of the quality of the division of a given network into communities (clusters). Specifically, the algorithm eliminates edges in a network that have the highest betweenness[7] until the modularity function of Newman and Girvan is maximized. In other words, the optimal number of clusters is the one in which the maximum value for the modularity function is reached. We have used the default parameters of VOSviewer in order to derive the bibliographic networks that we

[6] VOSviewer is a freely available computer program for the visualization of bibliometric networks that can be downloaded at http://www.vosviewer.com.

[7] Hence, the betweenness of an edge is larger the higher the number of pairs of nodes that it lies between.

present in subsequent parts of this chapter[8].

1.3 Results

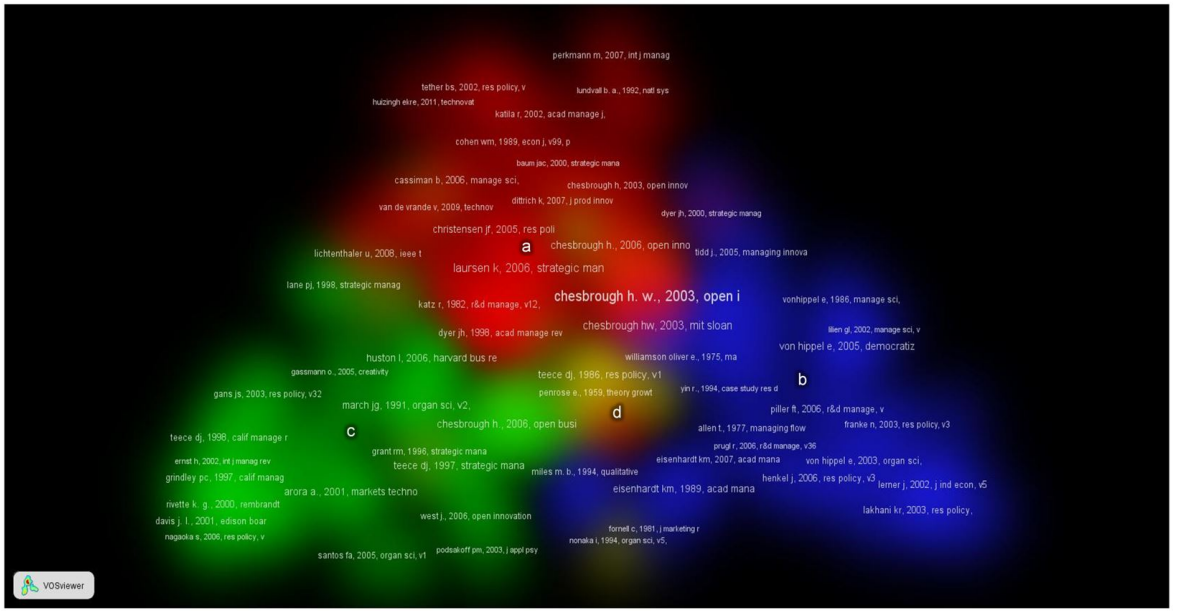
1.3.1 The foundations of open innovation research

The bibliographic network of the references cited by our set of open innovation publications is illustrated in Figure 1.3. The network was created based on the cited references that we derived from our set of 358 publications. Since the form of cited references tends to differ between journal sources, there is a need to convert them into a standardized form for further processing. Therefore, all cited references were standardized to a string that contains only a maximum of two initials of the author's first name, as well as the author's full surname and the year of publication. After this standardization effort, 11,873 unique references remained for further analysis. In Figure 1.3, however, we only portray references that have been cited a minimum of ten times. This restriction is imposed in order to capture only the most important references, whilst not overly complicating the interpretation of Figure 1.3. We do not impose restrictions with regard to the publication date of cited references, meaning that we also include references published after 2003. However, since our primary interest lies in identifying the foundations of open innovation research that are situated outside the field itself, we filtered out 28 publications that are both part of our set of 358 publications and receive a minimum of 10 citations from other publications in our set. Hence, the cited references portrayed in Figure 1.3 are not the ones contained by our dataset of 358 publications.

In Figure 1.3, each label represents a reference that is cited at least ten times overall by our set of publications. The greater the size of the fonts of a label, the more often the reference is cited by our set of publications. The distance between a pair of cited references represents the likehihood that these references are cited together by our set of publications. Thereby, a shorter distance corresponds with a greater likelihood of being cited together. Lastly, the colors and corresponding lowercase letters in the figure indicate clusters of cited references that can be distinguished. The grouping of a reference into a cluster indicates that this reference is more likely to be cited in combination with other references that are grouped in this cluster than with references that are grouped

[8] *See* Van Eck and Waltman (2010) for an elaborate discussion of these default parameters.

Figure 1.3: The bibliographic network of the references cited by publications on OI.



a. Strategic Partnering and External Sourcing

b. User-centric Innovation

c. Technology and Innovation Management

d. Resource-Based and Knowledge-Based View of the Firm

in other clusters. It can be observed from Figure 1.3 that the clustering resulted in four clusters, represented by the red, blue, green and yellow colors respectively. Figure 1.3 displays a relatively coherent network in which the red, blue and green clusters are tied together by the yellow, which is located near the center of the network. In order to interpret and label the clusters, we downloaded Web of Science records for the 123 cited references represented in the figure[9] and listed the most frequent terms in the keywords, title and abstract sections of these references per cluster. In addition, we read the abstracts and introductions of the cited references. Based on this effort, we labeled the clusters as follows: *'Cluster a – Strategic Partnering and External Sourcing'*, *'Cluster b – User-centric Innovation'*, *'Cluster c – Technology and Innovation Management'* and *'Cluster d – Resource- and Knowledge-based View of the Firm'* respectively. In what follows, we describe and discuss the cited references captured by each cluster. Although we aim to describe every cluster in as much detail as possible, we acknowledge that our description cannot fully capture the richness of every cluster.

Cluster a – Strategic partnering and external sourcing (37 items)

The thematic orientation of this cluster of references is best captured by the label *'Strategic Partnering And External Sourcing'* as most publications that are included in the group address different kinds of interorganizational collaboration arrangements. Most of these publications examine the contingencies influencing strategic partnering behavior (Hagedoorn 1993; Powell, Koput and Smith-Doerr 1996; Dyer and Singh 1998; Gulati 1998; Tether 2002; Hagedoorn 2002), the effects of strategic partnering on firm performance (Ahuja 2000; Baum, Calabrese and Silverman 2000; Dyer and Nobeoka 2000; Belderbos, Carree and Lokshin 2004; Faems, Van Looy and Debackere 2005; Dittrich and Duysters 2007), and the ways of governing interorganizational collaboration agreements (Van De Vrande, Lemmens and Vanhaverbeke 2006). Others focus specifically on the external sourcing of knowledge, often referred to as the inbound dimension of open innovation. These studies explore the complementarity between internal and external R&D (Veugelers 1997; Cassiman and Veugelers 2006) and study the effects of external knowledge sourcing on firm performance (Katila and Ahuja 2002; Laursen and Salter 2004; Fey

[9] We were only able to download Web of Science records for 92 of the 123 cited references since the remaining references are books that are not held by the Web of Science.

2005; Laursen and Salter 2006; Van De Vrande, Lemmens and Vanhaverbeke 2006). Taken together, these studies provide empirical evidence of the increased reliance of firms on external sources of knowledge, which is, at least in part, the trend that the open innovation concept aims to address. Therefore, it is not surprising that open innovation research draws upon these studies.

Whereas most of the aforementioned publications indicate that firms can benefit significantly from external knowledge sourcing, the cluster also contains publications which stress that realizing these benefits should not be taken for granted. Cohen and Levinthal's (1990) seminal contribution on the concept of absorptive capacity is the most prominent of these publications and is the second most-cited reference by our set of open innovation publications. Additional references to contemporary works on the concept (Szulanski 1996; Lane and Lubatkin 1998; Tsai 2001, Zahra and George 2002; Lane, Koka and Pathak 2006) highlight its recognition as a necessary condition for successful external knowledge sourcing in open innovation research. In similar vein, the presence of Katz and Allen's (1982) well-known contribution on the 'not-invented-here' syndrome arguably indicates that the concept is often regarded within open innovation research as a potential obstacle to successful knowledge sourcing.

Cluster b – User-centric innovation (34 items)

This cluster is labeled as '*User-centric Innovation*', since the majority of the references that it comprises focus explictly on the role of end users within firms' innovation processes. It captures Von Hippel's (1988) and (2005) books, entitled '*Sources of Innovation*' and '*Democratizing Innovation*' – the most-cited contributions in the cluster – as well as contemporary works that center on user communities and open source software (OSS) platforms. Most of these contemporary works study the motivation of users in participating in OSS platforms (Hars and Ou 2002; Harhoff, Henkel and Von Hippel 2003; Hertel, Niedner and Herrmann 2003; Lakhani and Von Hippel 2003; Von Krogh, Spaeth and Lakhani 2003; Jeppesen and Frederiksen 2006) and ways of engaging users to participate in them (Von Hippel and Katz 2002; Franke and Shah 2003; Lee and Cole 2003; Prugl and Schreier 2006). Others explore the conditions under which OSS platforms should be preferred to proprietary platforms (Lerner and Tirole 2002; West 2003) and the potential implications that this holds for organization science and theory (Von

Hippel and Von Krogh 2003). The inclusion of the above-listed publications among the references most cited by our set of open innovation publications indicates that users are considered important sources of external knowledge in existing open innovation research.

In addition to the contributions on user-centric innovation, the cluster also contains cited references that provide insights into the methodological foundations of open innovation research. Referencing to Glaser and Strauss's (1967) book on grounded theory, Miles and Huberman's (1984) book on qualitative research designs, and Eisenhardt's (1989, 2007) and Yin's (1994, 2003) contributions on case study methodology indicates that qualitative research, and especially case studies, play an important role in open innovation research. The inclusion of these contributions in this cluster may indicate that case studies are especial

Cluster c – Technology and innovation management (34 items)

Compared to the other clusters, this cluster is relatively more heterogenous with respect to the thematic areas that it covers. However, the majority of cited references grouped in this cluster can be placed under the umbrella of technology and innovation management and, therefore, the cluster has been labeled accordingly. The most-cited references of the cluster are those that put forward frameworks for the organization of innovation from a strategic management point of view. To this group of references belong publications on the exploration-exploitation dilemma of organizational learning (March 1991; Rothaermel and Deeds 2004), the dynamic capabilities framework (Teece, Pisano and Shuen 1997; Eisenhardt and Martin 2000; Teece 2007) and the recombinative capabilities framework (Kogut and Zander 1992). In essence, these frameworks describe how organizations can (re-)develop capabilities in order to survive in the wake of rapid technological change. The fact that they are cited extensively indicates that the insights from these general frameworks are relevant to open innovation research.

In addition to the more general frameworks on the organization of innovation, the cluster also contains a subset of publications that focus specifically on external technology commercialization. This subset encompasses Arora, Fosfuri and Gambardella's (2001) seminal contribution on 'markets for technology' as well as a number of contemporary works that explore the implications of these markets for external technology

commercialization. These works examine the antecedents and determinants of external technology commercialization (Gans and Stern 2003; Lichtenthaler 2005; Fosfuri 2006; Gambardella, Giuri and Luzzi 2007; Nagaoka and Kwon 2006), the challenges associated with managing external technology commercialization (Grindley and Teece 1997; Koruna 2004; Lichtenthaler 2005) and the ways to capture value from technology commercialization (Teece 1998). Hence, these publications address the outbound dimension of open innovation, whereas the publications belonging to the first cluster address its inbound dimension.

Cluster d – Resource- and knowledge-based view of the firm (18 items)

This cluster predominantly captures references that relate to the *Resource-based View (RBV)* and the *Knowledge-based View of the Firm (KBV)* and is, therefore, named after these theoretical frameworks. The cluster comprises both the seminal works on the RBV (Penrose 1959; Wernerfelt 1984; Barney 1991) and the KBV (Grant 1996) as well as works that incorporate a resource-based/knowledge-based perspective (Nonaka 1994; Hargadon and Sutton 1997; Nahapiet and Goshal 1998; Rosenkopf and Nerkar 2001; Howells 2006). Both the RBV and the KBV are based on the central premise that a focal firm can establish a position of sustainable competitive advantage through the creation and exploitation of idiosyncratic firm attributes (Wernerfelt 1984; Barney 1991). The fact that several of the key contributions on both the RBV and the KBV are grouped together in this cluster indicates that a considerable proportion of open innovation research takes into account this premise.

In addition to the seminal works on the RBV and the KBV, the cluster contains two other highly cited publications – Nelson and Winter's (1982) book entitled *'An Evolutionary Theory of Economic Change'* and Teece's (1986) publication entitled *'Profiting From Technological Innovation – Implications For Integration, Collaboration, Licensing and Public Policy'*. This indicates that our set of open innovation publications builds at least in part on Nelson and Winter's (1982) conceptualization of 'routines' as a framework for understanding technological change as well as Teece's (1986) conceptualization of 'appropriability' as a framework for understanding how to capture value from technological innovation. Lastly, the cluster contains Chesbrough's (2003b) and Chesbrough, Vanhaverbeke and West's (2006) seminal publications on open innovation. Since both

of these publications are books, they are not part of our sample and are displayed as such in Figure 1.3. Clearly, these works are amongst the most-cited references by our set of open innovation publications.

The relative importance of clusters of cited references

In order to assess the relevance of each cluster of cited references as a foundation for open innovation research, we calculated a number of publication-output and citation-based statistics per cluster. These statistics are presented in Table 1.2 below. Column 5 of the table shows the average number of citations that a reference received from our set of open innovation publications, whilst Column 6 provides the ratio between this average and the total sample average. From these columns, it can be derived that, on average, references belonging to '*Cluster a – Strategic Partnering and External Sourcing*' are cited the most by our set of open innovation publications. An average reference belonging to this cluster is cited 20 times while an average reference belonging to the other clusters is cited only 17 or 18 times. Furthermore, only references belonging to Cluster a are cited more than the average reference (18.57).

To put the above observations into context, we analyzed the extent to which the R&D collaboration literature builds upon the foundations of the open innovation literature. Column 7 shows the average number of citations that a reference received from publications on R&D collaboration between 2003 and 2013, whilst Column 8 gives the ratio between this average and the total sample average. It follows from Columns 7 and 8 that the references belonging to *'Cluster a – Strategic Partnering and External Sourcing'* have, on average, received by far the most citations from publications on R&D collaboration. Interestingly, references belonging to *'Cluster b – User-centric Innovation'* have received the least citations from Web of Science publications between 2003 and 2013. In fact, taken together, the information presented in Columns 5 to 8 of Table 1.2 indicates that it is primarily the enhanced focus on the user-centric perspective which distinguishes the open innovation literature from the broader literature on R&D collaboration.

1.3.2 Thematic areas in open innovation research itself

The bibliographic network of our set of open innovation publications, based on bibliographic coupling, is presented in Figure 1.4. The principles that apply in interpreting

Table 1.2: Indicators of publication output and citation impact per cluster of cited references.

Cluster	Label	Number of Items	Top 3 Most-Cited Articles	Average Number of Citations Per Item (Open Innovation Set)	Ratio to Average (Open Innovation Set)	Average Number of Citations Per Item (R&D Collaboration Set)	Ratio to Average (R&D Collaboration Set)
a	Strategic Partnering and External Sourcing	37	Cohen and Levinthal (1990) Laursen and Salter (2006) Powell et. al. (1996)	20.03	1.08	40.61	1.63
b	User-centric Innovation	34	Eisenhardt (1989) Von Hippel (2003) Lerner (2002)	17.00	0.92	5.71	0.23
c	Technology and Innovation Management	34	Gassman (2006) March (1991) Teece (1997	18.16	0.98	17.24	0.69
d	Resource-and Knowledge-based View of the Firm	12	Huston and Sakkab (2006) Teece (1986) Barney (1991)	18.17	0.98	30.83	1.24
Total		**123**	**n/a**	**18.57**	**n/a**	**24.84**	**n/a**

Figure 1.4: The bibliographic network of WoS-publications on OI.

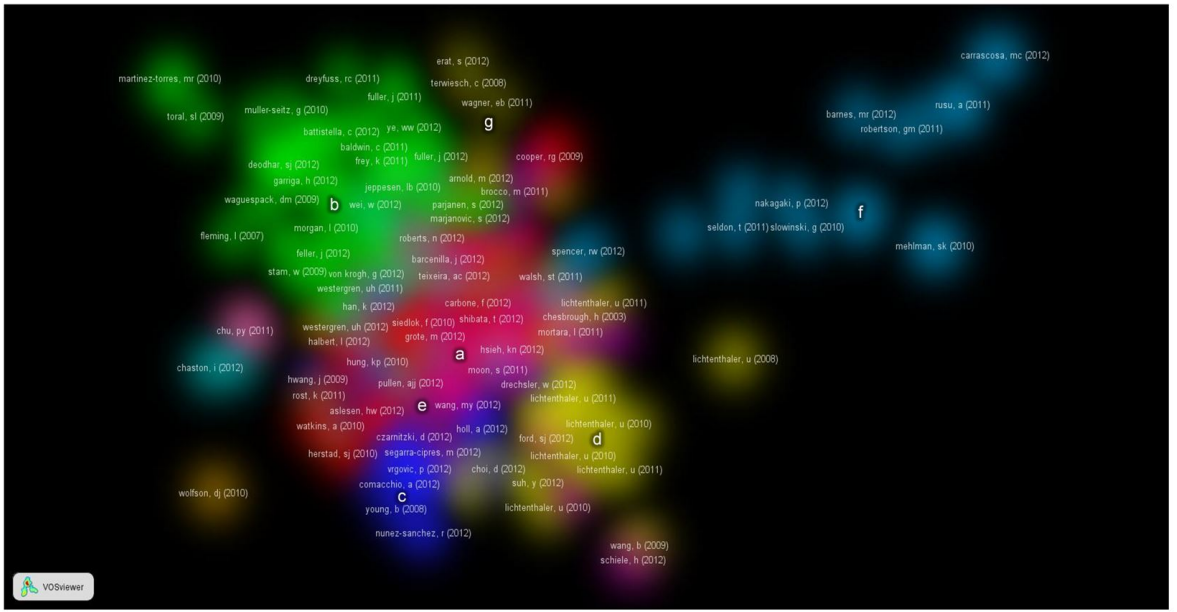


Figure 1.4 are the same as those that apply in interpreting Figure 1.3, except that in Figure 1.4, the sizes of the fonts of labels are equal. It is important to note that Figure 1.4 visualizes the bibliographic-coupling network for 344 of our 358 publications only. Firstly, we dropped a number of publications because their Web of Science records did not contain information on the references cited. We treated these publications as missing observations. Secondly, we dropped a number of publications because they had no cited reference in common with any other publication in our set. We treated these publications as outliers. Although the bibliographic coupling resulted in the identification of ten clusters, we decided to exclude three less coherent clusters – representing 29, 8 and 2 publications, respectively – from further analysis. These three clusters had the lowest coherence of all clusters, and a close examination of their contents revealed that they cover miscellaneous applications of open innovation that cannot be linked in a meaningful way. By excluding these clusters, we were left with 307 publications, grouped in seven clusters.

Figure 1.4 displays a relatively coherent bibliographic network in which each of the seven clusters is represented by a color and corresponding lowercase letter. In order to interpret and label the clusters, we followed the same approach we used to interpret and label clusters of cited references. We listed the most frequent terms in the keywords, title and abstract sections of these publications per cluster. In addition, we read the abstracts and introductions of the publications. Based on this effort, we labeled clusters as *'Cluster a – The Core of Open Innovation'*, *'Cluster b – User-centric Innovation'*, *'Cluster c – External Knowledge Sourcing'*, *'Cluster d – External Technology Commercialization'*, *'Cluster e – Implementation Mechanisms and Tools'*, *'Cluster f – Open Innovation Initiatives in Specific Industries'* and *'Cluster g – Idea Generation and Idea Competitions'*, respectively. In the following section, we discuss our interpretation of the themes that the clusters represent. Again, we acknowledge that, although we attempt to describe every cluster as eloborately as possible, our descriptions cannot fully capture the richness of each and every cluster.

Cluster a – The core of open innovation (94 items)

This cluster is both the largest – in terms of the number of publications that it contains – and the most centrally placed cluster; it has, therefore, been labeled as the 'core

of open innovation'. The cluster comprises Chesbrough's (2003a) seminal contribution '*The Era of Open Innovation*', which introduces the concept of open innovation, and a number of literature reviews that address the concept's basic dimensions (Dahlander and Gann 2010; Van De Vrande, Vanhaverbeke and Gassmann 2010). Furthermore, it includes a set of publications that address the implications of open innovation on the systemic level. These publications highlight the relevance of open innovation for public policy (Clausen and Rasmussen 2011; Karo and Kattel 2011), provide frameworks that describe how policy makers should respond to open innovation (De Jong, Kalvet and Vanhaverbeke 2010; Herstad, Bloch, Ebersberger and Van De Velde 2010), examine the policy initiatives that are currently in place for addressing open innovation (Mayer 2010; Zhao and Zheng 2011; Lee, Hwang and Choi 2012; Wang, Vanhaverbeke and Roijakkers 2012), and explore the implications of open innovation for regional innovation systems specifically (Cooke 2005; Belussi, Sammara and Sedita 2010; Isaksen and Onsager 2010; Todtling, Van Reine and Dorhofer 2011; Halbert 2012).

Although publications that focus on the concept of open innovation constitute the main part of the cluster, it also contains publications that elaborate on the concept of open business models. These publications explore how firms can create and capture value from an open innovation approach. Some publications outline how firms should develop and implement open business models in general (Chesbrough 2004; Chesbrough and Schwartz 2007; Munsch 2009; Sandulli and Chesbrough 2009). Others focus on the viability of open business models in specific industry (Davey, Brennan, Meenan and McAdam 2011), economic (Di Minin, Frattini and Piccaluga 2010), product (Jaspers and Van Den Ende 2010) and geographic (Li and Kozhikode 2009) settings. Finally, another subset of studies explores the link between business models and corporate venturing initiatives (Anokhin, Ortqvist, Thorgen and Wincent 2011a; Napp and Minshall 2011; Van De Vrande, Vanhaverbeke and Duysters 2011).

Cluster b – User-centric innovation (78 items)

This cluster captures contributions pertaining to user communities, user platforms, crowdsourcing and open-source software (OSS) development. Out of these topics, publications on OSS comprise the largest part of the cluster. Most of these publications describe the business models and strategies that firms should adopt in order to cre-

ate and capture value from OSS development in general (Dahlander and Wallin 2006; Gruber and Henkel 2006; West and Gallagher 2006; Stam 2009; Haefliger, Jager and Von Krogh 2010; Harison and Koski 2010; Morgan and Finnegan 2010; Perr, Appleyard and Sullivan 2010; Rolandsson, Bergquist and Ljunberg 2011; Deodhar, Saxena, Gupta and Ruohonen 2012; Rajala, Westerlund and Möller 2012). Others focus specifically on a key part of OSS development; the involvement of experienced and qualified users. These studies explain the conditions under which users are motivated to freely contribute their knowledge to OSS projects (Henkel 2006:2009) and the modes through which this contribution actually takes place (Toral, Torres and Barrero 2009a, Toral, Martinez-Torres and Barrero, 2009; Martinez-Torres, Toral, Barrero and Cortes 2010). A final segment of OSS-related studies explores the applicability of the principles of open source in non-software-related areas (Penin and Wack 2008; Raasch, Herstatt and Balka 2009; Müller-Seitz and Reger 2009:2010a:2010b).

Although the remaining publications grouped in this cluster do not focus on OSS development, the key topics addressed by these publications are very similar to those addressed by the publications on OSS. Many contributions focus on the motivation of users in participating in communities/platforms (Spaeth, Stuermer and Von Krogh 2010; Frey, Lüthje and Haag 2011; Fuller, Hutter and Faullant 2011; Battistella and Nonino 2012; Fuller, Matzler, Hutter and Hautz 2012), the identification of key participants (Fleming and Waguespack 2007; Fichter 2009) and the effects of users' contributions on contemporary platform development (Boudreau 2012). Other contributions present concrete cases to illustrate the frameworks and business models that have proven successful in benefitting from the contributions of users (Angehrn, Luccini and Maxwell 2009; Ebner, Leimeister and Kcmar 2009; Hildrum 2009; Kohler, Matzler and Fuller 2009; Leimeister, Huber, Bretschneider and Krcmar 2009; Lohman, Niesenhaus, Heim and Ziegler 2009; Adenbanjo and Michaelides 2011; Basole and Karla 2011; De Couvreur and Goossens 2011; Faraj, Jarvenpaa and Majchrzak 2011; Hutter, Hautz, Fuller, Mueller and Matzler 2011; Kohler, Fueller, Stieger and Matzler 2011; Bullinger, Rass, Adamczyk, Moeslein and Sohn 2012; Feller, Finnegan, Hayes and O'Reilly 2012; Parjanen, Hennala and Konsti-Laakso 2012; Shu and Chuang 2012; Tickle, Adebanjo, Michaelides, 2011; Ye, Xu, Jia and Jiang 2012). Finally, the remaining publications clarify the meaning of user communities (West and Lakhani 2008) and crowdsourcing (Marjanovic, Fry and Chataway 2012), and position these concepts within the broader frame of collaborative

innovation (Baldwin and von Hippel 2011) and the private-collective model of innovation (von Hippel and von Krogh 2006; Garriga, Aksuyek, Hacklin and Von Krogh 2012).

Cluster c – External knowledge sourcing (42 items)

The common denominator of the majority of publications captured by this cluster is that they focus their attention on the inbound dimension of open innovation; the external sourcing of knowledge. The majority of publications focus either on (i) the determinants/antecedents of firms' openness to external sources of knowledge or (ii) the effects of external knowledge sourcing on firm performance. The determinants-oriented publications link the openness of firms' external knowledge sourcing strategies to a number of firm characteristics such as firm size (Barge-Gil 2010; Moon 2011), firm age (Moon 2011), firms' R&D intensity (Barge-Gil 2010; Segarra-Cipres, Bou-Llusar and Roca-Puig 2012), the severity of firms' internal weaknesses (Keupp and Gassman 2009), firms' appropriability strategy (Moon 2011), firms' absorptive capacity (Bogers and Lhuillery 2011), the type of knowledge concerned (Bonesso, Comacchio and Pizzi 2011) and the complementarity between firms' external and internal R&D (Cassiman and Valentini 2009; Choi, Lee and Kim 2012).

The performance-oriented publications examine the relationship between external knowledge sourcing and firm performance, although there is considerable variation in the type of knowledge sourcing studied and the type of performance metrics used. Most studies examine the relationship between external knowledge sourcing and firms' innovative performance, without going into the specific dimensions of external sourcing behavior (Spithoven, Clarysse and Knockaert 2010; Bae and Chang 2012; Czarnitzki and Thorwarth 2012; Parida, Westerberg and Frishammar 2012). Others examine the link between specific dimensions of the firm's search behavior – most notably, search scope and depth (Chen, Chen and Vanhaverbeke 2011) and search diversity (Ebersberger and Herstad 2011) – and the firm's innovative performance. Yet, others study the performance effects of knowledge sourcing in conjuction with the performance effects of other approaches to open innovation (Faems, De Visser, Andries and Van Looy 2010; Neyens, Faems and Sels 2010; Love, Roper and Bryson 2011). Interestingly, very few studies – with the notable exception of Faems, De Visser, Andries and Van Looy (2010) and Kafouros and Forsans (2012) examine the effects of external knowledge sourcing

on financial performance.

Lastly, the cluster contains contributions that specifically address the implications of open innovation for small- and medium-sized enterprises (SMEs). These contributions provide accounts of SMEs' open innovation initiatives (Van de Vrande, De Jong, Vanhaverbeke and De Rochemont 2009) and examine the effects of these initiatives on SMEs' innovative performance (Parida, Westerber and Frishammar 2012; Pullen, De Weerd-Nederhof, Groen and Fisscher 2012) or financial performance (Lee, Park, Yoon and Park 2010). Other contributions focus on more specific issues, such as the role of absorptive capacity in SMEs (Spithoven, Clarysse and Knockaert 2010) and the utilization of innovation intermediaries by SMEs (Lee, Park and Song 2009).

Cluster d – External technology commercialization (33 items)

Whereas publications belonging to the previous cluster concentrate on the inbound dimension of open innovation, the publications in this cluster address the outbound dimension of open innovation – external technology commercialization. This cluster's publications tend to (i) describe best practices for managing external technology commercialization, (ii) investigate its determinants/drivers and (iii) explore its complementarity with external technology sourcing. Best practices for managing external technology commercialization relate to the integration of product and technology roadmaps (Lichtenthaler 2008b:2008d:2008e:2010) and the development of 'desorptive capacity' (Lichtenthaler and Lichtenthaler 2009; Lichtenthaler and Muethel 2012). The determinants of firms' strategic approaches to external technology commercialization relate to environmental characteristics concerning appropriability and technology markets, the level of integration of product marketing and licensing (Lichtenthaler 2007) and the personal characteristics of licensing managers (Bianchi, Chiaroni, Chiesa and Frattini 2011a).

Finally, the contributions that aim to integrate the outbound dimension of external technology commercialization with the inbound dimension of external technology sourcing discuss the implications of such an integrative perspective for the management of external technology commercialization in general (Lichtenthaler 2008b; 2010d) or describe the implications for the governance of knowledge flows (Lichtenthaler and Ernst 2006; Lichtenthaler 2008c:2009:2011b; Tukel, Kremic, Rom and Miller 2011) and the

management of intellectual property in particular (Chesbrough 2003; Alexy, Criscuolo and Salter 2009).

Cluster e – Implementation mechanisms and tools (33 items)

In the main, this cluster captures publications that describe the challenges associated with implementing open innovation in different organizational contexts and put forward a variety of mechanisms, best practices and tools that should be applied to overcome these challenges. A first subsection of publications describes the determinants of successful implementation mechanisms, best practices and tools in general (Traitler and Saguy 2009; Hopkins, Tidd, Nightingale and Miller 2011; Mortara and Minshall 2011; Remneland-Wikhamn and Wikhamn 2011; Hsieh and Tidd 2012). These publications denote the novelty of projects, the nature of existing resources, the timing of implementation and the existing organizational culture as the most important determinants. A second subsection of publications focuses specifically on the managerial challenges associated with implementing open innovation in SMEs (Bianchi, Campodall'Orto, Frattini and Vercesi 2010; Igartua, Garrigos and Hervas-Oliver 2010; Minshall, Mortara, Valli and Probert 2010; Albors-Garrigos, Etxebarria, Hervas-Oliver and Epelde 2011; Caetano and Amaral 2011). These publications highlight the idiosyncrasies of SMEs – most notably, focused business portfolios, specialized knowledge and limited resources – that impose unique challenges with respect to the implementation of open innovation initiatives (Bianchi, Campodall'Orto, Frattini and Vercesi 2010; Minshall, Mortara, Valli and Probert 2010). Whereas the first two subsections of publications present implementation tools and mechanisms for open innovation in general, the third and final subsection of publications presents implementation tools and mechanisms for specific facets of the open innovation process. These publications tend to focus specifically on the inbound perspective (Schiele 2010; Sjodin, Eriksson and Frishammar 2011; Jeon, Lee and Park 2011; Ford, Mortara and Probert 2012; Robertson, Casali and Jacobson 2012; Schiele 2012; Wang 2012) or the outbound perspective of open innovation (Bianchi *et. al.* 2010:2011; Lichtenthaler 2011c).

Cluster f – Open innovation initiatives in specific industries (19 items)

This cluster is distinct in that it is the least connected to the other clusters. This is explained by the fact that the publications belonging to this cluster study open innovation initiatives in specific industries, with most publications exploring open innovation in the bio-pharmaceutical context. These publications either explore the trend towards open innovation on the industry level (Ghauri and Rao 2009; Robertson and Mayr 2011; Rusu, Kuokkanen and Heier 2011; Barnes 2012; Carrascosa, Massaguer and Mestres 2012; Zdrazil *et. al.* 2012) or describe tools and best practices for managing open innovation on the level of biopharmaceutical firms/institutes (Lee *et. al.* 2011; Simiyu, Masum, Chakma and Singer 2010; Allarakhia and Walsh 2011; Calderon *et. al.* 2011; Seldon 2011; Nakagaki, Aber and Fetterhof 2012). In addition to contributions focusing on bio-pharmaceuticals, the cluster encompasses studies that focus on open innovation initiatives in the oil and gas industry (Gronlund, Sjodin and Frishammar 2010) and the space industry (Holmes 2009) respectively. The cluster is connected to the rest of the bibliographic network by a number of publications that are situated on its borderline with *'Cluster e – Implementation Mechanisms and Tools'*. These publications describe best practices for managing open innovation in general (Slowinski, Hummel, Gupta and Gilmont 2009; Slowinski and Sagal 2010) and the management of intellectual property within the framework of open innovation in particular (Slowinski and Zerby 2008; Mehlman *et. al.* 2010).

Cluster g – Idea generation and idea competitions (8 items)

This cluster captures publications that focus on how to manage ideas originating from users. The focus lies specifically on ideas developed within the framework of idea competitions that aim to generate solutions to problems from a crowd of external actors. The publications that are grouped in this cluster are very much related to the publications grouped in *'Cluster b – User-centric Innovation'*. However, the fact that publications on idea generation and idea competitions are grouped into a separate cluster indicates that this topic is sufficiently distinctive from the topics covered in Cluster b. Most of the publications describe how to manage idea competitions and the resulting ideas effectively (Wagner 2011; Alexy, Criscuolo and Salter 2012; Erat and Krishnan 2012; Lampel, Jha and Bhalla 2012). They investigate a broad spectrum of issues pertaining to the design of idea competitions, ranging from the specification of the problem to

be solved to the number and type of rewards that should be offered. The remaining publications address the contingencies under which idea competitions are beneficial to firms (Terwiesch and Xu 2008), examine the characteristics of the winners of these competitions (Jeppesen and Lakhani 2010), and investigate the influence of social ties on the market efficacy of online knowledge marketplaces (Dushnitsky and Klueter 2011).

The development and impact of clusters over time

In order to assess the relative importance of the themes identified, we calculated a number of citation-based statistics per cluster. These statistics are presented in Table 1.3. Firstly, it can be observed from Column 4 of the table that publications belonging

Table 1.3: Indicators of publication output and citation impact per thematic cluster.

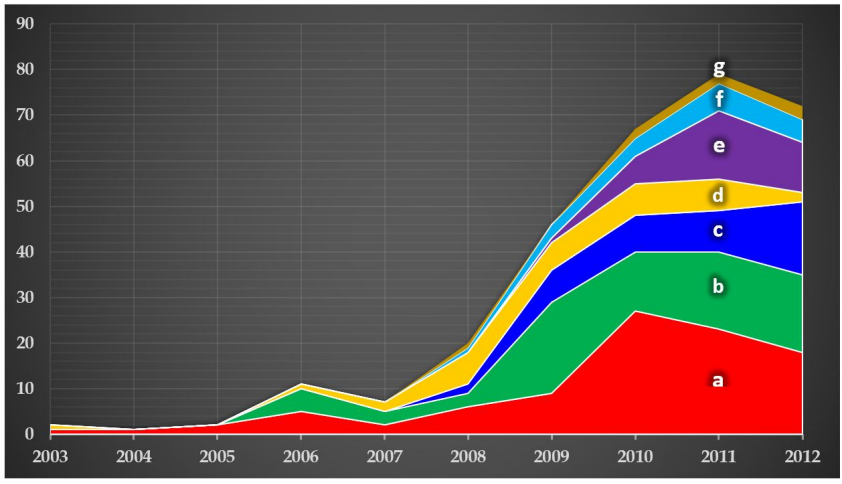
Cluster	Cluster Label	Number of Items	Average Age of Items	Total Number of Citations	Average Number of Citations Per Item	Average Number of Citations Per Item Per Year
a	The Core of Open Innovation	94	4.12	1490	15.85	2.57
b	User-centric Innovation	78	4.05	1032	13.23	2.54
c	External Knowledge Sourcing	42	3.28	340	8.10	1.93
d	External Technology Commercialization	33	4.79	562	17.03	3.09
e	Implementation Mechanisms and Tools	33	2.91	107	3.24	1.03
f	Open Innovation Initiatives in Specific Industries	19	3.42	92	4.84	1.47
g	Idea Generation and Idea Competitions	8	3.25	114	14.25	3.20
Total		307	3.86	3737	12.17	2.32

to Clusters a, b and d capture the 'oldest' publications on open innovation, on average. The publications that belong to these clusters have an average age of 4.12, 4.05 and 4.79 years respectively, which is higher than the sample average of 3.86 years. Moreover, Clusters a, b and d are those that have received the most citations of all clusters in total (see Column 5). This also holds if we control for the number of publications per cluster

(see Column 6), as well as the average age of publications (see Column 7). However, in the latter case, publications belonging to Cluster g score above the sample average. In fact, if we control for the age of publications, publications from Cluster g are cited the most, with an average of 3.20 citations received per year. The publications of Clusters a, b and d also receive more citations per year than the sample average of 2.32. However, publications belonging to Clusters c, f and e have a below average citation rate per year. Taken together, the statistics in Table 1.3 indicate that publications focusing on the themes of idea generation and idea competitions, external technology commercialization, the basics of open innovation and user-centric innovation have the highest citation impact, on average, of all the publications in our dataset.

We also plotted the distributions of the number of publications per year per cluster in order to assess the thematic development of research on open innovation over time. This plot is presented in Figure 1.5 below. It can be observed from the figure that the

Figure 1.5: The distribution of publications per thematic cluster over time.



Cluster *a*: The Core of Open Innovation, Cluster *b*: User-centric Innovation, Cluster *c*: External Knowledge Sourcing, Cluster *d*: External Technology Commercialization, Cluster *e*: Implementation Mechanisms and Tools, Cluster *f*: Open Innovation Initiatives in Specific Industries, Cluster *g*: Idea Generation and Competitors.

distribution of publications on open innovation follows a 'double boom' pattern, with peaks in terms of publication output arising in both 2006 and 2011. It is clear from Figure 1.5 that all seven themes that we have identified followed a similar pattern of growth in terms of publication output from 2008 onwards. Consequently, no notable fluctuations in the relative importance of themes can be observed in Figure 1.5, with the possible exception of Clusters c and d, which seem to have gained in importance in recent years. In other words, no significant shifts in the thematic orientation of open innovation research can be observed over the past decade.

1.4 Discussion

1.4.1 Implications

Our bibliometric review of the first decade of open innovation research complements and cross-validates existing reviews in two ways. First, whereas many of the existing reviews express the need for open innovation research to become more explicitly grounded in theory (Elmquist, Fredberg and Ollila 2009; Dahlander and Gann 2010; Van De Vrande, Vanhaverbeke and Gassmann 2010; Huizingh 2011; Lichtenthaler 2011; West and Bogers 2013), our review is the first to assess the foundations of open innovation research in an exhaustive way. Based on a co-citation analysis of the references cited by open innovation publications, our analysis reveals that open innovation research is primarily rooted in technology and innovation management, but also builds – selectively – on frameworks and concepts from the strategic management literature. Furthermore, our analysis highlights that it is primarily the enhanced focus on the user-centric perspective which distinguishes the open innovation literature from the broader literature on R&D collaboration.

Second, although existing reviews identify different strands of open innovation research, our review goes one step further by quantifying the relative importance of clusters as well as exploring the connections between them. On the basis of bibliographic coupling, we show that the first decade of open innovation research can be depicted by a relatively coherent network of publications. A subsequent comparative analysis of the publication output and citation impact of clusters suggests that publications focusing on the themes of idea generation and idea competitions, and external technology commercialization are cited most by contemporary publications. Lastly, an analysis of

the distribution of publication output per cluster over time reveals that the identified themes have been pursued consistently over the last decade.

1.4.2 Limitations and avenues for future research

While a systematic bibliometric review of open innovation research has distinct advantages, there are undeniably a number of limitations to our study. First, as our dataset includes only publications that contain the notion 'open innovation' in the title, abstract and keyword sections of the WOS database, we do not include publications of authors that deliberately refrain from using the label whilst covering related topics. Second, opting for a minimum threshold of ten citations for a cited reference to be included in our analysis of the foundations of open innovation research means that we may miss out on covering references that have been published more recently and, therefore, have had less time to be cited. Lastly, citation-based bibliometric methods might overstate the significance of relationships between publications to the extent that authors may refer to existing contributions for reasons other than mere recognition (*i.a.* Broadus 1983; Brooks, 1986; Bonzi and Snyder 1991; Bornmann and Daniel 2006).

Keeping these limitations in mind, our findings have clear implications with regard to the future direction of open innovation research. Firstly, as already noted above, existing reviews of open innovation research emphasize the need for future research to address the theoretical foundations underlying open innovation research by integrating it with prior research in existing fields. Van De Vrande, Vanhaverbeke and Gassmann (2010) propose that open innovation research should rely more on transaction cost and value theory (Williamson 1975; Zajac and Olsen 1993), the resource-based view of the firm (Wernerfelt 1984; Barney 1991; Grant and Baden-Fuller 2004), the dynamic capabilities approach (Teece, Pisano and Shuen 1997; Eisenhardt and Martin 2000; Teece 2007), the relational view of the firm (Dyer and Singh 1998), organizational learning theory (Levinthal and March 1993) and real options theory (Folta 1998). The results of our co-citation analysis clearly indicate that existing open innovation research already builds to a large extent on these (strategic) management theories. At the same time, our analysis reveals a lack of reliance on perspectives from the disciplines of economics and sociology, most notably transaction cost economics and network analysis; an observation which also signals potential for enrichment and further development.

Second, existing reviews argue that there is a need for a more encompassing perspec-

tive that integrates the inbound and outbound perspectives of open innovation into a single framework (Gassmann, Enkel and Chesbrough 2010; Huizingh 2011; Bogers and West 2013). Not only do scholars claim that open innovation research often addresses only one of these perspectives, they also claim that there is a bias in favor of the inbound perspective. While our findings confirm that the inbound and outbound perspectives are often addressed separately, the imbalance between research on the inbound and outbound perspectives is not confirmed.

Third, open innovation is claimed to rely mainly on case studies and qualitative research methods. Thus, existing reviews tend to call for large-scale quantitative studies as a complement to existing case study research on open innovation (Huizingh 2011; Lichtenthaler 2011). Our findings confirm that qualitative research, and case studies in particular, have been explicitly present in open innovation research during the past decade. However, our review also reveals that quantitative studies are present in our sample, but they tend to be located mainly in the *'External knowledge sourcing'* and '*External technology commercialization*' clusters. This suggests that research on some thematic areas might be more conducive to the application of large-scale quantitative approaches than others.

Finally, in terms of topics pursued, our study reveals that dominant themes are pursued consistently during the last decade. While such persistence is undoubtedly useful to arrive at in-depth and robust insights, the observed patterns also signal the absence of new, emerging, themes. As such, our findings suggest that the open innovation research stream could benefit from applying its own ideas: sourcing concepts and models from a broader range of theoretical perspectives as well as pursuing a broader range of topics might introduce dynamics resulting in more impact and proliferation. We hope our study inspires scholars to engage in such endeavours.

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Chapter 2

Patent Assignments as Indicator of Technology Trade

The Influence of Not Recording Patent Ownership Changes[1]

2.1 Introduction

In a seminal contribution, Arora, Fosfuri and Gambardella (2001) describe a shift towards a knowledge economy that distinguishes itself from earlier eras in the increasing role of knowledge as an economic commodity, bought and sold in markets for intermediate technological inputs. This contribution has laid the foundation for the emergence of an extensive scholarship that examines the nature and functioning of technology markets and the implications thereof for corporate strategy and public policy. Although this scholarship has relied on a wide array of measures of technology flows, empirical studies have traditionally been hampered by the unavailability of large-scale data sets on technology transactions (Serrano, 2010). This void has inspired contemporary empirical literature to employ data on patent assignments – transfers of patent ownership rights – in an attempt to better capture the dynamics of activity on technology markets.

[1] This chapter is based on a joint working paper with Stuart Graham (Associate Professor at the Scheller College of Business, Georgia Tech).

Scholarship has mainly relied on assignments recorded with the United States Patent and Trademark Office (hereafter USPTO) and has proceeded under the fundamental assumption that in contrast to other indicators of technology transfer, such as licensing agreements and strategic partnership agreements, parties have strong incentives to record assignments with the USPTO. However, although the patent statute and federal regulations provide some incentives for recording there is no mandatory legal requirement for parties to disclose assignments to the USPTO (Marco *et. al.*, 2015). Furthermore, recording an assignment with the USPTO is merely a ministerial act and not a determination of the validity of the assignment document or the effect of the assignment document on the ownership of the patent property by the USPTO.[2] Despite the obvious implications for the reliability and validity of the empirical results obtained, scholarship has thus far not delved into questions concerning the coverage, consistency and accuracy of assignments recorded with the USPTO or has implicitly assumed that any bias in recording patterns are distributed randomly. To address this issue, we examine recording patterns and draw implications in light of the empirical results obtained by existing studies that utilize recorded patent assignments.

Our approach is twofold in that it focuses on recording events that occur during two distinct stages of the patent life-cycle: (i) the time period prior to and (ii) after the issue of a patent.[3] We explicitly distinguish between these stages based on the intuition that assignments recorded prior to issue may reflect different economic phenomena than assignments recorded post-issue which may manifest itself in differences in recording patterns between both stages. First, we rely on the most recent version of the USPTO Patent Assignment Dataset (hereafter UPAD) and cross-check assignments recorded pre-issue by utilizing data on assignees as listed on US patent documents at their date of issue. We find that 17% of all patents that have a listed assignee on the date of issue, have no assignments recorded prior to this date in UPAD at all. This demonstrates that the assumptions made in existing literature concerning assignees' strong incentives to record (*i.a.* Serrano, 2006) do not translate into universal recording practices. Second, we assess the probability of recording assignments in the post-issue stage by utilizing

[2] *See* 37 CFR Part 3 and 37 CFR 3.54.

[3] The issuance of a patent is analogous to the grant of a patent. In general, a patent office grants a patent as a response to a successful patent application by issuing the patent to the applicant(s). In the remainder of this chapter the term pre-issue refers to the time period from the initial application date until the grant date of a patent whereas the term post-issue refers to the time period thereafter.

a sample of US patents that were subject to litigation suits between 1995 and 2004. Specifically, we identify the patents for which the assignee at issue is not listed as a plaintiff or defendant in law suits involving those patents given that these instances are indicative of a change of ownership in the post-issue stage. We subsequently verify whether a chain of ownership between the assignee at issue and either the plaintiff or defendant listed in a litigation suit can be established based on records in UPAD. Our findings reveal that in 54% of the cases in which the listed plaintiff or defendant is not the original assignee, a chain of ownership from the original assignee to the plaintiff or defendant cannot be established on the basis of UPAD-records.

We test for distributional differences between recorded and non-recorded assignments in both the pre-issue and post-issue stages of the patent life-cycle along a set of variables on the patent- and assignee-levels that are frequently employed in empirical literature. Our analyses reveal significant differences in recording patterns across technology classes, patent value indicators and types of assignees in both stages, thereby suggesting the existence of biases in such patterns that are not randomly distributed. Taken together, our results suggest a selection bias into recording patent assignments both prior to and after the issue of a patent.

The remainder of this chapter is structured as follows, in the second section we describe applications of patent assignment data and limitations thereof in existing literature. In the third section we present our analysis of recording patterns during the pre-issue stage of the patent life-cycle, which is followed by our analysis of such patterns during the post-issue stage in section four. We conclude by discussing the implications of our findings in section five.

2.2 Background

2.2.1 Applications of patent assignment data

The utilization of information on patent assignments in recent scholarship has been motivated by two primary properties of patent assignments. First, patent assignments represent a different kind of technology transaction than patent licensing, the most relied upon indicator of technology transfer, in the sense that they are more indicative of a traditional buyer-seller type relationship. A patent assignment is defined as a transfer by a party of all or part of its right, title and interest in a patent application

that includes the entirety of the bundle of rights that is associated with the ownership interest.[4] Patent licensing in contrast concerns the transfer of a bundle of rights which is by definition less than the entire ownership interest in a patent. Whereas a patent assignment comprises the transfer of the entire bundle of rights from assignor to assignee, a license is essentially a contractual agreement wherein the licensor agrees not to sue the licensee for patent infringement provided that the licensee fulfills its obligations and operates within the bounds delineated by the license agreement.[5] Second, whilst accounts of licensing agreements are often kept confidential between the involved parties, patent assignments are (at least to the extent that they are recorded) made publicly available by patent authorities such as the USPTO. As a result, patent assignments offer dynamic accounts of recorded ownership changes, which are observable over the entire patent life-cycle and are available on a large scale. It is therefore not surprising that an increasing number of empirical studies focusing on markets for technology, open innovation and the monetization of intellectual property rely on patent assignment data.

The earliest of these studies primarily employ patent assignment data in order to quantify inventive activity. To the best of our knowledge, Lamoreaux and Sokoloff (1997: 1999: 2001) are the first to use assignment records in an effort to provide a historical overview of inventive activity in the United States from the mid-19th until the beginning of the 20th century. Based on a sample of historical patent assignment documents, they provide evidence for the existence of a dynamic market for technology in the United States during this time period. Building upon the same data set Khan and Sokoloff (2004) demonstrate that the majority of patented technologies that have been invented by some of the greatest inventors of the 19th century, e.g. Thomas Edison, have changed ownership during their lifetime. In similar vein, Burhop (2010) analyzes records in the patent transfer register of Germany's Imperial Patent Office and finds that in stark contrast to the US, in Imperial Germany only about 8% of in-force patents have changed ownership.

Contemporary studies have mostly relied on assignments recorded with the USPTO in order to quantify the size of the current market for technology. Based on these data,

[4] *See* MANUAL OF PATENT EXAMINING PROCEDURE (MPEP) 301 (8th Ed. Rev. 1, 2003) (incorporating definitions from 37 C.F.R. §3.1.

[5] *See* MANUAL OF PATENT EXAMINING PROCEDURE (MPEP) 301 (8th Ed. Rev. 1, 2003) (incorporating definitions from 37 C.F.R. §3.1.

Chesbrough (2006) describes the emergence of a secondary market for intellectual property from the beginning of the 1980s onwards and interprets this trend as a direct consequence of firms shifting towards more open models of innovation. Serrano (2006: 2010) provides a mainly descriptive account of empirical regularities concerning the magnitude of patent trading across different technological fields, types of patentees and patent characteristics. His findings suggest that about 13.5% of all US utility patents have changed ownership at least once between 1983 and 2001, with the probability of a patent being traded being contingent upon its value and broadness, its transaction history, the technological field to which it belongs and the type of assignee to which it has been assigned. Mani and Nandkumar (2016) contribute to these insights by highlighting the differential impact of markets for technology on the value of technological capabilities across industries whilst the results of De Marco *et. al.* (2017) reveal that patents having a first non-US original applicant are less likely to be traded.

More recently, studies have also started to explore assignment records from sources other than the USPTO. For example, Ciaramella *et. al.* (2017) explore transactions of patents filed at the European Patent Office (EPO) and find that more than 30% of all EPO-patents have changed ownership between 1998 and 2012. A more detailed exploration of all patent transactions in the field of medical technologies highlights that more than two-thirds of these transactions occur between entities that belong to the same corporate entity. Gäßler (2016) engages in an extensive data-cleaning effort in an attempt to filter out such 'intra-group' changes of ownership of EPO-patents and finds that the transfer rate of granted patents per year remains constant at 7-8% between 1990 and 2013, when only 'inter-group' transactions are taken into account. Notably, this share is considerable less than the 30% reported by Ciaramella *et. al.* (2017), the 15% reported by Marco *et. al.* (2015) and the 13.5% reported by Serrano (2010).

Patent assignment data have also been utilized to study the determinants of and motivations underlying technology transactions. Serrano (2018) uses USPTO assignment data to test a model that estimates the gains from patent trading, finding evidence for his theory that certain conditions induce patent transfers that are surplus-enhancing for both the selling and the buying entity. Galasso, Schankerman and Serrano (2013) link these data with data on patent litigation and find that comparative advantages in patent enforcement may constitute a key component of the gains resulting from patent trades. This finding is supported by Chien (2016b) who shows that US patents that are assigned

are more likely to be involved in patent litigation cases than patents that have never changed ownership and Haber and Werfel (2015) who argue that the primary reason why individual patent holders assign their patents to patent assertion entities is that these entities offer them an insurance against the cost of potential litigation. Figueroa and Serrano (2015) report that patentees are more likely to assign patents that have a low fit with their technology portfolio, whilst being more likely to acquire patents that have a high fit with their technology portfolio. Gonzales-Uribe (2014) shows that the likelihood of a patent being traded increases if the patentee obtains venture capital funding. Caviggioli and Ughetto (2013) study the main drivers of corporate firms' decisions to engage in patent licensing and patent sales and find that these decisions are mostly driven by motivations related to strategic behavior. Jeong *et. al.* (2013) utilize data on transactions of patented technology in Korea to examine the licensing versus selling decision. Their findings reveal that the likelihood of selling patented technology increases when uncertainty is high or transaction costs are low. Fischer and Henkel (2012) study motivations of non- practicing entities to aggregate patent portfolios and report that these entities are more inclined to acquire patents that are broad, of high technological quality and that belong to highly dense technological fields. Scott Morton and Shapiro (2014) argue that such practices can discourage innovation and harm consumers because the smallest threat of outsized patent assertion imposes costs on downstream firms.

Lastly, patent assignments have also been employed by studies that are not primarily concerned with the functioning of markets for technology. Arora, Belenzon and Rios (2014) develop a novel measure of organizational structure based on within-firm patent assignment patterns in order to explore the interplay between organization structure, R&D and external knowledge. Hochberg, Serrano and Ziedonis (2015: 2018) examine the influence of patent trading on the financial health of startup firms. Their results suggest that increased levels of patent trading increase the annual rate of lending to startups. Serrano and Ziedonis (2018) study the deployment of patents of failed startups and find that most of these patents are acquired by operating firms that are active in the same sector as the failed startup. Lemley *et. al.* (2016) compare the outcomes of litigation cases involving patents that were acquired and litigation cases involving internally developed patents. They find that established firms generally fare better in litigation with their own patents whereas startup-firms do better with patents that they

purchased from other entities. Ciaramella (2017) relies on a data set of international patent assignments and shows that countries with favorable tax regimes towards patent revenues – so-called 'patent-box' countries – attract significantly more patent inflows than with less favorable regimes.

Despite all the aforementioned applications of patent assignment data, Marco *et. al.* (2015) note that the full potential of assignment records as a source of data has not yet been realized. They especially highlight the potential of patent assignments as complements to widely- used indicators of patent value and applications thereof in econometric models concerning intellectual property, R&D and productivity.

2.2.2 Limitations of patent assignment data

Notwithstanding the value of empirical contributions that have been made on the basis of patent assignment data, it is important to note that scholarship, has thus far not delved into exploring an important limitation of publicly available databases of patent assignments that might affect the reliability and validity of empirical findings: these databases do not contain the full population of patent assignments and the characteristics of the assignments that are publicly available may very well differ from the characteristics of those that are not. In essence, there is no mandatory legal requirement for parties to disclose assignments to the USPTO (Marco *et. al.*, 2015). Furthermore, recording an assignment with the USPTO is merely a ministerial act and not a determination by the USPTO of the validity of the assignment document or the effect of the assignment document on the ownership of the patent property. It is therefore somewhat surprising, that the scholarship that utilizes these data either neglects this limitation altogether or attempts to downplay its potential significance. For example, Chesbrough (2006) states that he *"... believes that the vast majority of patent asset transfers are reported..." (Chesbrough, 2006, p. 71)*, whilst Serrano claims that assignments need to be recorded with the USPTO by stating that *"...in contrast to strategic alliance and license transactions, the transfer of the ownership of patents is most often recorded because of the legal requirement that all assignments have to be filed with the USPTO in order to be legally binding..." (Serrano, 2010, p. 690)*. Others suggest that assignment are likely to be recorded, because assignees allegedly have strong incentives to record assignments with the USPTO. Fischer and Henkel (2012), for example, note that registering a patent assignment legitimizes the patent owner and prevents "good faith" defenses by third

parties. In similar vein, Serrano (2006: 2010: 2018) refers to a note by patent attorneys Dykeman and Kopko (2004) wherein they state that *"…although the recording of a patent assignment is not mandatory, it is best practice to record all assignments of patents and patent applications with the USPTO to preserve the priority of the assignment…"*.

There is no denying that federal laws and regulations do in fact provide some incentives for assignees to record an assignment with the USPTO. Most notably, 35 U.S.C. 261 specifies that *"An assignment, grant, or conveyance shall be void as against any subsequent purchaser or mortgagee for a valuable consideration, without notice, unless it is recorded with the Patent and Trademark Office within three months from its date or prior to the date of such subsequent purchase or mortgage."* This effectively implies that in case an assignee fails to record an assignment within the specified time frame, the original assignor may assign the patent (application) to a subsequent party and this subsequent assignment, if recorded, takes priority over the earlier assignment. In addition, 37 CFR 3.81(a) states that *"An application may issue in the name of the assignee consistent with the application's assignment where a request for such issuance is submitted with payment of the issue fee, provided the assignment has been previously recorded in the Office. If the assignment has not been previously recorded, the request must state that the document has been filed for recording set forth in 37 CFR 3.11"*. In other words, an assignee that requests a patent to issue in its name, must record the assignment with the USPTO at the time of making the request.

Despite the strong statutory language, recent studies provide strong indications that federal regulations may not be effective enough in motivating assignees to record their assignments. Marco *et. al.* (2015) report that despite considerable effort they could not find any case law wherein a party was denied notice protection for failing to record an assignment. Their detailed description of UPAD furthermore highlights the existence of broken chains of ownership and increasingly lengthy time lags between the date of execution of assignments and their recording date that often exceed the prescribed time period of three months. These observations are supported by Ewing and Feldman (2012) who, based on an in-depth case study of a large patent assertion entity (Intellectual Ventures), find that this entity has at times deliberately neglected to record its ownership interest in patents for sustained periods of time. They contend that *"...current laws provide limited opportunities for identifying and tracking activity in [markets for technology] and many opportunities for hiding…"* and conclude that a lack of transparency

concerning patent ownership has become a competitive tool for entities that are commonly associated with abusing the patent system for financial gain. Their findings not only suggest that not all assignments are recorded but also that non-recording may be motivated by strategic considerations. Hence, this implies that assignees may have incentives to not record assignments which offset the incentives for recording them provided by federal regulations. Although these findings give rise to concerns with regard to the reliability and accuracy of recorded assignments, relevant questions concerning the potential influence of non-recording have yet to be explored. It is the pursuit of addressing these questions that motivates the remainder of this chapter.

2.3 Recording Patterns During the Pre-issue Stage

2.3.1 Data and empirical analysis

The starting point for our empirical analysis of recording patterns during the pre-issue stage of the patent life-cycle is provided by federal regulations. As aforementioned, 37 CFR 3.1. states that an assignee of an allowed patent application that wishes a patent to issue in its name, must record the assignment in the assignment records of the USPTO prior to or at the time of making the request. In addition it specifies that for all applications filed prior to the enactment of the America Invents Act (AIA) on September 16th, 2012, the ownership of an application for an original patent initially vests in the named inventors of the invention that is covered by the patent. Therefore, in order to take action in a patent matter prior to this date, an assignee had to establish ownership of the patent or patent application by submitting documentary evidence of a chain of title from the inventor to the assignee. This implies that assignees listed on patent documents that have been issued prior to September 16th, 2012, who are not the named inventor, were in principle required to record an assignment with the USPTO in order to establish their ownership prior to or at the date of issue. These patents can thus be used to verify the extent to which assignments are recorded during the pre-issue stage in UPAD. [6]

[6] It is important to note that assignees may also make an assignment part of the file wrapper of the patent application or proceeding because doing so is required for taking action, *e.g.* prosecuting a patent application, requesting a reexamination or engaging in an interference proceeding. According to Marco *et. al.* (2015) *'these indication of assignment operate independently, meaning that an assignment recorded in the Office's assignment records does not, by itself, permit the assignee to take action; whilst recording in the file*

We rely on information derived from the front pages of US-patents at their date of issue contained by the USPTO's Basic Bibliographic File (hereafter BASIC_BIB) in order to identify patents that have an assignee listed at the date of issue who is not the named inventor. We restrict our sample to the full population of utility and reissue patents granted between 1990 and 2010 in order to avoid potential selection effects due to left and right censoring of the data. We drop all patents that are unassigned and that are assigned to individuals to make sure that we are only left with patents that are assigned to entities other than the individual inventor(s). This data cleaning effort results in a data set of 2,280,724 patents. We draw upon records from UPAD in order to verify whether the patents in our data set have been the object of assignments recorded prior to or at the date of their issue. Specifically, we check whether a patent number featured in BASIC_BIB is featured in the transaction records of UPAD as an assignment of assignor's interest that was recorded prior to or at the issue date of the patent. Our definition of non-recording is narrow in the sense that we do not assess whether a recorded assignment correctly establishes a chain of title between named inventor(s) and the listed assignee(s), but merely verify whether an assignment is recorded in UPAD at all. Therefore our results should be interpreted as lower bound estimates of the degree to which assignments correctly establish the chain of ownership of a listed assignee at the issue date of a patent.

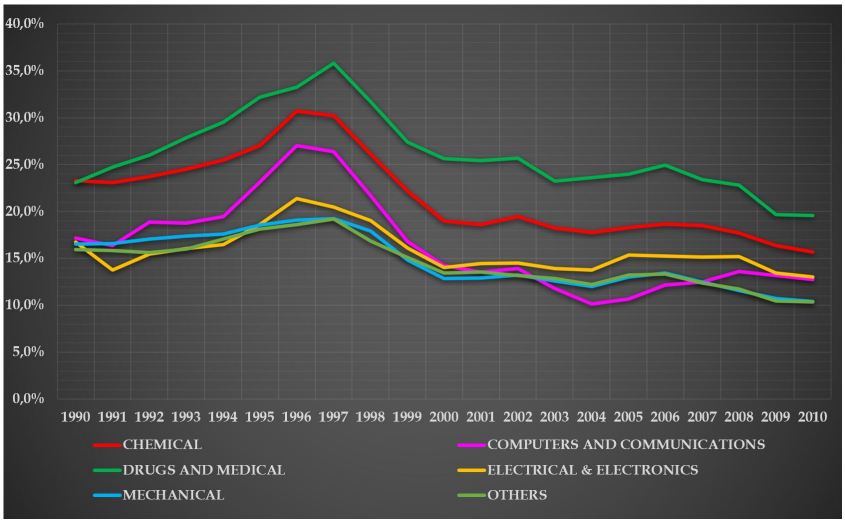
Our descriptive results reveal that the magnitude of non-recording is considerable: for 16.7% of all patents granted between 1990 and 2010 that have an assignee listed at the date of issue, no assignment has been recorded prior to this date in UPAD. To gain more detailed insights into recording patterns, we plot the distribution of non-recording as a percentage of issued patents over time across technology classes as defined by Hall, Jaffe and Trajtenberg (2001) in Figure 2.1. The figure reveals variation in the recording of assignments over time, showing an upward trend up until issue year 1997 – with more than 30% of assignments not being recorded for patents issued in that year – and a downward trend ever since up until 2010 – the year for which only 12% of pre-issue assignments have not been recorded in UPAD. The figure also highlights variation in recording patterns between technology classes that is consistent over time, with assignments of patents that are classified into the *DRUGS AND MEDICAL* and

wrapper to take action does not automatically result in a recording in the assignment records...thus since [UPAD] mirrors the Office's assignment records, it will not include any assignments made part of the file wrapper unless they were also recorded separately in the assignment records (p. 7).

Table 2.1: Non-recordation by technology class (pre-issue stage).

Technology class (Two-digit NBER sub-categories)	Patent Count	Not recorded in UPAD (count)	Not recorded in UPAD (share)
Above sample average			
31. Drugs	104,911	31,409	29.94%
33. Biotechnology	60,211	17,012	28.25%
14. Organic compounds	60,349	15,735	26.07%
46. Semiconductor devices	142,219	35,541	24.99%
15. Resins	72,286	18,049	24.97%
12. Coating	32,964	7,228	21.93%
52. Metal working	54,096	11,836	21.88%
24. Information storage	89,550	18,758	20.95%
11. Agriculture, food, textiles	12,728	2,654	20.85%
32. Surgery & medical instruments	77,518	15,192	19.60%
39. Miscellaneous-drug&med	15,333	2,981	19.44%
19. Miscellaneous-chemical	200,498	38,792	19.35%
51. Materials processing & handling	82,313	14,633	17.78%
61. Agriculture, husbandry, food	25,527	4,302	16.85%
Below sample average			
23. Computer peripherals	56,009	8,812	15.73%
68. Receptables	27,092	4,219	15.57%
69. Miscellaneous-others	141,218	21,479	15.21%
54. Optics	69,604	10,590	15.21%
49. Miscellaneous-elec.	58,982	8,748	14.83%
22. Computer hardware & software	230,224	32,939	14.31%
62. Amusement devices	14,820	1,993	13.45%
59. Miscellaneous-mechanical	81,002	10,845	13.39%
64. Earth working & wells	22,452	2,938	13.09%
43. Measuring & testing	78,627	10,041	12.77%
67. Pipes & joint	13,924	1,758	12.63%
13. Gas	9,398	1,186	12.62%
21. Communications	216,001	26,189	12.12%
44. Nuclear & x-rays	40,153	4,842	12.06%
63. Apparel & textile	19,703	2,362	11.99%
65. Furniture. House fixtures	25,633	3,061	11.94%
66. Heating	15,642	1,862	11.90%
42. Electrical lighting	46,393	5,417	11.68%
45. Power systems	103,803	11,638	11.21%
41. Electrical devices	91,563	9,887	10.80%
55. Transportation	55,906	5,656	10.12%
53. Motors, engines & parts	75,485	6,787	8.99%

Figure 2.1: The distribution of non-recording across technology classes over time.



CHEMICAL classes appearing to have a higher likelihood of not being recorded than patents in other technology classes. Interestingly, these two classes are the ones that Serrano (2010) identifies as having higher than average rates of patent trading, which suggests that the differences that he observes in patent trading between these classes and other classes may actually be underestimated. Table 2.1 breaks down technology classes into sub-classes and highlights that patents belonging to the sub-classes *DRUGS*, *BIOTECHNOLOGY*, *ORGANIC COMPOUNDS* and *SEMICONDUCTOR DEVICES* are most conducive towards non-recording. This observation is noteworthy given that all of these classes are representative of industries in which patents have been found to be most effective for appropriating rents from inventive activity (*i.a.* Cohen, Nelson and Walsh, 2000; Graham *et. al.*, 2008). Not surprisingly, these industries are also the ones that have been the focus of the bulk of empirical patent research. Hence, taken together, the numbers in Figure 2.1 and Table 2.1 suggest that a large share of patent-based research is focused on industries wherein the rate of recording assignments prior to issue is the lowest.

To further explore differences in recording patterns, we test for distributional differ-

ences between patents for which an assignment has been recorded prior to issue and those for which there is no such recording along a variety of dimensions that have been of interest to empirical studies on technology transactions, in particular those that rely upon assignment records. To do this, we estimate the following basic logistic regression model:

$$Prob\left(Y_{ij}=1 \mid X_{ij}\right)=F\left(\beta X_{ij}\right)+\varepsilon_i,$$

where Y_{ij} is a binary variable that is equal to 1 if an assignment has not been recorded in UPAD for the patent prior to its issue date and 0 if such a record does exist in UPAD, and X_{ij} is a vector of variables that identify a range of patent and assignee characteristics. We take into consideration that patents issued to the same assignee may not serve as independent observations and account for this by calculating robust standard errors that are clustered at the assignee-level. An overview of all variables that we include is presented in Table 2.2.

On the patent-level, we include dummy variables for technology classes and issue years to assess whether the differences that can be observed in Figure 2.1 are statistically significant. We also include a number of variables that might be related to recording patterns. We include a measure of the time period between the filing date of a patent application and its issue date represented by the variable *GRANT_LAG*. Given that the length of the grant lag has been shown to correspond with the number of communications with the USPTO (Popp, Juhl and Johnson, 2003), we expect that a lengthy grant lag may provide and assignee with more opportunities to record an assignment than a short one. We also include variables indicating whether the patent is assigned to multiple assignees – *CO_ASSIGNED* – and whether it is invented by a sole inventor or a team of inventors – CO_*INVENTED*. We expect that a larger number of parties that have an interest in the patent may complicate the recording of ownership changes.

Second, given that Serrano (2010: 2018) shows that the likelihood of patent trading increases in the value of patents we include multiple indicators that have been shown to capture different aspects of the value of patented inventions: (i) the number of forward citations a patent receives, (ii) the number of claims described in the patent document, (iii) nature of the patent family to which the patent belongs and (iv) the renewal of the patent. Forward citations are widely established as an indicator of the market value of patents (*i.a.* Grilliches, Hall and Pakes, 1991; Jaffe and Trajtenberg, 2002; Hall, Jaffe and Trajtenberg, 2005) whereas renewals are considered to be indicators of the private

Table 2.2: Variable descriptions (pre-issue stage).

Variable	Description
TECHNOLOGY CLASS	Distinguishes between six types of technology categories; (1) mechanical, (2) computers and communications, (3) drugs and medical, (4) electrical and electronic, (5) mechanical and (6) other.
GRANT_LAG(MONTHS)	The time period in months from the filing date of the application for patent i to its issue date.
TIME_LAG(MONTHS)	The time period in months from the issuance of patent i to the filing date of the first litigation suit which it is involve in.
CO_INVENTED	A dummy variable that takes the value of 1 if multiple named inventors are listed on the first page of patent i at issue.
CO_ASSIGNED	A dummy variable that takes the value of 1 if multiple assignees are listed on the first page of patent i at issue.
GENERALITY(IPC4)	The generality of patent i is calculated by $Generality_i = 1 - \sum_j^{n_i} s_{ij}^2$ where s_{ij} denotes the share of citations received by patent i that belong to IPC4-class j out of n_j IPC4-classes.
ORIGINALITY(IPC4)	The originality of patent i is calculated by $Originality_i = 1 - \sum_j^{n_i} s_{ij}^2$ where s_{ij} denotes the share of citations made by patent i that belong to IPC4-class j out of n_j IPC4-classes.
NR_CLAIMS	A count of the number of claims covered by patent i at issue.
USPTO_INCNT_3Y	A count of the number of citations received by patent i from other USPTO patent (application)s within a three-year time window.
RENEWAL_4Y	A dummy that takes the value of 1 if the maintenance fees for patent i has been paid at the first instance four years post issue, 0 otherwise.
DOCDB_ISTRIADIC	A dummy that takes the value of patent i has corresponding has equivalent DOCDB-patent-family-members that have been filed at the European Patent Office (EPO) and the Japan Patent Office (JPO), 0 otherwise
SMALL_ENTITY_ STATUS	A dummy variable that takes the value of 1 if assignee k has indicated small entity status with the USPTO by issue year t.
ASSIGNEE_TYPE	Distinguishes between four types of patentees; (1) companies, (2) universities, (3) government and non-profit entities and (4) other entities.
CORE_TECHNOLOGY	A dummy that takes the value of 1 if patent i belongs to the primary two-digit NBER-technology-category of assignee k, 0 otherwise.

value of patents (*i.a.* Pakes, 1986; Pakes and Simpson, 1989; Schankerman, 1991; Bessen, 2008). We include a measure of the number of forward citations received by a patent within a fixed time window of three years from other USPTO patents, represented by the variable *USPTO_INCNT_3Y*. We opt for a fixed time window of three years to account for truncation effects that might occur due to the fact that our sample comprises patents issued up to the year 2010. We also include a dummy variable, *RENEWAL_4Y*, which indicates whether the maintenance fees for a patent have been paid at the first instance that this is required. Although we can observe maintenance events at different instances for certain issue-year cohorts, the payment of maintenance fees after four years is the only renewal event that we can observe for our entire sample of patents. Patent families have been denoted as capturing yet another dimension of patent value (*i.a.* Harhoff *et. al.*, 1999; Harhoff *et. al.*, 2003; Putnam, 1996). Rather than incorporating a measure of patent family size, we include a dummy variable *DOCDB_ISTRIADIC* which indicates whether a US-patent has corresponding patents which are filed at the European Patent Office (EPO) and the Japanese Patent Office (JPO). Finally, following Tong and Frame (1992) and Lanjouw and Schankerman (2000) we also include a variable indicating the number of claims listed in a patent document, *NR_CLAIMS*, as an indicator of the 'legal value' of a patent.

Third, we take into account indicators that capture the breadth of an invention. Specifically, we include measures of generality and originality, represented by the variables *GENERALITY* and *ORIGINALITY* respectively, as proposed by Henderson, Jaffe and Trajtenberg (1997). Whereas the generality of a patent is an indicator of the spread of its impact across technology classes, originality is an indicator of the spread of prior art upon which the patent builds. Serrano's (2010) results indicate that patents with a high generality score are on average more likely to be involved in technology transactions. We calculate both indicators based on the four-digit level of the International Patent Classification System (IPC).

On the assignee-level we include measures that distinguish between assignees based on their size, location and activities. First, we include a dummy variable which indicates whether the address of the listed assignee is located within the borders of the United States, given that a previous study by De Marco *et. al.*(2017) has found that US-patents having a first original applicant from the US are more likely to change ownership than patents having a foreign first original applicant. Second, we incorporate

the entity status asserted to an assignee in a given issue year, represented by the variable *ENTITY_STATUS*, which is an indicator of the number of employees of an assignee. As specified by 35 U.S.C. 41(h) entities with less than 500 employees are entitled to a 50% reduction of patent fees. Small entity status is established based on a written assertion of the assignee to the USPTO. Serrano (2010) and Figueroa and Serrano (2015) present empirical evidence to support the notion that patents issued to small entities are more likely to be traded than patents issued to large entities. Third, we expect that recording patterns may differ across different types of assignees, based on the results of prior research Serrano (2010). On this account we utilize sector-allocation-algorithms described by Callaert *et. al.* (2011) to distinguish between four types of assignees based on the nature of their activities; (i) private firms, (ii) universities, (iii) governmental and non-profit entities and (iv) other entities.

Finally, we include the dummy variable *CORE_TECHNOLOGY* as a measure of the technological fit between a patent and the portfolio of its assignee. Following Figueroa and Serrano (2015), a patent is labeled as a core technology if it is classified into the same two-digit technology class to which the majority of the patents of the assignees' patent portfolio are classified. Figueroa and Serrano (2015) highlight that patents having a high technological fit with the portfolio of the assignee are more likely to change ownership. Summary statistics for our variables of interest are presented in Table 2.3 and correlations between them are presented in Table 2.4. Despite the relatively small correlation coefficients in Table 2.4, we include measures of patent value in separate specifications because they are essentially indicators of the same construct.

2.3.2 Results

We present the results of our logistic regressions in Table 2.5, whereby the dependent variable equals 1 if no assignment has been recorded with the USPTO prior to or at the date of issue of a patent and 0 otherwise. We present four different specifications, introducing the four different patent value indicators in each of the specifications respectively. The first observation that can be made from Table 2.5 is that the variation in the recording patterns across technology classes that we described above are confirmed to be statistically significant by the results of the logistic regressions. The coefficients of the technology class variables are consistently significant at the 1% level in all models and the effect sizes are substantial. The signs of the coefficients indicate that patents

Table 2.3: Summary statistics for variables of interest (pre-issue stage).

Variable	No. of Obs.	Mean	Std. Dev.	Min	Max
IN_UPAD_ASS_PREG	2,280,724	0.164	0.371	0	1
GRANT_LAG(MONTHS)	2,280,724	30.629	15.561	8.444	84.797
CO_INVENTED	2,280,724	0.668	0.471	0	1
CO_ASSIGNED	2,280,724	0.028	0.164	0	1
USPTO_INCNT_3Y	2,280,724	3.256	5.160	0	279
RENEWAL_4Y	2,280,724	0.863	0.344	0	1
DOCDB_ISTRIADIC	2,280,724	0.263	0.440	0	1
GENERALITY(IPC4)	2,280,724	0.596	0.267	0	0.98
ORIGINALITY(IPC4)	2,280,724	0.312	0.309	0	0.95
NR_CLAIMS	2,280,724	17.007	13.718	1	887
US_ASSIGNEE	2,280,724	0.503	0.500	0	1
SMALL_ENTITY_STATUS	2,280,724	0.129	0.335	0	1
CORE_TECHNOLOGY	2,280,724	0.440	0.496	0	1

classified into technology classes other than *DRUGS AND MEDICAL* are more likely to have recorded assignments in UPAD prior to issue than patents belonging to the base category *CHEMICAL*. This suggests that studies examining trends in patent trading across technology classes might report biased results in the sense that they may underestimate the volume of trade more substantially in the *DRUGS AND MEDICAL* and *CHEMICAL* sectors than in others.

The negative sign of the coefficient of the variable *GRANT_LAG* confirms our expectation that a lengthier time period between the dates of application and issue results in a higher probability of an assignment being recorded. We find no significant differences in recording patterns between patents that are assigned to a sole assignee versus those that are assigned to multiple assignees, however we do find significant differences in non-recording between sole-invented and co-invented patents. Assignees are less thus less likely to record assignments of co-invented inventions than of sole-invented ones.

With the exception of renewal, the indicators of patent value strongly suggest that patents of higher value are on average recorded more often than the ones of lower value. The probability of recording increases with the number of forward citations that a patent receives, with the number of claims that the patent conveys and with the patent being triadic. To the extent that these indicators correlate with the market value

Table 2.4: Correlations between variables of interest (pre-issue stage).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) IN_UPAD_ASS_PREG	1											
(2) GRANT_LAG(MONTHS)	-0.1503*	1										
(3) NR_INVENTORS	0.0639*	0.0771*	1									
(4) NR_APPLTS	0.0027*	0.0067*	0.1237*	1								
(5) USPTO_INCNT_3Y	0.0013	-0.0138*	0.0687*	-0.0087*	1							
(6) RENEWAL_4Y	0.0163*	-0.0646*	0.0131*	0.0001	0.0708*	1						
(7) DOCDB_ISTRIADIC	0.0066*	-0.0012	0.0633*	0.0174*	-0.0075*	0.0076*	1					
(8) GENERALITY(IPC4)	0.0107*	-0.0077*	0.0451*	0.0198*	0.1027*	0.0481*	0.0735*	1				
(9) ORIGINALITY(IPC4)	0.0504*	0.0946*	0.0823*	0.0359*	0.0086*	0.0037*	0.2399*	0.3370*	1			
(10) NR_CLAIMS	-0.0507*	0.1518*	0.0679*	-0.0152*	0.1519*	0.0427*	-0.0088*	0.0657*	0.0209*	1		
(11) US_ASSIGNEE	0.0629*	0.0369*	-0.0202*	-0.0681*	0.1009*	0.0304*	-0.1027*	0.0770*	-0.0620*	0.1908*	1	
(12) SMALL_ENTITY_STATUS	-0.0012	-0.0294*	-0.0940*	-0.0045*	-0.0365*	-0.0595*	-0.0668*	0.0492*	-0.0090*	0.0300*	0.1443*	1
(13) CORE_TECHNOLOGY	0.0020*	0.0052*	-0.0265*	-0.0225*	0.0450*	-0.0124*	-0.0032*	-0.0847*	-0.0814*	0.0533*	0.0704*	0.1769*

* p<0.01

Table 2.5: Results of logistic regressions (pre-issue stage).

	Dependent Variable: Non-recordation in pre-issue stage			
	(1)	(2)	(3)	(4)
COMPUTERS & COMMUNICATIONS	-0.0612	-0.0709	-0.120**	-0.109*
	(0.0571)	(0.0586)	(0.0569)	(0.0573)
DRUGS & MEDICAL	0.386***	0.386***	0.384***	0.375***
	(0.0323)	(0.0331)	(0.0320)	(0.0322)
ELECTRICAL & ELECTRONICS	-0.290***	-0.299***	-0.327***	-0.315***
	(0.0639)	(0.0650)	(0.0625)	(0.0635)
MECHANICAL	-0.422***	-0.437***	-0.442***	-0.431***
	(0.0366)	(0.0396)	(0.0359)	(0.0363)
OTHERS	-0.426***	-0.425***	-0.444***	-0.431***
	(0.0270)	(0.0278)	(0.0268)	(0.0268)
GRANT_LAG(MONTHS)	-0.0406***	-0.0383***	-0.0396***	-0.0396***
	(0.00161)	(0.00155)	(0.00161)	(0.00161)
CO_ASSIGNED	0.00338	-0.0106	0.00174	0.00305
	(0.0755)	(0.0752)	(0.0746)	(0.0750)
CO_INVENTED	0.238***	0.252***	0.235***	0.231***
	(0.0260)	(0.0274)	(0.0257)	(0.0260)
GENERALITY(IPC4)	-0.223***	-0.214***	-0.285***	-0.281***
	(0.0565)	(0.0580)	(0.0557)	(0.0561)
ORIGINALITY(IPC4)	0.574***	0.574***	0.622***	0.581***
	(0.0269)	(0.0277)	(0.0239)	(0.0270)
ln(USPTO_INCNT_3Y)	-0.0812***			
	(0.00743)			
ln(NR_CLAIMS)		-0.318***		
		(0.0237)		
DOCDB_ISTRIADIC			-0.120***	
			(0.0255)	
RENEWAL_4Y				0.0380
				(0.0282)
US_ASSIGNEE	0.383***	0.470***	0.363***	0.370***
	(0.0789)	(0.0823)	(0.0778)	(0.0780)
SMALL_ENTITY_STATUS	-0.144***	-0.141***	-0.145***	-0.132***
	(0.0367)	(0.0377)	(0.0372)	(0.0357)
UNIVERSITY	0.204***	0.212***	0.199***	0.204***
	(0.0338)	(0.0358)	(0.0336)	(0.0337)
GOV_NON_PROFIT	-0.118	-0.136*	-0.113	-0.0977
	(0.0772)	(0.0793)	(0.0784)	(0.0764)
OTHER	0.105	0.101	0.110*	0.111*
	(0.0671)	(0.0668)	(0.0665)	(0.0668)
CORE_TECHNOLOGY	-0.00455	0.000890	-0.00823	-0.00907
	(0.0173)	(0.0175)	(0.0171)	(0.0172)
Constant	-0.833***	-0.299***	-0.821***	-0.888***
	(0.0717)	(0.0720)	(0.0725)	(0.0657)
#Observations	2,280,724	2,280,724	2,280,724	2,280,724
Pseudo R-squared	0.0567	0.0648	0.0565	0.0561
Precision	59.78	60.32	57.85	58.65
Recall	0.47	1.50	0.43	0.43
Specificity	99.94	99.81	99.94	99.94
Year Dummies	Yes	Yes	Yes	Yes

Dependent variable is equal to 1 if no assignment for the patent has been recorded with the USPTO prior to or at the date of its issuance, 0 otherwise. Clustered robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

of patents, our results imply that empirical studies making the claim that the rate of patent transactions increases in the value of patents, may overestimate these effects due to a selection effect in recording towards patents of higher value. The same holds for studies that assert that patents representing more general purpose technologies are more likely to be traded on markets for technology than technologies with more narrow applications. The negative coefficient of the *GENERALITY* variable suggests that the probability of recording a patent assignment decreases in the generality of the patent. In other words, assignments recorded with the USPTO are prone to under-represent technologies that have more narrow applications. Interestingly, our results also show that assignments of patents that score higher on originality are recorded significantly less than patents that score low on originality.

On the assignee-level, we observe that recording patterns differ between patents that are assigned to US-assignees and patents that are assigned to assignees from other countries. Our results also indicate that patents assigned to small entities are more likely to be recorded than patents assigned to large entities. Whereas existing research suggests that small firms, as specialist suppliers of technologies, are more active on markets for technology than large firms, this finding may at least in part be based on the fact that the activities of these firms may be more observable than the activities of large firms. We also observe that of all different types of assignees, universities are the least likely to record assignments. Lastly, we observe no significant differences in recording between patents that belong to the core technology class of the assignee and those that do not.

2.4 Recording Patterns During the Post-issue Stage

2.4.1 Data and empirical analysis

The starting point for our empirical analysis of recording patterns during the post-issue stage of the patent life-cycle are records of patent suits whereby the name of the original assignee as listed on the front page of the patent differs from either the names of the plaintiff or defendant as specified by court documents at the filing date of the suit. We surmise that cases in which the plaintiff or defendant in a suit is not the same entity as the original assignee listed at the date of issue signal that a transaction of some kind has occurred either between the original assignee and the plaintiff or defendant directly

or indirectly through a series of transactions involving other entities in between. As aforementioned, the assignee of a patent is required to record transactions of any kind that influence the title in a patent in UPAD in order to establish a chain of ownership. Hence, cases in which the defendant or plaintiff in a suit is an entity other than the original assignee, signify actual changes in the ownership of a patent that occur post-issue and that should be recorded in UPAD. We can therefore utilize these cases in order to examine the reliability and accuracy of UPAD for transactions that occur post-issue. [7]

We collected data on over 24,000 patents litigated between 1990 and 2006 and restricted our sample to suits involving utility patents and re-issue patents granted between 1990 and 2000 that have been litigated between 1995 and 2004 in order to rule out potential selection effects due to left and right censoring of the data. For the remaining 9,654 patent-suit pairs we manually compared the names of the plaintiffs and defendants involved in the suit to the name of the assignee listed at the date of issue in BASIC_BIB. We identified 2,295 patent-suit pairs representing 1,616 unique patents, in which the names did not match. We subsequently collected all records for these patents from UPAD and engaged in a manual validation effort to verify whether a chain of ownership between the original assignee and the plaintiff or defendant listed in a suit involving the patent could be established based on these records. We identified 34 different scenarios in which the chain of ownership could be established and 6 different scenarios in which it could not be established.

Summary statistics for these scenarios are presented in Table 2.6. It should be noted that in our assessment we consider all events recorded in UPAD that may explain the trajectory from the original assignee to the plaintiff or defendant, including name changes, mergers, security interests, license agreements etc.. We label only those cases as 'not recorded' for which none of these events provide a link between the original assignee and the plaintiff or defendant. We also check whether events establishing the chain of ownership have been recorded prior to the filing date of the suit, in order to filter out recordings that establish a chain of ownership between the original assignee and one of the parties in suit, but are likely to be triggered directly by the suit. We consider all patent-suit pairs for which a chain of ownership cannot be established on the basis of

[7] It is important to note that when asserting patents, patent owners need to show that they have legal title to patents they plan to assert. Parties can illustrate this by submitting assignment agreements and for the chain of ownership to be established it does not matter whether these agreements have previously been recorded with the USPTO or not (Dubal *et. al.*, 2011).

records in UPAD prior to the filing date of the suit as non-recorded.

The magnitude of non-recording is substantial: for 53.8% of all patent-suit pairs, no direct or indirect link can be made between the original assignee and one of the parties involved in the suit prior to the filing date of the suit. Although the patents in our sample can be involved in multiple suits, we did not observe any differences concerning non-recording between different suits involving the same patent. In other words, we did not find instances in which the chain of ownership could be established for one suit in which a focal patent is involved but not for the other suits in which it is involved. This makes it possible to quantify the probability of non-recording on the unique patent-level. In that case, the results indicate that for 60.1% of all patents in our sample it is not possible to make a direct link between the original assignee and the plaintiff or defendant prior to the filing date of the suit. In Table 2.7 we break down the non-recording rates per technology class. Although the non-recording rates across technology classes are more evenly distributed than during the pre-issue stage, post-issue assignments in the DRUGS AND MEDICAL class are the least likely to be recorded in UPAD as more than two thirds of such assignments are not recorded.

Our approach towards analyzing differences in recording patterns is largely analogous to the analysis of non-recording in the pre-issue stage. We test for distributional differences between patents for which a chain of ownership can be established prior to the filing date of the suits on the basis of records in UPAD and patents for which this link cannot be made. Similar to our above analysis of non-recording in the pre-issue stage, we include indicators of interest on both the patent-level and the level of the original assignee. However, it should be noted that in this case the original assignee listed at issue essentially functions as assignor in our sample and therefore our findings on the assignee-level should be interpreted as such. Although the obligation to record changes of ownership is ultimately vested with the assignee, we surmise that the assignor can exert influence over the assignee's decision to record an assignment (or not). We estimate the following logistic regression model:

$$Prob\left(Y_{ij} = 1 \mid X_{ij}\right) = F\left(\beta X_{ij}\right) + \varepsilon_i,$$

where Y_{ij} is equal to 1 if a chain of ownership cannot be established based on events recorded in UPAD between the original assignee at issue and the plaintiff or defendant prior to the filing date of the suit, and X_{ij} is a vector of variables that identify a range of characteristics specific to each patent. We include the same variables that we

Table 2.6: Classification of recordation events (post-issue stage).

	TOTAL NUMBER OF CASES	REGISTERED PRIOR TO SUIT FILING	REGISTERED AFTER SUIT FILING
Correct cases			
1. Assignee and defendant seem to be co-owners.	2	1	1
2. Assignee and plaintiff seem to be co-owners.	10	7	3
3. Assignee assigned patent to another party which subsequently changed its name to defendant's.	4	3	1
4. Assignee assigned patent to another party which subsequently changed its name to plaintiff's.	40	26	14
5. Assignee assigned patent to another party which subsequently gave a contribution agreement to the plaintiff.	2	2	0
6. Assignee assigned patent to another party which subsequently merged and changed its name to plaintiff's.	1	0	1
7. Assignee assigned patent to defendant, multiple chains in between.	19	14	5
8. Assignee assigned patent to defendant.	106	79	27
9. Assignee assigned patent to plaintiff, multiple chains in between.	124	102	22
10. Assignee assigned patent to plaintiff.	728	563	165
11. Assignee changed its name and subsequently assigned patent to plaintiff, multiple chains in between.	1	0	1
12. Assignee changed its name and subsequently assigned patent to plaintiff.	9	6	3
13. Assignee changed its name multiple times and subsequently assigned patent to plaintiff.	4	2	2
14. Assignee changed its name to defendant's.	32	21	11
15. Assignee changed its name to plaintiff's, indicated by "formerly known as" in the assignor-field in UPAD.	6	6	0
16. Assignee changed its name to plaintiff's.	174	109	65
17. Assignee changed its name, merged subsequently and changed its name to plaintiff's.	2	1	1
18. Assignee gave a license to plaintiff.	6	5	1
19. Assignee gave a security interest to plaintiff.	6	5	1
20. Assignee gave an exclusive license to plaintiff.	7	3	4
21. Assignee has a second lien security agreement with plaintiff.	2	0	2
22. Assignee has assigned patent to both the plaintiff and defendant, whom seem to be co-owners.	1	0	1
23. Assignee has assigned patent to plaintiff, which has subsequently assigned it to defendant.	1	0	1
24. Assignee merged and changed its name to defendant's.	5	3	2
25. Assignee merged and changed its name to plaintiff's.	96	76	20
26. Assignee merged and subsequently assigned patent to plaintiff.	3	2	1
27. Defendant and plaintiff seem to be co-owners.	1	1	0
28. Defendant assigned patent to another party which subsequently changed its name to original assignees'.	1	1	0
29. Defendant assigned patent to original assignee.	3	3	0

Table 2.6: Classification of recordation events (post-issue stage) (continued).

	TOTAL NUMBER OF CASES	REGISTERED PRIOR TO SUIT FILING	REGISTERED AFTER SUIT FILING
Correct cases			
30. Defendant changed its name to plaintiff's.	1	1	0
31. Inventor assigned ownership to assignee, a termination of assignment has returned ownership to original inventor, original inventor assigned patent to plaintiff.	2	2	0
32. Plaintiff and assignee seem to be co-owners.	2	2	0
33. Plaintiff assigned patent to original assignee.	8	8	0
34. There is an agreement of rescission and waiver between assignee and plaintiff.	1	1	0
Total correct cases	**1,410**	**1,055**	**355**
Incorrect cases			
1. Assignee and defendant are mentioned in UPAD, however the chronology of events is incorrect (broken chain of ownership).	1	0	1
2. Assignee and defendant are mentioned in UPAD, however they cannot be linked to each other in any way (broken chain of ownership).	1	0	1
3. Assignee and plaintiff are mentioned in UPAD, however the chronology of events is incorrect (broken chain of ownership).	37	0	37
4. Assignee and plaintiff are mentioned in UPAD, however they cannot be linked to each other in any way (broken chain of ownership).	102	0	102
5. No link in can be made between assignee and plaintiff/defendant in UPAD in any way.	602	0	602
6. There are no records for this patent in UPAD at all.	142	0	142
Total incorrect cases	**885**	**0**	**885**
Total	**2,295**	**1,055**	**1,240**

included in our analysis of non-recording during the pre-issue stage with the exception of *GRANT_LAG* and *RENEWAL_4Y*. Instead of measuring the time period between the filing date of a focal patent and its issue date, we include a measure of the time period between the issue date and the first filing date of a suit that involves the focal patent, represented by the variable *TIME_LAG*. We expect that a lengthier time period between the date of issue of a patent and the filing date of a suit in which it is involved may explain recording, given that it provides the assignee more time to record events in UPAD that establish its chain of ownership. We do not include the variable *RENEWAL_4Y* because for the great majority of the patents in our sample the time period between the filing of the first suit involving the patent exceeds the time window for the payment of the first maintenance fee. In other words, for the bulk of sample patents *RENEWAL_4Y*

Table 2.7: Non-recordation by technology class (post-issue stage).

Technology class (One-digit NBER categories)	Patent count	Not recorded in UPAD (count)	Not recorded in UPAD (share)
3. Drugs & medical	333	226	67.87%
4. Electrical & electronics	186	119	63.98%
1. Chemical	203	129	63.55%
5. Mechanical	214	130	60.75%
6. Others	267	154	57.68%
2. Computers & communications	382	199	52.09%

will by default be equal to 1. We do also not include maintenance events that occur after the patent has been involved in a suit, since these might be influenced by the outcome of that suit. We again take into account that patents issued to the same assignee do not serve as independent observations and calculate robust standard errors that are clustered at the level of the original assignee. A description of all variables is presented in Table 2.2, whilst summary statistics and correlations are presented in Tables 2.8 and 2.9 respectively.

Table 2.8: Summary statistics for variables of interest (post-issue stage).

Variable	No. of Obs.	Mean	Std. Dev.	Min	Max
IN_UPAD_ASS_PREG	1,457	0.612	0.487	0	1
TIME_LAG(MONTHS)	1,457	59.535	37.988	0	174.193
NR_INVENTORS	1,457	2.466	1.824	1	16
NR_APPLTS	1,457	1.020	0.151	1	3
USPTO_INCNT_3Y	1,457	7.093	12.532	0	196
DOCDB_ISTRIADIC	1,457	0.285	0.451	0	1
GENERALIRY(IPC4)	1,457	0.703	0.192	0	0.96
ORIGINALITY(IPC4)	1,457	0.359	0.311	0	0.89
NR_CLAIMS	1,457	22.686	29.694	1	868
US_ASSIGNEE	1,457	0.786	0.409	0	1
SMALL_ENTITY_STATUS	1,457	0.244	0.430	0	1
CORE_TECHNOLOGY	1,457	1.226	0.974	0	1

Table 2.9: Correlations between variables of interest (post-issue stage).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) IN_UPAD_ASS_PREG	1										
(2) TIME_LAG (MONTHS)	-0.1213*	1									
(3) NR_INVENTORS	0.0189	-0.1065*	1								
(4) NR_APPLTS	-0.0125	-0.0124	0.0969*	1							
(5) USPTO_INCNT_3Y	-0.0841*	-0.0917*	0.0783*	-0.0249	1						
(6) DOCDB_ISTRIADIC	0.0631	0.0236	0.0784*	0.0247	0.0122	1					
(7) GENERALITY (IPC4)	0.0624	-0.0212	0.0480	-0.0229	0.0684*	0.0106	1				
(8) ORIGINALITY (IPC4)	0.0541	-0.0601	0.0653	-0.0196	0.0836*	0.2717*	0.4119*	1			
(9) NR_CLAIMS	-0.0110	-0.0458	0.1293*	-0.0189	0.1657*	0.0256	0.1027*	0.1351*	1		
(10) US_ASSIGNEE	-0.1368*	-0.0306	-0.0180	-0.0177	0.0991*	-0.1611*	0.0918*	-0.0341	0.0518	1	
(11) SMALL_ENTITY_STATUS	0.0128	-0.0197	-0.1472*	0.0179	-0.0718*	-0.0925*	0.0217	-0.0621	-0.0531	0.1084*	1
(12) CORE_TECHNOLOGY	-0.1564*	-0.0386	-0.0544	0.0057	0.0999*	-0.0573	-0.0943*	-0.0687*	-0.0083	0.0915*	0.1458*

* $p<0.01$

2.4.2 Results

The results of our logistic regressions are presented in Table 2.10. Compared to the pre-issue stage, the results presented in Table 2.10 highlight less explicit differences between patents having assignments recorded in UPAD and patents for which there are no such records. First, we do not find significant differences in post-issue recording patterns across technology classes. The coefficients of the technology classes are not significant in any of the specified models. Second, of the value indicators, only the coefficient of *USPTO_INCNT_3Y* is significant, with the negative sign indicating that the odds of having a recorded assignment in UPAD are significantly higher for patents that are cited more frequently. The coefficients for *NR_CLAIMS* and *DOCDB_ISTRIADIC* are not significant in any of the specified models. Thirdly, we do not observe significant differences between patents having recorded and non-recorded assignments in terms of their generality and originality scores. The results do highlight that assignments of patents that have originally been assigned to two or more assignees (co-assigned patents) are more likely to be recorded than patents that have originally been assigned to a sole assignee.

On the original assignee-level, the results show that patents that are assigned by US-assignees during the post-issue stage are far more likely to be recorded than those that are assigned by non-US-assignees. The coefficient for *US_ASSIGNEE* is significant at the 1%-level in all models and the effect size is noteworthy, a change from the non-US to US-assignee category corresponds with a 15 percentage point increase in the probability of an assignment being recorded post-issue. The results also show that assignments by universities are less likely to be recorded with the USPTO than assignments by companies. The coefficient is significant at the 1%-level in all specifications and the effect size is substantial, a change from the company category to the university category corresponds with a 34 percent point increase in the probability of not being recorded. Lastly, the results highlight that patents that belong to the core technology of the original assignee are more likely to have post-issue assignment records in UPAD than non-core technologies, although the effect size is rather modest.

In sum, we find some indication that the probability of non-recording in the post-issue stage of the patent life-cycle is related to patent value, as measured by the number of forward citations, and a number of characteristics of the original assignee. Our results suggest that the probability of non-recording decreases with the number of citations

Table 2.10: Results of logistic regressions (post-issue stage).

	Dependent Variable: Non-recordation in post -issue stage		
	(1)	(2)	(3)
COMPUTERS & COMMUNICATIONS	-0.194	-0.400	-0.406
	(0.265)	(0.253)	(0.254)
DRUGS & MEDICAL	0.0714	0.0136	0.00762
	(0.269)	(0.268)	(0.268)
ELECTRICAL & ELECTRONICS	0.0750	0.00435	0.0120
	(0.283)	(0.284)	(0.282)
MECHANICAL	0.0429	0.0126	0.0421
	(0.297)	(0.305)	(0.303)
OTHERS	-0.213	-0.272	-0.255
	(0.248)	(0.246)	(0.245)
TIME_LAG (MONTHS)	-0.00449*	-0.00429*	-0.00433*
	(0.00258)	(0.00256)	(0.00255)
CO_ASSIGNED	-1.077**	-1.044**	-1.064**
	(0.447)	(0.450)	(0.450)
CO_INVENTED	-0.0603	-0.0726	-0.0884
	(0.152)	(0.154)	(0.152)
GENERALITY(IPC4)	0.652*	0.560	0.583
	(0.378)	(0.368)	(0.372)
ORIGINALITY(IPC4)	0.00903	-0.00894	-0.0945
	(0.255)	(0.257)	(0.268)
ln(USPTO_INCNT_3Y)	-0.216***		
	(0.0706)		
ln(NR_CLAIMS)		-0.0699	
		(0.0819)	
DOCDB_ISTRIADIC			0.159
			(0.155)
US_ASSIGNEE	-0.720***	-0.741***	-0.740***
	(0.200)	(0.200)	(0.202)
SMALL_ENTITY_STATUS	-0.0216	0.00381	0.0172
	(0.171)	(0.170)	(0.171)
UNIVERSITY	2.454***	2.419***	2.423***
	(0.579)	(0.580)	(0.577)
GOV_NON_PROFIT	0.839	0.920	0.900
	(0.799)	(0.820)	(0.833)
OTHER	1.793***	1.799***	1.829***
	(0.607)	(0.618)	(0.618)
CORE_TECHNOLOGY	-0.240***	-0.261***	-0.261***
	(0.0842)	(0.0840)	(0.0841)
Constant	1.446***	1.598***	1.387***
	(0.507)	(0.557)	(0.515)
#Observations	1,457	1,457	1,457
Pseudo R-squared	0.0953	0.0898	0.0900
Precision	68.77	68.05	67.80
Recall	83.28	82.94	82.94
Specificity	40.46	38.69	37.99
Year Dummies	Yes	Yes	Yes

Dependent variable is 1 if the chain of ownership between the original assignee and the plaintiff or defendant cannot be established based on records from UPAD prior to the filing date of the suit, 0 otherwise. Clustered robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

that a patent receives, with the original assignee having residence in the US and with the patent belonging to the core technology of the original assignee, whilst increasing with the original assignee being a university. We note that these results should be interpreted with a certain level of caution, provided that our sample of patents consists of litigated patents, which have been found to be more valuable on average than other patents in prior research (*i.a.* Lanjouw and Schankerman, 2001; Bessen, 2008; Allison *et.al.* 2009).

2.5 Discussion

2.5.1 Implications

Our study aimed at addressing open questions concerning the reliability and accuracy of patent assignments recorded with the USPTO as indicator of technology transactions. By verifying assignments recorded in UPAD against patents with a listed assignee at issue, we demonstrated that about 17% of patents that have been assigned prior to their issue do not have corresponding records in UPAD that indicate such an assignment. Furthermore, based on a sample of patents involved in litigation cases that signify changes in ownership post-issue, we show that in about 54% of these cases, the chain of ownership from the original assignee to one of the parties involved in the suit cannot be established by drawing upon records represented in UPAD. Subsequent analyses, especially those pertaining to the pre-issue stage, reveal significant distributional differences between recorded and non-recorded assignments across characteristics on both the patent and assignee-levels of analysis that have been of interest to the literature on technology transactions. These findings have clear implications for scholarship on markets for technology, open innovation and patent monetization as well as policy reforms directed at the US patent system.

First, to the extent that recording patterns observed prior to grant are representative of recording patterns during the entire patent life-cycle, our results suggest that the finidngs of studies quantifying activity on markets for technology on the basis of publicly available patent assignment data are likely to underestimate the overall magnitude of this activity. Furthermore, our results highlight differences in non-recording rates across technological domains, with the highest observable non-recording rates relating to patents that belong to technology classes that have been featured most prominently

in existing patent-based research: *DRUGS AND MEDICAL*, *CHEMICALS* and *SEMICONDUCTORS*. This implies that the differences in patent trading across industries as reported in existing empirical analyses (*i.a.* Serrano, 2018; Mani and Nandkumar; 2016) may in part capture differences in recording patterns rather than actual differences in volumes of trade. Our results also suggest that selection into recording with the USPTO is related to the same patent and assignee characteristics that existing studies associate with greater activity on technology markets. In particular, our results reveal that the probability of recording primarily increases with patent value and generality, with the results being most outspoken for the recording of ownership changes prior to patent issue, and decreases with the 'size' of the assignee. This suggests that the higher likelihood of patents of greater value and patents that are more general purpose of being part of transactions, as reported by existing studies (*i.a.* Serrano, 2011: 2018), may be attributable, at least in part, to the fact these patents are more likely to be recorded in UPAD. The same holds for observed higher levels of activity by small entities on technology markets (*i.a.* Serrano, 2011; Figueroa and Serrano, 2015). Taken together, our findings hint at a bias due to selection into recording that is non-randomly distributed. One the one hand, this calls for a more cautious interpretation of the empirical results of existing studies that rely on patent assignment data. On the other hand, it should inspire future studies to select samples such that this bias is minimized.

Second, our findings also have clear implications for policy initiatives aimed at improving the US patent system. A primary function of the patent system is to give notice to the public of the existence, scope and ownership of property rights. This notice function has been shown to encourage subsequent innovation and limit duplication of inventive effort (*i.a.* Scotchmer and Green, 1990; Furman *et. al.*, 2018; Baruffaldi and Simeth, 2018). The notice function is also paramount towards achieving efficient technology markets, which function better when actors are able to quickly determine who the holders of certain property rights are (Hegde and Luo, 2017). In addition, information concerning which parties have an interest in a patent is also highly relevant in the context of patent litigation, allowing both plaintiffs and defendants to understand their relative bargaining positions in a potential suit. Our results find support for the claim of Marco *et. al.* (2015) and others (*i.a.* Roin, 2005; Fromer, 2009; Lemley, 2012; Chien, 2016a) that current federal laws do not provide sufficient incentives for all actors to publicly disclose their ownership interest in a patent. In more than 50% of the litigated

cases that we analyzed, we were unable to establish the chain of ownership from the original assignee to the plaintiff or defendant prior to the filing date of the suit. To the extent that our sample is representative of the entire sample of patent assignments, this implies that the actual ownership of a considerable share of patents cannot be readily determined after their grant. In that sense, our results cannot rule out Ewing and Feldman's (2012) assertion that rather than providing ample opportunities for tracking activities on technology markets, existing regulations may actually provide parties with opportunities to hide their activities. The high frequency of non-recording is also testimony to the difficulty of capturing the activities of patent assertion entities reported by prior studies (Ewing and Feldman, 2012; Fisscher and Henkel, 2012). In combination, our results highlight the need for a more reliable and accurate system for the recording of patent ownership changes that resembles existing registries for physical property.

2.5.2 Limitations

Our study is subject to a number of limitations which merit a careful interpretation of our results. First, we should note that our results are most outspoken for the recording of ownership changes in the pre-issue stage, which may be due to the fact that we have a much greater 'validation' set in the pre-issue stage than in the post-issue stage. Although our sample of patents that have an assignee listed at the date of issue is representative of the population of patents assigned prior to issuance, this sample may not necessarily be comparable to the population of assignments that occur post-issue. Whilst the regulations for recording assignments prior to and after patent issue are essentially the same, thereby providing similar incentives for recording assignments prior to or after issue, this does not necessarily mean that the incentives for non-recording do not vary during both stages. Although we make an attempt to explore such differences by utilizing litigation records to explore recording patterns that occur post-issue, we should note that it is unclear to what extent this sample of litigated patents is representative of the population of post-issue assignments. Most notably, patents involved in litigation have consistently been found to be more valuable on average than patents that are not litigated (Allison *et. al.*, 2009; Chien, 2016b). This suggests that our analyses of recording patterns in the post-issue stage may only capture dynamics in recording ownership changes of patents that belong to the upper echelons of the distribution of patent value.

Second, although we test for distributional differences between recorded and non-recorded assignments based on characteristics of patents and assignees that have been of primary interest to the literature on technology markets, we do not uncover the motives underlying the non-recordation of assignments. To the best of our knowledge a study by Chien (2012) is the only study that attempts to uncover the motives for not disclosing patent ownership information. According to this study, the failure to record patent ownership changes may not necessarily be motivated by a desire to hide patent ownership information but may rather be due to: (i) cost considerations (mainly attorney fees), (ii) poor record-keeping practices, (iii) tax considerations and (iv) inconsistent self-identification before the USPTO. At the same time, the study also stresses that companies do withhold patent ownership information deliberately in order to gain a strategic advantage. This claim is supported by an empirical analysis of 915 patent litigation cases which reveals that in about 33% of the cases the plaintiff listed was not the patent owner of record on the day that the litigation case was initiated. Although Chien ultimately suggests that the non-recording of ownership information is more likely to be motivated by practical rather than strategic considerations, she herself admits that this claim is based on anecdotal rather than empirical evidence. Even though understanding the motives underlying non-recording would undoubtedly enrich our analysis, we believe that the lack thereof does not undermine our results. Hence, regardless of these motives, the resulting lack of complete and accurate publicly available ownership records does raise the type of concerns that we have described throughout this chapter. Hence, our study is mainly focused on the implications of non-recording rather than its potential causes and these implications hold regardless of what the cause is.

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Chapter 3

Patent Notice (Failure) in the Era of Patent Monetization:

On the (Lack of) Transparency of Patent Ownership Changes[1]

3.1 Introduction

Legal and economic commentators have described a trend towards the monetization of patents that is manifested in both the increasing number of patent transactions and the monetary gains generated by them.[2] Whilst the attribution of this trend varies from the institutional commodification and assetization of patents to changes in contextual factors that have forced organizations to open up their innovation processes, there is a

[1] This chapter is based on a joint working paper with Arina Gorbatyuk (PhD-candidate at the Center for IT & IP Law, KU Leuven). Earlier versions of this chapter have been presented at the 2016 Congress of The International Association for the Advancement of Teaching and Research in Intellectual Property (ATRIP) in Krakow, Poland and the 2016 Conference of the European Policy for Intellectual Property (EPIP) in Oxford, UK.

[2] *See* e.g. David Teece and Peter Grindley, Managing Intellectual Capital: Licensing and Cross-Licensing in Semiconductors and Electronics, CAL. MAN. REV. 39, 8-41 (1997) (reporting a significant increase in the licensing revenues of Texas Instruments from US$50 million in 1986 to more tan US$500 million in the mid-1990s); Kevin Rivette and David Kline, Rembrandts in the Attic: Unlocking the Hidden Value of Patents (2000) (reporting that IBM increased its licensing royalties from US$ 100 million in 1990 to almost US$ 1 billion in 1999).

consensus that patent monetization is on the rise from the mid-1990s onwards.[3] This trend coincides with the rise of markets for technology wherein exchanges comprise intermediate technological inputs that are largely disembodied from goods and services.[4] Although technology markets have the potential to be engines of economic growth, in the sense that they enable a division of labor between the entities that invent and the entities that manufacture most efficiently, it is widely recognized that they function inefficiently due to information asymmetries between buyers and sellers of technology that arise due to the public good nature of inventions.[5] Patents can, at least in part, provide a remedy to this matter by simultaneously enabling purposive knowledge flows and limiting unintended knowledge spillovers. Specifically, patents may facilitate technology transactions by: (i) protecting buyers and sellers of technology against the expropriation of inventions (the appropriation function) and (ii) by aiding contract negotiations between buyers and sellers via the disclosure of technical details concerning the invention (the notice function). For patents to facilitate technology transactions it is of paramount importance that patent offices provide complete and accurate information to the public regarding the holders of patent rights.[6] In other words, patent ownership information

[3] *See* Rochelle Dreyfuss and Susy Frankel, From Incentive to Commodity to Asset: How International Law is Reconceptualizing Intellectual Property, MICH. J. INT. LAW 36, 557, 566 (2015) (arguing that "multilateral soft an hard laws, as well as bilateral, plurilateral, and regional agreements" have reconceptualized IP as an asset and have "progressively detached it from its grounding in incentive-based principles"); Henry Chesbrough Marcel Bogers, Explicating Open Innovation: Clarifying an Emerging Paradigm for Understanding Innovation, in Henry Chesbrough *et. al.*, New Fron-tiers in Open Innovation 1, 27 (2014) (observing that companies cannot afford to solely rely on their own R&D in an era in which the sources of knowledge for innovation are widely distributed in the economy).

[4] *See* Ashish Arora *et. al.*, Markets for Technology: The Economics of Innovation and Corporate Strategy ch.1. 1, 2 (2001) ("This vision of knowledge creation integrated with knowledge use has become inadequate for understanding economic growth in the twenty-first century. Over the past ten to fifteen years, there has been a rapid growth in a variety of arrangements for the exchange of technologies or technological services, ranging from R&D joint ventures and partnerships to licensing and cross-licensing agreements, to contracted R&D. Although we lack comprehensive empirical measures of the increase in such arrangements over time, all the available evidence suggests that the trade in technologies is more common than it was in the past.").

[5] *See* Ashish Arora and Alfonso Gambardella, Ideas for Rent: An Overview of Markets for Technology, IND. CORP. CHANGE., 19, 775, 787 (2010) (denoting uncertainty concerning (i) property rights, (ii) the value of technology and (iii) transaction processes as persistent barriers to the efficient functioning of technology markets)

[6] *See* Colleen Chien, 1, 1, The Who Owns What Problem in Patent Law, (2012), available at http://digitalcommons.law.scu.edu/facpubs/190 (stating that "patent ownership is a critical component of patent notice" and that "if patents provide the right to exclude, the public is entitled to know who might

is a critical constituent of the notice function of the patent system.

In this chapter, we argue that current regulations do not allow to establish with certainty who owns a particular patent. Specifically, we focus on patent ownership changes and highlight that, whilst patent offices impose strict legal requirements concerning the adequate disclosure of the identity of the initial applicant(s) of a patent, their requirements are considerably less strict with respect to the disclosure of ownership once patent rights have been assigned to other parties. In other words, the likelihood of identifying the actual owner(s) of a patent is significantly reduced following changes in the ownership of the patent. Hence, somewhat paradoxically, whilst a greater transparency of patent ownership facilitates technology transactions, such transactions might in fact result in a decrease of the transparency of ownership in return. We highlight that this is the result of insufficient requirements for the registration of assignments as currently imposed by patent offices and the enforcement thereof and illustrate the universal nature of this issue based on a comparative analysis of rules on the establishment of patent ownership throughout the patent lifecycle of one regional patent office – the European Patent Office (hereafter EPO) – and five national patent offices – the United States Patent and Trademark Office (hereafter USPTO), the Japan Patent Office (hereafter JPO), the United Kingdom Intellectual Property Office (hereafter UK IPO), the French Institut National de la Propriété Industrielle (hereafter INPI) and the German Patent and Trademark Office (hereafter DPMA).

Our analysis reveals that the patent application stage, at which the initial title in a patent is established, is the only stage during the lifetime of a patent at which the adequate disclosure of the identities of the holders of rights to a patent is strictly enforced. Although all patent offices under study require parties to file notice when a patent is assigned, no provisions exist for strictly enforcing the failure to meet this requirement. Despite the clear detrimental implications of a failure to disclose information concerning the identities of patent owners for the functioning of technology markets, we could only identify one initiative that aims to remedy the flaws of current patent provisions – the USPTO's Notice on "Changes to Require Identification of Attributable Owner". We rely on a discussion of the relevant elements of this Notice as a foundation for proposing a number of 'minimal requirements' that future initiatives by patent offices should impose in order to warrant a more adequate, accurate and timely disclosure of patent

do the excluding".

ownership information.

The remainder of this chapter is structured as follows. In the second paragraph we discuss the disclosure function of the patent system and highlight its deficiencies. In the third paragraph we examine the patent provisions concerning the disclosure of the identity of the initial applicant(s) of a patent followed by an overview of the provisions with respect to the recordation of changes of ownership in paragraph four. In paragraph five, we discuss the USPTO's Notice on "Changes to Require Identification of Attributable Owner" followed by a proposal of recommendations for future initiatives aimed to improve the transparency of patent ownership in paragraph six. Finally, we present our concluding remarks in paragraph seven.

3.2 The Notice Function of the Patent System

3.2.1 The relevance of disclosing patent information

The most common justification for the patent system is a utilitarian one that defines the patent system as a property regime that aims to incentivize inventive effort that is desirable from a societal viewpoint yet may not be exerted – at least not at socially optimal rates – in its absence.[7] Because the inventive process often results in outcomes that have the characteristics of a public good that is non-excludable and non-rivalrous, it enables actors other than the original inventor to reap the rewards of their inventions.[8] If inventions can be imitated at a cost that is lower than the initial cost of creating them, original inventors may not be able to appropriate sufficient ex post rents that arise from their invention. As a result, inventors may have ample incentives to develop

[7] *See* Kenneth W. Dam, The Economic Underpinnings of Patent Law, 23, J. LEGAL STUD. 247, 247 (1999) ("The patent system prevents others from reaping where they have not sown and thereby promotes research and development (R&D) investment in innovation. The patent law achieves this laudable end by creating property rights in inventions.); Roberto Mazzoleni & Richard R. Nelson, The Benefits and Costs of Strong Patent Protection, 27 RES. POL. 273, 275 (1998) (suggesting that the main underlying justification of the patent system is that "patents are needed to provide firms with the requisite incentive to invent, and that this does justify the costs of the temporary monopoly their granting gives").

[8] *See* Kenneth W. Dam, The Economic Underpinnings of Patent Law, 23, J. LEGAL STUD. 247, 247 (1999) (noting that "innovation is essentially the creation of information, which has different economic characteristics from goods."); Joseph E. Stiglitz, Knowledge as a Global Public Good, 308, 308 (1999) (characterizing public goods as having two distinct properties: "nonrivalrous consumption— the consumption of one individual does not detract from that of another— and nonexcludability—it is difficult if not impossible to exclude an individual from enjoying the good").

inventions, which results in lower levels of investment in research and development than what is socially desirable.[9] The primary role of the patent system is to mitigate against this underinvestment problem by granting inventors exclusivity over their inventions, allowing them to capture an adequate ex post return. By doing so, the patent system remedies the inefficiency of private markets to effectively stimulate and allocate investment into research and development in the presence of externalities.

However, granting inventors a temporary exclusive right to prevent others from practicing – making, using, importing or selling – their inventions may come at a significant social cost. Patent protection may enable patentees to set a premium price that is well above the market price of their invention, especially for inventions that are difficult to substitute. Such monopoly pricing leads to an underutilization of the invention and disproportionately transfers wealth from consumers to the patentee. In order to compensate for this deadweight loss to society, the legislator imposes the requirement on patentees to give public notice of the subject matter for which patent protection is sought. This enables third parties to identify and understand patent rights that could potentially read on their inventions. The disclosure of inventions in patent documents – which we refer to as *patent notice* in the remainder of this article – is typically thought of as being part of a patent bargain as the *quid pro quo* of granting an exclusive right to inventors. The patent bargain metaphor's omnipresence within the patent law community is demonstrated by the US-courts advancing the quid pro quo rationale in a number of renowned US-court-cases.[10]

[9] *See* Janusz A. Ordover, A Patent System for Both Diffusion and Exclusion, 5 J. ECON. PERS. 43, 43 (1991) ("If the owners of knowledge-assets have only minimal property rights, their returns may not be high enough to recoup their initial investment, much less attain a sufficient return to compensate them for undertaking a risky project. As a result, the initial investment may not be undertaken, thereby harming dynamic efficiency").

[10] *See* e.g. Bonito Boats, Inc. v. Thunder Craft Boats, Inc., 489 U.S. 141, 150-151 (1989) ("The federal patent system thus embodies a carefully crafted bargain for encouraging the creation and disclosure of new, useful and nonobvious advances in technology and design in return for the exclusive right to practice the invention for a period of years."); J.E.M. AG Supply, Inc. v. Pioneer Hi-Bred International, Inc., 534 U.S. 124, 142 (2001) ("The disclosure required by the Patent Act is the quid pro quo of the right to exclude."); Eldred v. Ashcroft, 537 U.S. 186, 224 (2003) ("Complete disclosure as a precondition to the issuance of a patent is part of the quid pro quo that justifies the limited monopoly for the inventor as consideration for full and immediate access by the public when the limited time expires".); Pfaff v. Wells Electronics, Inc., 525 U.S. 55, 63 (1998) (stating that "the patent system represents a carefully crafted bargain that encourages both the creation and the public disclosure of new and useful advances in technology, in return for an exclusive monopoly for a limited period of time").

Whilst there is considerable disagreement among commentators regarding the role that patent notice should serve in shaping patent policy – with some denoting it as a central function of the patent system and others deeming it to be merely an ancillary objective at best – the potential benefits to society of disclosing inventions in patent documents are universally recognized.[11] Firstly, an effective patent notice facilitates subsequent – follow-on – invention by enabling other inventors to learn about the characteristics and potential applications of an invention.[12] This *teaching function* not only allows others to make, use and further develop an invention after the patent term, but also to be inspired by, invent around and build upon it during the patent term.[13] In addition, signaling the achievements of others helps inventors to avoid investments that would result in duplications of existing inventions.[14] When the notice function is poorly served, the original inventor may very well be the only person who possesses sufficient knowledge to further build upon her invention. This is not desirable from

[11] *See* e.g., Jeanne C. Fromer, Patent Disclosure, 94 IOWA L. REV. 539, 542 (2009) and FED. TRADE COMM'N, The Evolving IP market place: aligning patent notice and remedies with competition, ch. 3. 73, 75-80 (2011) for arguments in favor of considering patent notice as a central aim of the patent system and Alan Devlin, The Misunderstood Function of Disclosure in Patent Law, 23 HARV. J. L. & TECH. 401, 411 (2010) and Benjamin N. Roin, The Disclosure Function of the Patent System (Or Lack Thereof), 118 HARV. L. REV. 2007, 2028 (2005) for arguments in favor of treating patent notice as an ancillary objective of the patent system. Whereas the former view advances that patent notice is an objective of the patent system that is equally important to offering incentives to promote invention, the latter view argues that no sacrifices should be made to the 'incentive objective' in the name of patent notice. Thus, the latter view does not challenge the view that patent notice should be an objective of the patent system, it merely states that as an objective it is less important than the incentive objective.

[12] *See* Kewanee Oil. Co. v. Bicron Corp., 416 U.S. 470, 481 (1974) ("When a patent is granted and the information contained in it is circulated to the general public and those especially skilled in the trade, such additions to the general store of knowledge are of such importance to the public weal that the Federal Government is willing to pay the high price of 17 years of exclusive use for its disclosure, which disclosure, it is assumed, will stimulate ideas and the eventual development of further significant advances in the art.").

[13] *See* e.g. Jeanne C. Fromer, Patent Disclosure, 94 IOWA L. REV. 539, 541 (2009) ("patent disclosure indirectly stimulates future innovation by revealing the invention's design so that others can use it fruitfully when the patent term expires and design around, improve upon, or be inspired by the invention, even during the patent term.").

[14] *See* Edmund W. Kitch, The Nature and Function of the Patent System, 20 J.L. & ECON. 265, 278 (1977) (stating that "once a patent has been issued, other firms can learn of the innovative work of the patent holder and redirect their work so as not to duplicate work already done" and that "under a regime of trade secrecy, the competitive firm might never learn of a competitor's processes and would not learn of the technology incorporated in a new product until it was marketed. During this period, the investments made in a search for technology already invented by others is wasted.").

a societal point of view, given that most inventions are continuations, combinations or re-combinations of the ideas, discoveries and concepts developed by parties other than the original inventor.[15] Commentators often refer to Sir Isaac Newton's famous aphorism *"If I have been able to see further, it is by standing on the shoulders of giants"* and argue that *"... in the current evolution of high technologies, almost all technical progress builds on a foundation provided by earlier inventors"*.[16] An effective patent notice enables to stand on the shoulders of giants by levelling the playing field between the original inventor and the public by reducing the 'information advantage' of original inventors.

Secondly, an effective patent notice serves to clarify the 'legal' boundaries of an invention, which is paramount to a more efficient allocation of investment in invention.[17] Knowing in detail the boundaries that define a claimed invention allows inventors to avoid inadvertent infringement upon the intellectual property of others and thus prevents unnecessary and wasteful litigation. By holding the users of technology liable for infringement regardless of whether it is intentional or not, the patent system assigns the burden of avoiding litigation to these users. Given that infringers face significant consequences upon infringement, it is imperative that technology users are enabled to identify and understand applicable patent rights with reasonable certainty and that such clearance efforts can be undertaken at a reasonable cost.[18] An effective patent notice limits the uncertainty regarding infringement liability by informing the public

[15] *See* W. Brian Arthur, The nature of technology: what it is and how it evolves, (2009) (describing the 'combinatorial evolution' of technology, thereby highlighting that new technologies do not come from nowhere but arise as combination of other technologies).

[16] *See* Suzanne Scotchmer, Standing on the Shoulders of Giants: Cumulative Research and the Patent Law, 5 J. ECON. PERS. 29, 29 (1991) (contending that "most innovators stand on the shoulders of giants, and never more so than in the current evolution of high technologies, where almost all technical progress builds on a foundation provided by earlier innovators" and providing many examples of technologies that are improvements of earlier technologies.).

[17] *See* Festo Corp. v. Shoketsu Kinzoku Co., 535 U.S. 722, 730-31 (2002) (holding that "The patent laws "promote the Progress of Science and useful Arts" by rewarding innovation with a temporary monopoly. U. S. Const., Art. I, § 8, cl. 8. The monopoly is a property right; and like any property right, its boundaries should be clear. This clarity is essential to promote progress, because it enables efficient investment in innovation. A patent holder should know what he owns and the public should know what he does not.").

[18] *See* FED. TRADE COMM'N, The Evolving IP Market Place: Aligning Patent Notice and Remedies With Competition ch.3. 73, 74 (2011) (stating that "under its strict liability regime, the patent system confers patent rights and assigns the burden of avoiding infringement to users; as a corollary, the system also needs to facilitate users' ability to identify and understand the patent rights at hand" and "fundamentally, an effective notice system, in which prospective technology users can ascertain applicable patent rights at reasonable cost and with reasonable certainty, is essential for patents to operate as a property system.").

about the outer bounds of a patentee's right to exclude.[19] The lower this uncertainty, the less time and effort a third party needs to spend on resolving conflicts and the more it can focus on activities that the patent systems aims to incentivize.[20]

3.2.2 The deficiencies of patent notice

Although the benefits of an effective patent notice are certainly compelling in theory, empirical research concerning the effectiveness of patent notice has produced inconclusive results.[21] For example, based on a survey of US-inventors of patented inventions, Jaffe and his contributors found that less than five percent of the surveyed inventors considered patent documents to have had a significant influence on the development of their inventions.[22] On the other hand, Cohen and colleagues, based on a survey of the R&D managers of large US-enterprises, found that more than half of the respondents considered patent documents to be at least moderately important for their ongoing R&D projects.[23] Despite these seemingly mixed empirical results, there is a strong consensus among legal commentators that the potential benefits of disclosing technological information through patent documents are not fully realized in practice.[24] In particular,

[19] *See* FED. TRADE COMM'N, The Evolving IP Market Place: Aligning Patent Notice and Remedies With Competition ch.3. 73, 75-76 (2011) (expressing that patent notice "helps third parties and patentees to avoid uncertainty as to their rights" and that "such uncertainty can greatly inhibit innovation and competition.").

[20] *See* FED. TRADE COMM'N, Hearing on the Evolving IP Marketplace: Fulfilling the Patent System's Notice Function 123 (Mar. 19, 2009) (statement of David J. Kappos) (noting that a notice function that is not functioning well forces all participants to "...spend undue amounts of effort on dealing with conflict instead of employing people, investing in doing research and development to create more innovation."), available at https://www.ftc.gov/sites/default/files/documents/public_events/evolving-ip-marketplace/090319transcript.pdf.; Ibid at 132 (stating that "the lack of clarity around patent rights...routinely forces action to move away from technology areas, move into different technology areas, steer clear of innovations that [one would] otherwise want to invest in.").

[21] *See* Lisa Larrimore Ouellette, Do Patents Disclose Useful Information?, 25 HARV. J. L. & TECH. 546, 561-565 (2012) for a comprehensive overview of existing surveys of the value of patent disclosures.

[22] *See* Adam B. Jaffe, Manuel Trajtenberg & Michael S. Fogarty, The Meaning of Patent Citations, in Adam B. Jaffe & Manuel Trajtenberg, Patents, Citations and Innovation: A Window on the Knowledge Economy 379, 389-390 (2002).

[23] *See* Wesley M. Cohen et. al., R&D Spillovers, Patents and the Incentive to Innovate in Japan and the United States, 31 RES. POL'Y. 1349, 1362-1364 (2002); Lisa Larrimore Ouellette, Do Patents Disclose Useful Information?, 25 HARV. J. L. & TECH. 546, 561-565 (2012) (highlighting that the results of the Cohen study have been interpreted very differently by various legal commentators).

[24] *See* Lisa Larrimore Ouelette, Do Patents Disclose Useful Information?, 25 HARV. J. L. & TECH. 546, 561-565 (2012) (arguing that the surveys that legal commentators refer to in order to support the strong

commentators advance that existing legal requirements do not adequately encourage the authors of patent applications to include technological information that is useful to the public. Their arguments mainly center around three properties of the information contained in patents; its *uniqueness*, its *completeness* and its *clarity*.

Concerning *uniqueness*, the main argument raised is that the patent system does not encourage the dissemination of information that would otherwise not become publicly available.[25] This argument is founded on the conjecture that some inventions are inherently more self-revealing in nature than others and that it is the more self-revealing inventions for which patent protection is most suitable. After all, these inventions can be reverse-engineered with relative ease once they enter the public domain, whereas inventions that are not self-revealing are less vulnerable to such efforts and can often be protected effectively through secrecy.[26] Insofar as the patent system only encourages the disclosure of inventions that readily disclose themselves once they enter the public domain, patent documents do not convey information that third parties could not obtain through other channels. Therefore, patent documents may present the public with little unique information.

Although this argument is certainly compelling, it has been refuted on multiple grounds. First, many patented inventions never become commercially available, because patent rights themselves do by no means impose the requirement on patentees to prac-

that patents are not a useful source of information for inventors do not necessarily provide empirical evidence to support this strong claim.)

[25] *See* Benjamin N. Roin, The Disclosure Function of the Patent System (Or Lack Thereof), 118 HARV. L. REV. 2007, 2015 (2005) (questioning the assumption that "when an inventor files for a patent, she discloses information to which the public would not otherwise have access in exchange for the exclusive rights to her invention").

[26] *See* Alan Devlin, The Misunderstood Function of Disclosure in Patent Law, 23 HARV. J. L. & TECH. 401, 418 (2010) (suggesting that "other things being equal, innovators patent inventions that they believe are vulnerable to reverse engineering" and concluding that "the concerns of many commentators that a patent system without disclosure would cause information to remain hidden indefinitely are misplaced" and highlighting that "patent laws likely were not designed to appeal to the inventors of concealable technology, for whom trade secret is the avenue of greatest allure."); Benjamin N. Roin, The Disclosure Function of the Patent System (Or Lack Thereof), 118 HARV. L. REV. 2007, 2015 (2005) (stating that "the reason why many inventors file for a patent is that their secret will be disclosed to the public as soon as they begin using or selling their inventions." and "many inventions that are difficult to reverse engineer will never be patented because the inventor would be unable to detect infringement, rendering the patent of little value.").

tice their inventions.[27] For these inventions the patent document may very well be the only source of information that is readily available to the public. Second, when inventions do become commercially available, the average time-to-market in most industries is considerably lengthier than the average time between the filing and publication of a patent application.[28] Thus, third parties often have access to the information that is enclosed in patent documents long before reverse-engineering efforts can even be thought of. Third, even if an invention is susceptible to successful reverse-engineering, it may be less time-consuming and costly to retrieve information from patent documents.[29] Fourth, even though a patent document itself may not contain unique information, its existence may inspire the dissemination of relevant information about the invention through other channels.[30] An example of such 'peripheral disclosure' is an academic scientist whose employer only allows her to present or publish the results of her research

[27] *See* Jeanne C. Fromer, Patent Disclosure, 94 IOWA L. REV. 539, 545 (2009) (emphasizing that "the patent right is not an exclusive right to market or practice a particular invention"); Continental Paper Bag Co. v. Eastern Paper Bag Co., 210 U.S. 405, 429 (1908) (explicitly stating that "...exclusion may be said to have been of the very essence of the right conferred by the patent, as it is the privilege of any owner of property to use or not use it, without question of motive"); Kurt M. Saunders, Patent Nonuse and the Role of Public Interest as a Deterrent to Technology Suppression, 15 HARV. J.L. & TECH. 389, 391 n.10 (2002) (referring to several empirical studies to support the claim that "approximately forty to ninety percent of issued patent are not used or licensed by the patentee.").

[28] *See* Benjamin N. Roin, The Disclosure Function of the Patent System (Or Lack Thereof), 118 HARV. L. REV. 2007, 2016 (2005) (noting that "in pharmaceuticals, for example, it takes years for most patented inventions to reach the market, and patent disclosures can therefore provide public access to information long before it could be reverse engineered from the final product").

[29] *See* Benjamin N. Roin, The Disclosure Function of the Patent System (Or Lack Thereof), 118 HARV. L. REV. 2007, 2017 (2005) (arguing that "because reverse engineering can be expensive, a patent disclosure may be more efficient at broadly disseminating information, specifically to companies outside the patentee's industry."); Jeanne C. Fromer, Patent Disclosure, 94 IOWA L. REV. 539, 558 (2009) (stating that "patentees regularly make commercially available inventions difficult to take apart and understand, increasing the cost and decreasing the effectiveness of reverse-engineering as a way to understand an invention."); Alan Devlin, The Misunderstood Function of Disclosure in Patent Law, 23 HARV. J. L. & TECH. 401, 405 (2010) (noting that "when reverse engineering is necessary due only to a lack of effective patent disclosure, capital expended on such engineering is socially wasteful, even if the end result is otherwise desirable.").

[30] *See* FED. TRADE COMM'N, Hearing on the Evolving IP Marketplace: Recent Scholarship in Patent Markets 200-201 (Apr. 17, 2009) (statement of Polk Wagner) (highlighting that "the fact that people patent means that they go on and they give papers or they produce products or they do other things that then provide the information about the innovation, even if the patent itself isn't a particularly great medium for transferring the technological knowledge").

after a patent has been applied for.[31] Finally, empirical studies reveal that inventors do not only seek patent protection for inventions that are self-revealing but also for those that are not.[32] This is a strong indication that the patent system does in fact encourage the disclosure of unique information that would otherwise remain secret.

Concerning *completeness* and *clarity*, commentators' main concern is that existing legal disclosure requirements do not provide sufficient incentives for patentees to adequately disclose their inventions. There is an inherent tension between the public interest for information to be disclosed as completely and clearly in patent documents as possible and the private interest of patentees to limit the opportunities of third parties to appropriate rents from their inventions. The rationale underlying this tension is largely axiomatic. The more complete and clear the information conveyed in a patent document, the more it reveals about the inner workings and legal boundaries of an invention, and thus, the lower the costs of potential competitors of a patentee to invent around or build upon her invention. Patentees, therefore, have an incentive to withhold or obfuscate information that is relevant, necessary or even vital to fully understand the inner workings of their inventions and the limits of their rights thereto.[33] This disincentive is the reason why legal disclosure requirements are needed to warrant an adequate disclosure of inventions.[34] Given that inventors have little to no incentives to disclose more information than strictly required, these requirements determine the amount and nature of the information that will be disclosed. Despite the strong statutory language of these requirements however, commentators regularly cite anecdotal

[31] *See* Jason Rantanen, Peripheral Disclosure, 74 U. PITT. L. REV. 1, 16-37 (2012) (defining peripheral disclosure as "the non-patent sharing of information. . . that is being provided by an inventor in a form other that the patent document. . . [and] that an inventor could not share with the public without losing some ability to monetize the invention under a regime relying on secrecy to appropriate the value of an invention" and providing several examples of peripheral disclosure).

[32] *See* Alan Devlin, The Misunderstood Function of Disclosure in Patent Law, 23 HARV. J. L. & TECH. 401, 432 (2010) (concluding that "the phenomenon of inventors patenting non-self-revealing technologies demonstrates that patent law's disclosure function continuous to have value in many instances" and mentioning three explanations for the existence of this phenomenon).

[33] *See* Suzanne Scotchmer & Jerry Green, Novelty and Disclosure in Patent Law, 21 RAND J. ECON. 131, 132 (1990) (noting that "disclosing technical information confers a positive externality on a firm's competitors, which the firm might want to avoid.").

[34] *See* Alan Devlin, The Misunderstood Function of Disclosure in Patent Law, 23 HARV. J. L. & TECH. 401, 419 (2010) (arguing that current disclosure requirements ". . . create a disincentive to seek patent protection by requiring inventors to reveal the inner working of their discoveries, thus reducing the cost to their rivals of recreating those inventions.").

evidence to support their claim that only few patents contain written descriptions that allow for the invention to be carried out by a third party. Whilst, some attribute this to an insufficient enforcement of existing requirements, others go as far as suggesting that these requirements allow for, if not, encourage the exclusion of relevant technological information from patent documents.

3.3 Patent Notice and the Market for Patent Monetization

3.3.1 Patent notice as driver of technology transactions

A third and often overlooked benefit of patent notice is that it can facilitate the transfer of technology which, according to economic commentators, has considerably gained in importance since the beginning of the 1990s. Although the utilitarian justification primarily highlights the importance of the patent system for getting inventions developed, increasing activity on 'markets for technology' has led commentators to recognize that the patent system may be equally important for getting these inventions put to use. There is an extensive economic scholarship suggesting that in today's knowledge-based economy the capabilities needed to develop inventions are increasingly removed from the capabilities that are needed for commercializing them.[35] Due to the increasing complexity of technologies and the globalization of markets it is often not feasible for a single firm to be the source of all innovative aspects of a product. A firm that initiates the development of an invention is not necessarily the one that is best positioned to bring it to the market. And even if a firm is able to successfully commercialize an invention it may not be able to oversee all of its potentially useful applications. As a result, innovation processes have become more 'open' in the sense that the pathway to inno-

[35] *See* e.g. Ashish Arora *et.* al., Markets for Technology: The Economics of Innovation and Corporate Strategy ch.1. 1, 2 (2001) ("This vision of knowledge creation integrated with knowledge use has become inadequate for understanding economic growth in the twenty-first century. Over the past ten to fifteen years, there has been a rapid growth in a variety of arrangements for the exchange of technologies or technological services, ranging from R&D joint ventures and partnerships to licensing and cross-licensing agreements, to contracted R&D. Although we lack comprehensive empirical measures of the increase in such arrangements over time, all the available evidence suggests that the trade in technologies is more common than it was in the past."); See Henry Chesbrough & Marcel Bogers, Explicating Open Innovation: Clarifying an Emerging Paradigm for Understanding Innovation, in Henry Chesbrough *et. al.*, New Frontiers in Open Innovation 1, 27 (2014) (observing that companies cannot afford to solely rely on their own R&D in an era in which the sources of knowledge for innovation are widely distributed in the economy).

vation often transcends the boundaries of a single entity.[36] This trend is manifested in the development and growth of markets for technology where exchanges involve intermediate technological outputs rather than commercial end products.[37]

Markets for technology have the potential to become important drivers of economic growth and consumer welfare by allowing for a division of labor between the entities that invent and the entities that commercialize most efficiently.[38] The entities that do not possess the capabilities and resources that are needed to commercialize inventions can specialize in the development and supply of technology, whilst the entities that do possess these capabilities and resources no longer need to develop all their technologies in-house. By offering a pathway to innovation without commercialization, such specialization increases both the supply of technology and the competition among technologies by lowering the entry barriers for entities that do not have the resources to manufacture, market and distribute their inventions.[39] This is illustrated by the entry of many small-and medium-sized enterprises that make a profitable business as specialist suppliers of technology to larger manufacturing firms since the beginning of the 1990s. A greater supply of and competition among technologies not only leads to the development of qualitatively better and cheaper technologies but also to technologies that can be applied more widely and can be distributed to consumers faster.[40] In essence, a division of innovative labor allows for gains to be made from trading technologies, and the magnitude of these gains are dependent on the efficiency of markets for technology.

An effective patent notice can positively affect the functioning of these markets in two primary ways. First, by disclosing the subject matter of claimed inventions, patents

[36] *See* Henry Chesbrough & Marcel Bogers, Explicating Open Innovation: Clarifying an Emerging Paradigm for Understanding Innovation, in Henry Chesbrough *et. al.*, New Frontiers in Open Innovation 1, 27 (2014) (defining open innovation as "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with each organization's business model.").

[37] *See* e.g. Ashish Arora *et. al.*, Markets for Technology: The Economics of Innovation and Corporate Strategy ch.1. 1, 2 (2001).

[38] *See* e.g. Ashish Arora *et. al.*, Markets for Technology: The Economics of Innovation and Corporate Strategy ch.1. 1, 9 (2001) (contending that "technology markets are a precondition for the existence of specialized technology suppliers operating in vertical markets" and that "specialization and division of labor is a powerful determinant of industry and economic growth.").

[39] *See* FED. TRADE COMM'N, The Evolving IP Market Place: Aligning Patent Notice and Remedies With Competition ch.1. 31, 33 (2011).

[40] *See* FED. TRADE COMM'N, The Evolving IP Market Place: Aligning Patent Notice and Remedies With Competition ch.1. 31, 33 (2011).

signal the availability of technologies to potential buyers, licensees, investors and collaborators and bring these parties together with the owners of technologies. Second, patents define rights on intangible concepts making it easier for parties to negotiate and form contractual agreements. An effective patent notice helps to overcome what economists refer to as Arrow's information paradox.[41] Named after economist Kenneth Arrow, this paradox describes the inherent information asymmetry that exists between an entity expressing interest in a given technology and the proprietor of this technology. Whereas the former cannot assess the authenticity of the technology without having sufficiently detailed information about it, the latter has an incentive to disclose as little information as possible. Due to the non-excludable and non-rivalrous nature of public goods, the disclosure of too much information may reduce the interested party's willingness to pay and may erode the bargaining position of the proprietor. On the other hand, the disclosure of too little information may devalue the technology to a price level that the proprietor is not willing to accept because the interested party cannot determine whether the technology is genuine or not. As a result, both parties lose in this game and transactions that rationally should happen – those that would benefit both the proprietor and the interested party – may not materialize. This situation is more intuitively explained by a practitioner who draws parallels with the functioning of consumer markets:

> *It's just like the situation where you're shopping for any kind of a product, and you're not sure if you're looking at the genuine thing, right? Whether it's a watch or a car or whatever, you wind up in conflict over the value of it because you don't have confidence in its authenticity. [. . .] "When we look at [a] watch we don't know whether it's really a Rolex, so, we're going to devalue that thing, right? And on both sides of the equation, if it's a genuine thing you're not going to get enough for it because of the devaluation factor. And on the other side, you're not willing to pay enough for it because you're concerned that it might not be genuine. So, ironically, I think sort of everybody loses in this equation. There is a tremendous amount of unproductive effort spent. And then the result winds up being suboptimal at the very end of all of that effort.*[42]

[41] *See* Kenneth J. Arrow, Economic Welfare and the Allocation of Resources for Invention, in 609 NAT'L BUREAU OF ECON. RES., The Rate and Direction Of Inventive Activity, (1962).

[42] *See* Fed. Trade Comm'n, Hearing on the Evolving IP Marketplace: Fulfilling the Patent System's Notice Function 131-132 (Mar. 19, 2009) (statement of David J. Kappos).

Patents can remedy this situation by offering protection from misappropriation by third parties and encouraging inventors to disclose relevant information that they would otherwise have kept secret. Although patents do not necessarily simplify the valuation of inventions, they do at least provide a starting point for negotiations between technology owners and interested third parties. As a result, patents are often an integral part of technology exchanges and have as such become transactable pieces themselves.

3.3.2 The significance of transparent patent ownership information

The adequate disclosure of an invention for which patent protection is sought is one of the patentability requirements commonly imposed by patent offices.[43] Although there are differences between the procedural requirements that patent offices impose, they generally require that an acclaimed invention is described in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.[44] A patent document should at least contain one or more claims that define the critical elements of an invention, such that the patent examiner can assess whether it meets the other patentability requirements of novelty, non-obviousness/inventive step and usefulness/having an industrial application.[45] The requirement to codify inventions conform the standards of patent offices is a strict one in the sense that a failure to do so has serious implications for the parties having an ownership interest in a (prospective) patent. It can provide grounds both for the refusal of a patent application during the pre-grant stage as well

[43] *See* WIPO, WIPO Intellectual Property Handbook: Policy, Law and Use, 21 (2004).

[44] *See* for instance Art. 112 of the United States Code (USC) Title 35 requires that the specification of an invention "…shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention…". Art. 83 of the Convention on the Grant of European Patents (European Patent Convention) of 5 October 1973, Munich (EPC): "The European patent application shall disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art". . *See* also Margarete Singer and Dieter Stauder, The European Patent Convention: A Commentary: Procedural patent law, article 90 to article 178. Sweet and Maxwell, London, p. 355; Halpern SW, Seymore SB, Port KL (2015) Fundamentals of United States intellectual property law: copyright, patent, trademark. Wolters Kluwer, Alphen aan den Rijn, p. 197.

[45] *See* e.g. Art. 27(1) Agreement on Trade Related Intellectual Property Rights 1994 (TRIPS), Art. 52(1) EPC, 35 U.S.C. 101, 35 U.S.C. 102, 35 U.S.C. 103. See also 38 WIPO (2004) supra n 43, p. 17-21; Cottier T, Vron P (2015) Concise international and European IP law: TRIPS, Paris Convention, European enforcement and Transfer of technology. Kluwer Law International, Alphen aan den Rijn, p. 92; Singer and Stauder (2003), supra n 44, p. 64; Halpern et al. (2011), supra n 44, p. 196).

as for the revocation of a patent during the post-grant stage. The requirement for an adequate disclosure of inventions is therefore a powerful instrument for reducing the uncertainty about the function and characteristics of patent-protected technologies. Reducing this uncertainty lowers the aforementioned information asymmetry that characterizes markets for technology.

For a technology transfer to occur though, the detailed information describing an invention must be complemented with information concerning the ownership interest in this invention. Hence, purposive technology transactions can only be established by a formal agreement of some sort with the actual owner(s) of technologies. Therefore, even the most detailed information regarding the functions and characteristics of a technology is of little use to an interested buyer or licensee, unless the owner(s) of that technology is known to her. This by default demands that the potential buyer or licensee can identify the owner(s) of an invention ex ante the transaction. Transparent ownership information is generally thought of as being part of the 'social contract' between a patentee and society and providing accurate patent ownership information is therefore an obligation and not a matter of choice. [46] Patent authorities generally impose rules that require for the owner of an application for an original patent to be established when the original application is filed. The original applicant is presumed to be the owner of an application for an original patent and any patent that may be issued therefrom unless she assigns her ownership rights to another entity. The original applicant can exercise this right either pre-grant or post-grant and there is in principle no limit to the number of times that the ownership of a patent can change. It is this right to assign that provides the legal foundation for the transferability of patent-protected technologies.

However, commentators have raised concerns that suggest that the requirements for the registration of assignments as currently imposed by patent authorities and the enforcement thereof are ineffective to an extent that they are detrimental to the transparency of ownership. It has even been suggested that a lack of transparency of ownership has become a competitive tool for entities that are commonly associated with

[46] *See* Colleen Chien, The Who Owns What Problem in Patent Law, (2012), 1,1 available at http://digitalcommons.law.scu.edu/facpubs/190 (stating that "asking applicants and patentees "who owns it?" in order to provide this information to the public is well within the scope and statute and the [USPTO's] reasonable interpretation of it" and "asking for changes in ownership to be provided in the course of other communication with the patent office (office actions, maintenance fees, etc.) is a sensible and minimally burdensome way of getting it").

abusing the patent system for financial gain. Most notably, based on a thorough analysis of the activities of the well-known patent assertion entity – Intellectual Ventures – Ewing and Feldman conclude that the *"…current laws provide limited opportunities for identifying and tracking activity in… [technology markets] …and many opportunities for hiding…"*.[47] As an example, they describe a case in which Intellectual Ventures recorded a change of ownership for a patent only 2,506 days after the date that the agreement had been executed. This effectively means that Intellectual Ventures could not be identified as the owner of the patent that had been assigned to it for a period of almost seven years. Although this case might be considered extreme, in a detailed description of assignments recorded with the USPTO, Marco *et. al.* show that relatively long time-lags between the execution and recordation of ownership changes are certainly not an exception.[48] They note that although a timely recordation with the USPTO should, in principle, occur at the latest three months after the date of execution, the average time lag between execution and recordation amounts to 182 days and is increasing since 2005.

Although these findings strongly suggest that not all assignments are recorded in a timely fashion, they are likely to capture only a share of the lack of transparency of ownership in technology markets. To the extent that current patent provisions are indeed ineffective for monitoring ownership changes and provide opportunities for entities that want to hide their ownership, these entities might opt not to report an ownership change at all.[49] In other words, the total population of patent ownership changes may be unobservable, which limits the inferences that can be made on the basis of recent applications of patent assignments as indicators of technology transfer in economic literature.[50] In economic terms, there may be a selection bias if recorded

[47] *See* Tom Ewing and Robin Feldman, The Giants Among Us, STAN. TECH. L. REV. 1, 37 (2012).

[48] *See* Alan Marco *et. al.*, The USPTO Patent Assignment Dataset: Descriptions and Analysis, USPTO Working Paper No. 2015-2. (2015), available at: https://ssrn.com/abstract=2849634.

[49] The USPTO itself acknowledges this issue, by courtesy of the following disclaimer on the website of its online repository of assignment documents; "…When relevant information is given to the USPTO to be recorded in the USPTO's assignment database, the USPTO simply puts the information on the public record and does not verify the validity of the information. Recordation is a ministerial function–the USPTO neither makes a determination of the legality of the transaction nor the right of the submitting party to take the action…". *See* http://assignment.uspto.gov.

[50] For example, by utilizing the USPTO Patent Assignment Database, Serrano CJ, The dynamics of the transfer and renewal of patents. RAND J. Econ. 41, 686. explores general patterns of technology trading whilst Galasso, Schankerman and Serrano, 2011, explore the relation be- tween technology trading and the

assignments are not representative of the whole population of assignments. The notion that ownership changes may be reported relatively late after their execution date or may not be reported at all implies that the likelihood of identifying the actual owner(s) of a technology for which patent protection is sought, may be considerably lower once the ownership of this technology has been assigned. Thus, somewhat paradoxically, whilst the adequate disclosure of ownership enables transactions of patent-protected technologies, such transactions might in turn have a negative effect on the adequate disclosure of subsequent ownership. Given that patent authorities are the ones responsible for regulating and monitoring the registration of patent ownership changes, this observation warrants a thorough examination of their patent provisions concerning the registration of ownership changes and the enforcement thereof.

Therefore, in the two subsequent paragraphs we present a legal comparative analysis of the requirements that six different patent authorities impose concerning the recordation of patent ownership changes. To provide a complete understanding of the rationale behind these requirements we start our analysis in section three with an examination of patent provisions concerning the establishment of the initial applicant(s) of a patent prior to and at the date of grant. Hence, requirements concerning the recordation of ownership changes are likely to be better understood in light of the ways in which patent authorities establish the identity of the initial applicant(s) of a patent. In section four we focus specifically on patent provisions with regard to patent ownership changes that may occur both prior to and after grant. We include five national patent offices – the United States Patent and Trademark Office (hereafter USPTO), the Japanese Patent Office (hereafter JPO), the French Institut National de la Propriété Industrielle (hereafter INPI), the German Patent and Trade Mark Office (hereafter DPMA) and the United Kingdom Intellectual Property Office (hereafter UK IPO) – and one regional patent office – the European Patent Office (hereafter EPO) – in our analysis. These patent offices were selected provided that they are the most active patent offices in terms of patents granted and are known to exert variation in legal provisions concerning patent-related matters.

enforcement of patent rights and Serrano (2011) estimates the gains from trade on markets for technology.

3.4 The Establishment of the Initial Applicant(s)

3.4.1 The right to initiate a patent application

Prior to analyzing in depth, the requirement to disclose the identity of the initial patent applicant(s), it is essential to understand how the patent offices under study establish who has the right to initiate a patent application and thus consequently become a patent applicant. Each patent office has dedicated provisions in place that specify who has the right to apply for a patent and depending on the patent office, three aspects are taken into account in order to define whether a person has the right to apply for a patent: (i) whether the person is the inventor or assignee; (ii) whether the person is a natural or a legal person and (iii) whether the person meets certain residence or nationality requirements.

Concerning the first aspect, the regulations in all jurisdictions under study indicate that a patent application can be initiated either by an inventor herself or by her successor in title (e.g. an assignee).[51] Nevertheless, if an applicant is not an original inventor, an inventor has the right to be mentioned as an inventor.[52] Moreover, the request for grant of a patent in some jurisdictions needs to contain the designation of the inventor/inventor's oath or declaration which allows to identify an inventor.[53] If an applicant

[51] *See* Art. 60(1) EPC; 37 Code of Federal Regulations (C.F.R) 1.42; 35 U.S.C. 118; Art. 29(1) of the Japanese Patent Act (JPA); Art. 33(1) JPA; Art. 34 JPA; L611-6 of the French IP Code (CPI); Section 6 of the German Patent Law (PatG); Section 7(2) of the UK Patent Act (UK PA). See also Singer and Stauder (2003), supra n 44, p. 184; Haedicke M, Timmann H (2014) Patent law: a handbook on European and German patent law. Beck, Mnchen, p. 246 and 344; Doi T (2007). Japan. In: Vanhees H, Blanpain R (eds.) Intellectual Property. Kluwer Law International, The Hague, p. 104; Kawaguchi H (2007) The essentials of Japanese patent law: cases and practice. Kluwer Law International, Alphen aan den Rijn, p. 36; Pollaud-Dulian F (2011) Proprit intellectuelle: la proprit industrielle. Economica, Paris, p. 212; Torremans P (2008) Holyoak and Torremans: intellectual property law. Oxford university press, Oxford, p 94; Thorley S, Miller R, Campbell D, Burkill G, Birss C (2006) Terrell on the law of patents. Sweet and Maxwell, London, p. 42.

[52] In spite of that assignment, an inventor has the right to be mentioned as an inventor in the patent, e.g. Art. 4ter Paris Convention for the Property of Industrial Property; Art. 62 EPC; 25 U.S.C. 115 (a); Art. 36(1)(ii) JPA; L611-9 CPI; Section 37 PatG; Section 63 PatG; Section 13 UK PA; Section 10 UK Patent Regulations (PRs). See also Cottier et al. (2015), supra n 45, p. 242; Singer and Stauder (2003), supra n 44, p. 200; Doi (2007), supra n 50, p. 105; Pollaud-Dulian (2011), supra n 50, p. 213; Haedicke and Timmann (2014), supra n 50, p. 245; Thorley *et. al.* (2006), supra n 50, p. 45.

[53] *See* for instance Art. 81 EPC; Rule 19 EPC Regulations; 35 U.S.C. 115; Section 37 PatG; Rule 10 UK PRs; point 7 of the UK IPO Patent Form 7 Statement of inventorship and of right to grant of a patent. *See* also Guidelines for Examination in the European Patent Office 2015 (EPO Guidelines for Examination), A-III, 5.3; Haedicke and Timmann (2014), supra n 50, p. 386; Thorley *et. al.* (2006), supra n 50, p. 45.

is not an inventor or is not the sole inventor, the EPO, for instance, has to communicate to a designated inventor information about the applicant and her application[54] which is meant to prevent applications being made without consent of the inventor. In case an invention was developed by more than one inventor and/or was assigned to more than one person, the application can be filed jointly.[55] It is important to note that prior to the implementation of the America Invents Act in 2012, a patent application by the USPTO could only be filed by an inventor. Currently, the USPTO identifies three scenarios: the filing of an application by an inventor[56]; the filing of an application by a party other than the inventor (by an applicant-assignee)[57] and the issuance of a patent to a non-applicant assignee[58]. Prior to the reform a patent application could only be filed by an inventor or on behalf of the inventor[59].

Considering that the right to apply for a patent can be assigned from an inventor (a natural person) to another natural person or a legal person (e.g. organization whose employee developed an invention), the regulations in all six jurisdictions specify that a patent application can be filed not only by a natural person but also by a legal person.[60] A typical example of an assignment of a patent application from a natural person to a legal person is the obligation of an inventor-employee to assign her rights to apply for patent protection to her employer.[61] This requirement is generally specified in an employment agreement.

Finally, some patent offices take into consideration the residence or nationality requirements when establishing whether an inventor or assignee has the right to apply

[54] *See* Rule 19 (3) EPC Regulations. See also EPO Guidelines for Examination, A-III, 5.4; Haedicke and Timmann (2014), supra n 50, p. 245.

[55] *See* Art. 59 EPC; 37 C.F.R. 1.42; 37 C.F.R. 1.45; Art. 38 JPA; L613-29 CPI; Section 6 PatG; Section 7(1) UK PA. See also EPO Guidelines for Examination, A-II, 2; Singer and Stauder (2003), supra n 44, p. 181 and 186; Doi (2007), supra n 50, p. 107; Pollaud-Dulian (2011), supra n 50, p. 214; Haedicke and Timmann (2014), supra 50, p. 248; Torremans (2008), supra n 50, .p 94; Thorley et al. (2006), supra n 50, p. 42.

[56] *See* 35 USC 111.

[57] *See* 35 USC 118.

[58] *See* 35 USC 152.

[59] *See* 35 USC 118 (pre-AIA).

[60] *See* Art. 58 EPC; Section 4(2) PatV. *See* also EPO Guidelines for Examination, A-II, 2; Singer and Stauder (2003), supra n 44, p. 180; Haedicke and Timmann (2014), supra n 50, p. 344; Kawaguchi (2007), supra n 50, p. 35.

[61] *See* Art. 60(1) EPC; Art 35(2) JPA; L611-7 CPI; Section 13 of the Gesetz uber Arbeitnehmererfindungen 1957 (ArbnErfG); Section 29 UK PA. *See* also Singer and Stauder (2003), supra n 44, p. 187; Doi (2007), supra 45, p. 104; Kawaguchi (2007), supra n 50, p. 36; Pollaud-Dulian (2011), supra n 50, p. 223; Torremans (2008), supra n 50, p 95; Thorley *et. al.* (2006), supra n 50, p. 43.

for a patent. For instance, the JPO does not allow foreign nationals who do not have a residence or domicile in Japan to file a patent application.[62] However, the filing is allowed in case a patent applicant satisfies the requirement of reciprocity.[63] In some jurisdictions it is foreseen that the patent applicant, who is not a resident or a national of the country in question may appoint an agent (e.g. a lawyer or a patent attorney) to represent her in that particular country.[64]

3.4.2 Determining the identity of the initial patent applicant(s)

Information requirements to accord a filing date

A review of the procedures of the patent offices under study to accord a filing date reveals that in all six jurisdictions an applicant in general does not have to provide detailed information about her identity at the initial patent application stage. Although there are some minor differences between offices regarding the scope of the requirements to accord a filing date, the requirement to provide the necessary information that allows for the applicant to be contacted is the only requirement that needs to be fulfilled in order to initiate the patent application process.

Whereas no specific requirement to provide information regarding the identity of a patent applicant to accord a filing date is advanced by the USPTO, it is indicated in the regulations that "when filing an application, a correspondence address must be set forth in either an application data sheet, or elsewhere, in a clearly identifiable manner, in any paper submitted with an application filing".[65] If the applicant does not provide a correspondence address, the USPTO "may treat the mailing address of the first named inventor as the correspondence address".[66] The EPO does explicitly include the requirement to provide information regarding the identity of a patent applicant and requests

[62] *See* Art. 25 JPA. *See* also Doi (2007), supra n 50, p. 104; Kawaguchi (2007), supra n 50, p. 35.

[63] *See* Art. 25 JPA, Doi (2007), supra n 50, p. 104: "Article 25 provides the status of aliens as follows: an alien who has neither domicile nor residence (a business establishment, in the case of a legal entity) in Japan shall not enjoy patent rights or other rights relating to patents, except in cases that come under the following items: (i) where the country of his nationality entitles Japanese nationals to enjoy patent rights or other rights relating to patents under same conditions as its nationals; (ii) where the country of his nationality is prepared to entitle Japanese nationals to enjoy patent rights or other rights related to patents under the same conditions as its nationals, if Japan entitles the nationals of that country to enjoy patent rights or other rights relating to patents; (iii) where otherwise provided in a treaty".

[64] *See* for instance Section 25 PatG.

[65] *See* 37 CFR 1.33(a).

[66] *See* 37 CFR 1.33(a).

the provision of "information identifying the applicant or allowing the applicant to be contacted".[67] According to the Guidelines for Examination in the EPO, "any kind of information which allows the applicant to be contacted will be considered to fulfill requirement in particular: (a) the name and address of the applicant's representative, (b) a fax number, (c) a PO box number".[68]

The same level of information is requested by the INPI[69] and the UK IPO[70]. The UK IPO carefully specifies in its Formalities Manual which parts of the provided form "Request for grant of a patent" (Form 1)[71] need to be filled in to provide sufficient information to "identify the person applying for a patent" and "enable that person to be contacted by the patent office"[72,73]. In practice, however, the UK IPO may accord a filing date even if not all the aforementioned requirements are fulfilled at the time of filing. It can be sufficient to provide contact information such as "name, e-mail, telephone number and/or mobile number".[74] In addition to the requirements of INPI and the UK IPO, the DPMA also prescribes to provide the name of the applicant and file a request for the grant of a patent, in which additional information about the identity of a patent applicant must be provided.[75]

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[67] *See* Rule 40(1)(b) EPC.

[68] *See* the EPO Guidelines for Examination, A-II, 4.1.2. Moreover, in case there are multiple applicants, it will be considered sufficient if information concerning only one of the applicants is provided (EPO Guidelines for Examination, A-II, 4.1.2).

[69] *See* L612-2 CPI. *See* also Pollaud-Dulian 2011, p. 242.

[70] *See* Section 15(1) UK PA. See also Torremans 2008, p. 48.

[71] F1 is Patents Form 1 'Request for grant of a patent'.

[72] *See* Section 15(1b) UK PA.

[73] In particular, sufficient information includes: "the name and address of the applicant in part 2 of the F1; the name and address or other contact details for an agent or an address for service in part 4 of the F1; an e-mail address, telephone number or fax number of a contact point for the applicant recorded in part 12 of F1". *See* UK IPO Formalities Manual, 2.05. Similar to the UK IPO, the DPMA prescribes to fill in the provided form that specifies the exact amount of information with regard to the identity of the applicant in Section 4 PatV.

[74] *See* the UK IPO Manual of Patent Practice, Section 15, p. 2. Moreover, if the application is submitted without a name and address of an applicant or an agent but a contact phone number, e-mail address or other contact details were indicated, the UK IPO will try to contact the applicant in order to grant a filing date (UK IPO Formalities Manual, 2.06)

[75] *See* Section 35(1) PatG. See also Haedicke and Timmann (2014), supra n 50, p. 464 and 476.

Information requirements to initiate the formal examination of patents

At the stage of formal examination patent examiners require more detailed information about the identity of an applicant at the initial date of application. Generally, the document that applicants need to provide to examiners is referred to as a request[76], except for the USPTO, where the term used is the 'application data sheet'.[77] An important part of the content of the request/ data sheet is the identification of an applicant.[78]

At the USPTO, the application data sheet[79] should be provided when an application is filed by the person other than an inventor, regardless of whether it is a provisional or nonprovisional application.[80] The data sheet contains information about the applicant[81] which "includes the name (either natural or legal person) and address of the legal representative, assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the

[76] *See* Art. 78(1)(a) EPC; Rule 57(b) EPC Regulations. See also Haedicke and Timmann (2014), supra n 50, p. 372.; Art. 36 (1) JPA; R 612-3 CPI; Section 34(3) PatG; Section 14(2) UK PA. The components of the request may vary depending on the patent office (Art. 4(1) PCT; Art. 4 PCT Regulations; Rule 41(1) EPC Regulations; 37 CFR 1.76; Art. 36(1) JPA; R612-10 CPI; Section 4 PatV; Section 12(1) UK PRs. *See* Haedicke and Timmann (2014), supra n 50, p. 372 and 468; Doi (2007), supra n 50, p. 105; Kawaguchi (2007), supra n 50, p. 173; Pollaud-Dulian (2011), supra n 50, p. 246.

[77] The similarity in the requirements in different patent offices can again be explained by the fact that the Patent Law Treaty 2000 (PLT) harmonized the maximum amount of formal requirements by making a reference to the ones applicable to the international applications under the Patent Cooperation Treaty 1970 (Art. 6(1) PLT). The logic cannot be applicable to Japan and Germany since they did not ratify the PLT but it is visible that Germany patent office was still influenced by the PCT standard. The PCT, among other documents, obliges a patent applicant to submit a request (Art. 3(2) PCT). The request consists of in total five components, among which one requires to provide the name of and other prescribed data concerning the applicant and the agent (if any) (Art. 4(1)(iii) PCT). In particular, the applicant needs to indicate the persons name, her address and her nationality and residence (Rule 4.5 PCT Regulations). When the applicant is a natural person her name shall be indicated by the persons family name and given name(s), the family name being indicated before the given name(s) (Art. 4.4(a) PCT Regulations). A legal entity is required to indicate its full, official designations (Art. 4.4(b) PCT Regulations). If there are multiple applicants, the indication of the address of only one of them is sufficient (Art. 4.4(d) PCT Regulations). To simplify the procedure the PCT provides a patent applicant with a special request form, which contains all the above-mentioned components (PCT Request Form PCT/RO/101).

[78] *See* 37 CFR 1.76; 41(2) EPC Regulations; 36(1) JPA; R612-10 CPI; Section 4 PatV; 12(1) UK PRs.

[79] *See* 37 CFR 1.76.

[80] *See* 37 CFR 1.46(b). The application data sheet also "must be submitted when required by § 1.55 or 1.78 to claim priority to or the benefit of a prior-filed application under 35 U.S.C. 119, 120, 121, 365, or 386" (37 CFR 1.46(a)).

[81] *See* 37 CFR 1.76(b).

matter".[82] To facilitate the application process, the UPSTO provides an applicant with an application data sheet form.[83] However, if a nonprovisional application is submitted by an inventor, it suffices to only file an inventor's oath or declaration, which focuses on disclosing the name of the inventor.[84] The document needs to identify "each inventor by his or her legal name; and a mailing address where the inventor customarily receives mail, and residence, if an inventor lives at a location which is different from where the inventor customarily receives mail, for each inventor".[85] For a provisional patent application, instead of the inventor's oath or declaration, the applicant is obliged to include a cover sheet[86] or a cover letter which specifies that the application is a provisional application.[87] If those documents are not provided, the application will be treated as a nonprovisional one.[88] Both documents require to identify an inventor.

The EPO, JPO, INPI, DPMA and UK IPO also provide clear instructions concerning the information about the identity of an applicant that has to be provided in the request. Similar to the application data sheet form of the USPTO, these offices provide applicants with a special 'request form' that they need to fill in, in order to facilitate the application process and make sure that the information provided by every applicant is similar.[89] Deviating from the USPTO, this request form has to be sent regardless of whether the application is initiated by an inventor herself or not. Generally, patent applicants need to provide their names, addresses and nationality, residence or principle place of business.[90] When it comes to the identity of an applicant, nearly all patent

[82] *See* 37 CFR 1.76(b)(7).

[83] *See* http://www.uspto.gov/sites/default/files/documents/aia0014.pdf

[84] *See* 35 USC 111(a)(2)(c); 35 USC 115, 37 CFR 1.63.

[85] *See* 37 CFR 1.63(b). This information has to be supplied, unless the indicated information is provided in an application data sheet (37 CFR 1.76).

[86] The cover sheet identifies: (i) the application as a provisional, (ii) the name or names of the inventor or inventor or inventors, (iii) the residence of each named inventor, (iv) the title of the invention, (v) the name and registration number of the attorney or agent (if applicable), (vii) the correspondence address, and (viii) the name of the US Government agency and Government contract number. 37 CFR 1.51(c). Similar to an application data sheet the USPTO provides a cover sheet form.

[87] See 37 CFR 1.53(c)(1).

[88] *See* 37 CFR 1.53(c)(1).

[89] *See* EPO - Request for grant of a European patent Form 1001., INPI - La requête en délivrance, DPMA Antrag auf Erteilung eines Patents, UK IPO Request for grant of a patent Form 1.

[90] *See* 41(2)(c) EPC Regulations: 'the name, address and nationality of the applicant and the State in which his residence or principle place of business in located'; 36(1) JPA: 'the name or appellation of the applicant and his domicile or residence'; R612-10(4) CPI: 'the surname and name(s) of the applicant, his nationality, his place of residence or od business'; Section 4 PatV: 'information on the applicant'; 12(1) UK

offices distinguish between information that a natural person and a legal person need to provide. [91] Ultimately, at the stage of formal examination every patent office under study requests the provision of a sufficient detail of information that allows to identify and contact the initial patent applicant. Moreover, most patent offices require to disclose information concerning the representatives/agents of the initial applicant as well.[92]

3.4.3 The failure to establish an initial applicant

In case there are any deficiencies in the submitted documents, either during the preliminary examination to accord a filing date or during the examination of formal requirements, patent applicants are generally allowed to correct these deficiencies within a specified time frame.[93] The accordance of a filing date is considered as the first step of the examination process, and, therefore, a patent office will not proceed with the examination before a filing date is accorded. For instance, the USPTO will notify a patent applicant about the need to provide the required information in case some information is missing and request the patent applicant to provide the missing information within two months from the receipt of the notification.[94] In case of failure to provide the necessary documents after the expiration of this time period, the patent application will be withdrawn.[95] If the applicant complies with the requirements within two months, the USPTO will accord a filing date.

Identical procedures are established at the EPO, the INPI, the UK IPO and the DPMA.[96] However, the time period within which an applicant needs to provide re-

PRS 'full name, address and postcode of the applicant or of each applicant'. See also the mentioned above forms.

[91] Natural persons must indicate their family name and a given name, whereas legal persons must indicate their full official designations. The address must include all the relevant administrative units, including the house number and postal code. The EPO additionally asks for the correspondence address. The applicants are also asked to provide their phone number, email and fax. Rule 41(2)(c) EPC Regulations; Section 4 (1)(a) PatV. *See* also the request forms.

[92] *See* for instance identified request forms, Rule 41 (2)(d) EPC Regulations.

[93] *See* 37 CFR 1.53(b); 37 CFR 1.53(c); Art. 90 (4) EPC; Rule 55 and Rule 58 EPC Regulations; R612-8 CPI; R612-45 CPI; Section 35 (2,3) PatG; Section 42 PatG; Section 15(3) UK PA; Section 15A(6) UK PA; Section 12(2,3,9) UK PRs; Section 18 UK PRs. See also WIPO (2004), supra n 43, p. 25.

[94] *See* 37 CFR 1.53(e)(1); 37 CFR 1.181(f).

[95] *See* 37 CFR 1.53(e)(3).

[96] *See* Art. 90(4) EPC; Rule 55 EPC; R612-8 CPI; Section 35(2)(3) PatG; Section 15(3) UK PA. See also Haedicke and Timmann (2014), supra n 50, p. 404 and 476; Pollaud-Dulian (2011), supra 50, p. 242. The

quired information varies. The EPO, the INPI and the UK IPO, similarly to the USPTO, request the corrected documents to be submitted within two months from the receipt of the notification[97] whereas the DPMA limits the time period to one month.[98] The withdrawal of the application is also foreseen in case of non-compliance with the requirement.[99] If the applicant complies with the requirements within the prescribed time period, the filing date will be accorded the date of the receipt by the patent office of all required corrections.[100]

It is noteworthy that, despite the existing mechanism of correcting deficiencies, the issue of the identification of an applicant is unlikely to be subject of the correction at this stage of the examination process. In particular, as aforementioned, the USPTO does not even denote the document identifying an applicant as one that needs to be filed to accord a filing date. The EPO specifically excludes the failure to provide information identifying the applicant or allowing the applicant to be contacted from the ones that are subject to notification.[101] Similar to the EPO, the DPMA only refer to missing parts in the description and drawings, no reference is made to the missing parts in the request or failure to provide the name of the applicant.[102] Arguably this lack of attention to the identification of an applicant can be explained by the fact that in case the basic contact information is not provided then it is evident that it is not possible to continue the examination since no information can be transmitted to the patent applicant from the patent office. Thus, it is in the interest of the applicant to provide sufficient information enabling her to be contacted at this stage of the application process and it is unlikely that the applicant will deliberately not provide this limited amount of information to the patent office. Complete information is requested at the latter stage of examination. Consequently, potential deficiencies with regard to the identification of patent applicants can be corrected and completed during that stage.

In general, in order to successfully complete the formal examination of a patent application, a patent applicant has to satisfy all patent application requirements. If some requirements are missing or incomplete, the USPTO notifies an applicant and

JPO does not have a separate procedure of establishing a filing date.

97 *See* Rule 55 EPC; R612-8 CPI; Section 35(2)(3) PatG; Section 12(3, 9) UK PRs.

98 *See* Section 35(2)(3) PatG.

99 *See* Art. 90(2) EPC, R612-8 CPI, Section 12(3) UK PRs.

100 *See* Art. 5(4)(a) PLT; Art. 11(2)(b) PCT; Art. 90(5) EPC; Rule 55 EPC Regulations; 15(4) UK PA.

101 *See* Rule 55 EPC Regulations.

102 *See* Section 35(2)(3) PatG.

gives her the opportunity to correct the defects within specified time limits.[103] If an applicant fails to correct the identified deficiencies the application will be considered withdrawn.[104] The EPO, the INPI, the DPMA and the UK IPO also requests applicants to correct any deficiency[105], generally within the time limit of two months.[106] The non-compliance with the request will lead to a refusal of the application.[107] Since the identification of a patent applicant is part of the patent application requirements, the non-sufficient communication of this information may lead to refusal of the application. Thus, applicants are incentivized to timely submit the required information to avoid these negative consequences. This strict approach ensures that patent offices collect sufficient information about patent applicants.

3.4.4 The disclosure of the identity of initial applicants to the public

Patent offices not only collect information about the identity of a patent applicant but also disclose it to the public. The disclosure takes place twice: at the date of the publication of the patent application and at the date of publication of the granted patent. Provided that the formal examination of required documents has been successful, the USPTO publishes a patent application "promptly after the expiration of a period of 18 months from the earliest filing date for which a benefit is sought under the title".[108] The application can be published earlier, if an applicant so requests.[109] It must be noted that provisional applications are not published.[110] The scope of the published documents generally equals to the amount of information which was provided to the USPTO

[103] *See* CFR 37 CFR 1.53(f)(1); 37 CFR 1.53(g)(1). It must be noted that the USPTO indicated that the applicant will be given a period of time but the exact time is not specified in the provisions.
[104] *See* CFR 37 CFR 1.53(f)(1); 37 CFR 1.53(g)(1).
[105] *See* Art. 90(5) EPC; Section 45(1) PatG; Section 15A UK PA; Section 12(2) UK PA (the UK IPO specifically focuses on the identification of a patent applicant). *See* also Haedicke and Timmann (2014), supra 50, p. 373 and 469.
[106] *See* Rule 58 EPC Regulations, Art. 90(3)(4) EPC, Art. 90(5) EPC, Section 45(1) PatG, 18(1) DPMAV [at least one month], Section 12(3) UK PA.
[107] *See* Art. 90(5) EPC; L612-12 CPI; Section 48 PatG; Section 12(3) UK PA. It must be noted that the CPI only stresses that a patent application will be abandoned when one of the requirements are not met. However, it does not specify the procedure of modification and time limit. Such a procedure is only suggested when the inventor is not designated. The time limit of correcting it is 16 months (R612-11 CPI).
[108] *See* 35 USC 122(b)(1); 37 CFR 1.211.
[109] *See* 35 USC 122(b)(1).
[110] *See* 35 USC 122(b)(2); 37 CFR 1.211(b).

during the prior stages of the patent application process.[111] Identical procedures are established by the EPO, the JPO, the INPI, the DPMA and the UK IPO.[112] Thus, the information with regard to the identity of a patent applicant is made publicly available and can be found in the registries of patent offices.

After the successful completion of both the formal and substantive examinations, the USPTO grants a patent. It grants a patent to the person who applied for the patent[113], unless the patent was transferred and the patent office was notified about such transfer.[114] The patent owner obtains a certificate for a patent.[115] Afterwards, the USPTO publishes specifications and enters the information into the register.[116] The USPTO procedures are not significantly different from the ones established by the EPO, the JPO, the INPI, the DPMA and the UK IPO.[117] In particular, the mention of the grant is published in the official patent office gazette[118] and the specifications are also published soon after.[119] Each patent office also maintains a register, in which specific matters have to be registered and maintained.[120] Registers contain information about patent owners (e.g. names, addresses, nationality or residence or place of business).[121] Information about representatives/agents, where applicable, is also registered.[122] Consequently, the

[111] *See* 37 CFR 1.215(a)(b).

[112] *See* Art. 93 EPC; Rule 68 EPC Regulations; Art. 64 JPA (stresses that the name, and the domicile or residence of the applicant(s) for the patent is to be published (Art. 64(2)(i) JPA)); R612-39 CPI; L612-21(1) CPI; Section 31(2) PatG; Section 32(1)(2) PatG; Section 16 UK PA; Section 26(1) UK PRs; Section 44(1) UK PRs (in particular stresses that the name of the applicant and the address of the applicant and his address of service (Section 44(1)(a)(c) UK PRs)).

[113] *See* 35 USC 151.

[114] *See* 35 USC 152.

[115] *See* 35 USC 151; 35 USC 153.

[116] *See* 35 USC 10(a)(1); 35 USC 154; 35 USC 10(a)(1); 37 CFR 1.11(a). Access to the register is available electronically at http://patft.uspto.gov.

[117] *See* Rule 74 EPC Regulations; Art. 97(3) EPC; Art. 98 EPC; Art. 28(1) JPA; Art. 66(3) JPA; R612-71 CPI; L612-21 CPI; R612-74 CPI; Section 58(1) PatG; Section 32 PatG; Section 24 UK PA. It has to be noted that the registration of unitary patents at the EPO is foreseen in the separate part of the European Patent Register (Rule 16 I. 3 Draft Rules 1-24 relating to unitary patent protection consolidated version 2014 (Draft Rules on UPP).

[118] *See* Art. 97(3) EPC; L612-21 CPI; R612-74 CPI; Section 58(1) PatG; Section 32(5) PatG; Section 24(1) UK PA.

[119] *See* Art.98 EPC; Art. 66(3) JPA; L612-21 CPI; R612-75 CPI; Section 58(1) PatG; Section 32(1) PatG; Section 32(3) PatG; Section 24(3) UK PA.

[120] *See* Rule 143 EPC Regulations; Art. 27(1)(ii) JPA; L612-21 CPI; Section 30(1) PatG; Section 44(4) UK PRs. All patent offices provide electronic access to those registries.

[121] *See* Rule 143(1)(c) EPC Regulations; Art. 66(3)(i) JPA; Section 30(1) PatG; Section 44(4)(b) UK PRs.

[122] *See* Rule 143(1)(h) EPC Regulations; Section 30(1) PatG.

public can access all necessary information concerning the initial owner of a patent.

Overall it can be concluded that the USPTO, as well as other patent offices under study, have similar legal provisions governing the identification of patent applicants. All patent offices provide patent applicants with clear requirements concerning the scope of information that needs to be provided in order to sufficiently identify an applicant. Moreover, non-compliance with those requirements leads to negative consequences, such as refusal of a patent. Such a strict remedy should presumably motivate applicants to provide the requested information to patent offices in due time. In our view, since patent offices may refuse to grant a patent unless a patent applicant sufficiently discloses her identity, it can be concluded that patent offices value this information and acknowledge its importance. In addition, patent offices timely disclose the collected information to the public, acknowledging its relevance not only for patent offices but also for third parties.

3.5 The Recording of Patent Ownership Changes

We contend that in order to establish transparency of patent ownership it is insufficient to ensure that the information concerning the original applicant and owner is efficiently collected and disclosed to the public, given that patent applications and granted patents are often subject to ownership changes that are initiated by transactions (e.g. assignments), operations of law (successions, insolvency proceedings) or court decisions. Unless the changes of applicants during the pre-grant stage or owners during the post-grant stage is notified to the patent office in question, the information concerning the 'current' patent owner that is available to the public will be incorrect. It is therefore important to examine whether and to what extent the patent offices under study employ mechanisms that (i) allow initial or subsequent patent applicants and/or owners to notify them about ownership changes,[123] (ii) foresee effective remedies stimulating patent applicants or owners to request the recordation of the changes and (iii) monitor ownership information and transmit ownership changes to the public in a timely

[123] It must be noted that we only focus on the changes of ownership that occur during the prosecution of an application and after the grant, leaving aside issues pertaining to the assignment of rights to apply for a patent from an inventor to a third person. Moreover, we focus only on transfers of rights initiated by transactions, in particular transfers of ownership that are part of an assignment agreement, leaving aside transfers of ownership rights initiated by an operation of law or court decisions.

fashion.

3.5.1 The system for recording changes of patent applicant(s) and owner(s)

The possibility to record a change of applicant or owner is implemented in all patent offices under study.[124] However, the requirements concerning the recordation do vary across jurisdictions. Specifically, differences can be observed with respect to the following aspects: (i) the forms and documentation required; (ii) the parties that can file the request; (iii) the timing of recordation and (iv) the fees associated with the recordation.

Forms and required documentation

The USPTO establishes that in order to record a change of ownership the "document" has to be submitted to the patent office for recording and it has to be accompanied by a cover sheet.[125] However, the exact content of the document is not specified. Presumably, the submission of an assignment agreement is intended, however, there is no straightforward obligation to submit the agreement itself.[126] Thus, in principle the submission may relate to any document suggesting that a transaction took place.[127] More specific

[124] *See* Rule 22 EPC; Rule 85 EPC Regulations; 35 USC 261; 37 CFR 3.11(a); Art. 27(1)(i) JPA; L613-9 CPI; L613-55 CPI; Section 30(3) PatG; Section 30 UK PA; Section 32(2)(b) UK PA. See also Singer and Stauder (2003), supra 44, p. 262; USPTO MPEP, 301; Doi (2007), supra 50, p. 113; Thorley et al. (2006), supra n 50, point 10-12. The need for this mechanism is also acknowledged in the PLT. The PLT establishes that each contracting party should have a system installed allowing patent applicants or owners to record changes in the person of the applicant or owner (Rule 16 PLT Regulations). The PLT does not suggest that the recording should be obligatory; it only indicates that the recordation of the change of an applicant or owner should be possible and the necessary mechanisms should be established at patent offices.

[125] *See* 37 CFR 3.28.

[126] "The rules permit submission of true copies of assignment-related documents; original documents are not required nor desired, as they will not be returned." The word "permit" suggests that there is no obligation to submit copies of assignment-related documents. Moreover, the term "assignment-related documents" does not necessarily suggest that it has to be an assignment agreement.

[127] It must be noted that if the standing of the plaintiff (or defendant, depending on the circumstances) is questioned by the opposite party during the court proceedings, based on the assumptions that the plaintiff does not own a patent, the court will verify the rights possessed by the plaintiff. In Gaia Technologies Inc. v. Reconversion Technologies, Inc., United States Court of Appeal, Federal Circuit. August, 1996 the US Court of Appeals concluded that the appellant lacked standing based on the fact that she could not provide sufficient evidence demonstrating that she was an owner of a patent at stake. The appellant based her right on the minutes of the meeting of the shareholders. The evidence was not sufficient since "the relevant status require an assignment of patents. . . to be in writing". The judge based his analysis on the Arachnid Inc. v Merit Industries Inc. 939 F. 2d 1574, 19 USPQ2d 1513 (Fed.Cir.1991) where a similar problem was discussed. In Arachnid Inc. v. Merit Industries Inc. Arachnid tried to claim her rights by providing a

information is provided concerning the contents of the cover sheet. It needs to contain: (i) the name of the party conveying the interest; (ii) the name and address of the party receiving the interest; (iii) a description of the interest conveyed or transaction to be recorded; (iv) identification of the interests involved; (v) the name and address of the party to whom correspondence concerning the request to record the document should be mailed; (vi) the date the document was executed and (vii) the signature of the party submitting the document.[128] Thus, in principle the identity of a subsequent patent owner is sufficiently disclosed when all fields of the cover sheet are completed. For the simplification of the process of recording, the USPTO developed an online system for recording assignments – the Electronic Patent Assignment System (EPAS).[129] To the best of our knowledge, such a system currently only exists at the USPTO.

Similar to the cover sheet of the USPTO, the other five patent offices also advance that the request for recording has to be filed. [130] To simplify the process, the INPI, the DPMA and the UK IPO provide a specific application form[131] that needs to be submit-

consulting agreement as an evidence document. The court has decided that a consulting agreement, was considered not sufficient, since it "was an agreement to assign, not an assignment" and it "does not rise to the level of a present assignment of an existing invention" (at 1580, 19 USPQ2d).

[128] *See* 37 CFR 3.31.

[129] *See* http://epas.uspto.gov.

[130] *See* 22(1) EPC Regulations; http://www.jpo.go.jp/english/faqs/procedures.html#anchor2-5; R613-55 CPI; 28 DPMAV; 47(1) UK PRs. The similarities in the format can again be partly explained by the fact that Rule 16 of the PLT harmonized the procedure for the Member States. In particular, Rule 16(1)(a) PLT indicates that a change of an applicant should be registered upon a request for recordation "signed by the applicant or owner, or by the new applicant or new owner" and a delivery to a patent office of prescribed information and documents. It also suggests information that may be provided in the request: "(i) indication to the effect that a recordation of a change in applicant or owner is requested; (ii) the number of the applications or patents concerned; (iii) the name and address of the applicant or owner; (iv) the name and address of the new applicant or new owner; (v) the date of the change in the person of the applicant or owner; (vi) the name of a state of which the new applicant or new owner is a national if he is the national of any state, the name of a state in which the new applicant or new owner has her domicile, if any, and the name of a state in which the new applicant or new owner has a real and effective industrial or commercial establishment, if any; (vii) the basis of the change requested." A patent office may request additional documents (Rule 16(2) PLT), for instance, a copy of the contract verifying the transfer of application or ownership, so called 'evidence documents'.

[131] *See* the INPI form 'Demand d'inscription au register national d'un acte affectant la propriété ou la jouissance d'un depot'; the UK IPO Form 21; the DPMA 'Antrag auf Eintragung. It is also specified in a legal provision which exact information has to be indicated on the request. It needs to specify the file number of a patent; the name, domicile and address of the owner of a patent, information on the assignee; and in case the assignee has accorded a representative, the name and address of the representative (§28(2) (DPMAV).

ted to them. These offices may also request to submit additional evidence documents, e.g. any document proving the change of ownership (for instance, an assignment agreement or a declaration signed by the parties)[132]. Those evidence documents are either an obligatory part of a recordation, as in case for the EPO[133], the JPO and the UK IPO,[134] or may be requested in particular situations. For instance, the DPMA does not require to provide any evidence documents if the request is signed by both an initial patent applicant/owner and a subsequent applicant/owner or their representatives.[135] However, if the request is signed only by a subsequent applicant/owner, she needs to either attach a declaration signed by the registered applicant/owner or provide other evidence documents, such as an assignment agreement, proving that the assignment took place.[136] The evidence document needs to be signed both by an initial applicant/owner and a subsequent applicant/owner.

[132] *See* Rule 22(1) EPC Regulations; R613-56 CPI; §28(3)(2) DPMAV; Section 47(2) UK PRs. The EPO, for instance, specifies that "registrations of transfers (assignments) of European patent applications are recorded in the European Patent Register at the request of an interested party and on production of documents satisfying the EPO that the transfer has taken place. This might be a copy of or extract from an official document, or a declaration signed by both parties" (http://www.epo.org/service-support/faq/ownfile.html#faq-287). Thus, evidence documents do not have to be original assignment agreements. The JPO, however, seem to prescribe that "the original assignment document" has to be sent to the patent office. Instead of the original assignment document, you can submit a notarized copy of the document that has been certified by a notary public. A notarized copy of the document certified by a notary public is also admissible. http://www.jpo.go.jp/english/faqs/procedures.html#anchor2-5

[133] The EPO suggests that an interested party needs to provide "clear-cut evidence of a transfer" (Decision of the Legal Board of Appeal of 13 October 1998 (EPO J 26/95), point 2). In particular, the documents which "only created the obligation to assign rights" are not admissible since they "did not constitute the assignment itself" (Decision of Technical Board of Appeal 3.3.02 of 26 April 2012 (EPO T 1751/07), point 2). For example, in the Decision of the Legal Board of Appeal 3.1.1 of 24 January 2002 (EPO J 0012/00), it has been decided that the provided Employee Confidentiality and Inventions Agreement and the Proprietary Information and Inventions Agreement were not since "they both not equivalent to an assignment agreement" (point 7) and "they did not show clearly that an assignment of the co-applicant's right to the European Patent Application. . . had really been carried out" (point V). The EPO Legal Board of Appeal has also established that it is sufficient to provide extracts from the assignment agreements as evidence and not a full agreement: "the submission of extracts in the form of the pages concerning the transfer of rights is not unusual and is commonly attributable to the fact that, in the interests of the parties, not all details of such an agreement, which may be broader in scope, should be disclosed" (Decision of the Legal Board of Appeal 3.1.01 of 15 June 2015 (EPO J 0016-14), point 2.2.2).

[134] *See* Rule 22(1) EPC Regulations; Rule 47 UK PRs; http://www.jpo.go.jp/english/faqs/procedures.htm

[135] *See* § 28(3) DPMAV.

[136] *See* § 28(3) DPMAV.

The right to apply for the recording

The USPTO does not explicitly specify who has the right to apply for the recording of ownership changes. It seems that any party could file a cover sheet, for instance, through the Electronic Patent Assignment System (EPAS). Based on the provided information the change of ownership will be recorded. It is even more surprising that the provided information is not verified by the USPTO which is explicitly mentioned on the EPAS web page.[137] In our view such a practice can lead to inconsistences and incorrect recordings, considering that a person applying for the recording may not be obliged to provide any evidence documents.

The EPO allows 'any interested party' to request a recording.[138] However, in comparison to the USPTO, the EPO does oblige such a party to provide evidence documents with every application, such as a copy of an assignment agreement or a declaration signed by both parties. The other patent offices seem to be less flexible and specify that the recordation has to be requested at least by one of the parties to an assignment (or on their behalf).[139] For instance, the JPO foresees two scenarios: (i) either both a registered holder (registered applicant/owner) and a successor (subsequent applicant/owner) apply together for registration of an assignment or (ii) a successor can request the recordation with the written consent of the right holder.[140] A similar logic is applied by the DPMA: if the request is submitted only by the successor, evidence of the assignment has to be submitted.[141]

The timing of recording

The USPTO advises to record a change of ownership within three months from the date of an assignment to avoid potential negative consequences for the subsequent applicant/owner.[142] However, in general, the change of an applicant or an owner can be registered at any time during the lifecycle of a patent. A transfer is generally only acknowledged from the date when the office receives all the required documents and

[137] *See* https://epas.uspto.gov : "Assignment information provided by the user will be recorded as provided and will not be verified or modified by the USPTO."
[138] *See* Rule 22 EPC Regulations.
[139] *See* http://www.jpo.go.jp/english/faqs/procedures.html#anchor2-5; R613-55CPI; 28(3) DPMAV; 32.09 Manual of Patent Practice.
[140] *See* http://www.jpo.go.jp/english/faqs/procedures.html#anchor2-5.
[141] *See* 28(3) DPMAV.
[142] *See* 35 USC 261.

the fees are paid.[143] A noteworthy observation in the European contexts is that a change of an owner of a European patent can only be recorded by the EPO during the opposition period or during opposition proceedings.[144] The registration of transfers made afterwards fall within the responsibility of national patent offices. [145] It must be noted that, overall, the Rule 22 of the EPC Regulations governs both a change of ownership in European patents and unitary patents and the procedure of recording a change of ownership does not differ. However, when it comes to the timing of recordation, it can be presumed that the EPO will record a change of an owner of a unitary patent throughout the life of a patent since the EPO is under obligation to administer the Register for unitary patent protection.[146] Moreover, the unitary patent could only be transferred for all participating Member States simultaneously,[147] which, in comparison to the current European patent, significantly simplifies the search of the actual owner since owners of unitary patents cannot differ depending on the territory.

Fees

Only the USPTO and the DPMA do not impose the payment of any fees in order to record a change of applicant/owner.[148] However, recordation with the USPTO is only free of charge when the request is submitted through an online assignment system. If the request is not submitted electronically the fee amounts to 40 dollars.[149] The EPO requires the payment of 100 euros;[150] the INPI requires 26 euros per recording but limits the maximal payment to 260 euros if multiple recordings are requested[151]; the

[143] *See* for instance the Decision of the Technical Board of Appeal 3.4.01 of December 2010 (EPO T 0128/10): "According to Rule 22 EPC in conjunction with Rule 85 EPC, the procedural requirements to be fulfilled for recording the transfer of a European patent in the European Patent Register consist in the filing of a request of the interested party, the production of documents providing evidence of the transfer, and the payment of an administration fee. These requirements do not need to be fulfilled at the same time. If they are met on different dates, the transfer shall only have effect vis-à-vis the EPO at the date on which all the requirements mentioned above are fulfilled", point 3.5.

[144] *See* Rule 85 EPC Regulations.

[145] *See* IX., National law relating to the EPC.

[146] *See* Art. 9(1)(b) UPR.

[147] *See* Art. 3(2) UPR.

[148] *See* 37 CFR 3.41; Information of Costs, Fees and Expenses (A9510.1) of the German Patent and Trade Mark Office and of the Federal Patent Court 2014 do not specify any fees.

[149] *See* 37 CFR 3.41.

[150] *See* Fee code 022 http://www.epoline.org/portal/portal/default/epoline.Scheduleoffees.

[151] *See* Tableau annexe: redevances de procédure, Section 6, Arrêté du 24 avril 2008 relatif aux redevances de procédures perçues par l'Institut national de la propriété industrielle.

UK IPO requires 50 pounds[152]; the JPO requires 4,200 yen (around 30 euros) for a change of an applicant and 15,000 yen (around 120 euros) for a change of an owner[153].

Overall, the fees for recording a single change of ownership with most patent offices are relatively low. However, considering that entire bundles of patents can change ownership at the same time and that patent protection is territorial in nature the fees can add up to significant amounts quickly. Especially when an ownership change relates to inventions for which patent protection is sought in multiple jurisdictions, the fees associated with the recording of ownership changes might discourage parties to record such changes of ownership. In the European context, this problem is partially mitigated by the unitary patent since a change of ownership is recorded for all participating Member States simultaneously.[154] Thus, in comparison to the European patent, the fee to record an ownership change is considerably lower.

3.5.2 The failure to record changes of applicant(s) and owner(s)

The USPTO specifies that a non-recorded assignment may be void "against any subsequent purchaser or mortgagee... unless it is recorded in the USPTO within three months from its date or prior to the date of such subsequent purchase or mortgage".[155] This means that a subsequent transaction will prevail over the previous and the former will lose the rights to the patent. Nevertheless, the remedy may not be effective when the assignment of rights is initiated by an operation of law (succession, insolvency), since the registered patent owner seized to exist and there is no risk that a patent will be subsequently assigned. On the other hand, according to the EPO the rules regulating the recording of the change of ownership are not applicable in the context of universal succession in law (e.g. inheritance and merger).[156] Thus, the universal succession may

[152] *See* Rule 6 Schedule 1 PRs.

[153] *See* https://www.jpo.go.jp/tetuzuki_e/ryoukin_e/ryokine.htm.

[154] *See* Art. 3(2) UPR.

[155] *See* 35 USC 261. See also AIPPI US Q190 'Contracts regarding Intellectual Property Rights (assignments and licenses) and third parties', p. 2.

[156] *See* Decision of Technical Board of Appeal 3.3.04 of 17 June 2004 (T 15/01), point 11. In this case, the Technical Board of Appeal concluded that "when an applicant or patentee ceases to exist, his universal successor in law [in this case the subject was a merger] immediately and automatically acquires the party status in proceedings pending before the EPO". On the contrary, if a subsequent patent owner obtains rights, for instance, through an assignment agreement, the EPO established that she lacks standing unless the change of ownership was recorded before the proceedings (see more explanation below and footnote...). In addition, the EPO established that the "change of name does not alter the identity of the

in general be treated as an exceptional case and may not be a good example to question effectiveness of established remedies. The effectiveness of the remedy established by the USPTO can also be questioned when there is a close relationship between an assignee and the assignor and/or a high level of trust is established between the two. Under these circumstances it is unlikely that any subsequent purchase will occur and, therefore, a non-registered subsequent owner will not bear any negative consequences of not recording the change of ownership. Since in the USC a remedy of non-enforceability is not foreseen, it can be assumed that the non-recordation of a change of ownership cannot prevent the subsequent owner from defending her rights in court.[157] However, the opposite party can in principle question the ownership status that will be subsequently verified by the court.[158]

A 'USPTO-type remedy' is also established by the UK IPO[159] which in addition indicates that if the recording is not done within six months from the transaction, the court or comptroller shall not award the actual owner costs or expenses.[160] The INPI and DPMA induce a broader effect of non-recording a change of applicant or owner: non-enforceability of patent rights against third parties until the recording is made.[161]

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legal person" (Decision of the Legal Board of Appeal 3.1.01 of 27 July 2006 (EPO J 0016/05 3.1.01), p. 12).

[157] *See* In Gaia Technologies Inc. v. Reconversion Technologies, Inc., United States Court of Appeal, Federal Circuit. August, 1996 it is stated that "the recording of an assignment is necessary only to protect the assignee from subsequent bona fide purchasers without notice".

[158] *See* In Gaia Technologies Inc. v. Reconversion Technologies, Inc., United States Court of Appeal, Federal Circuit. August, 1996, the appellant could not prove she was the owner of a patent, since she could not provide sufficient evidence documents and, thus, lacked standing. However, if the appellant proved she was a legitimate owner of a patent by providing sufficient evidence (an assignment agreement), she would be allowed to defend her rights in court and the proceedings would continue. "If Gaia can prove that it was the assignee of the Intellectual Property at the time the suit was filed, Gaia has standing to sue for the patent infringement under 25 USC 281 (1994) as a patentee". It must be noted, however, that in this case the change of ownership was recorded by the UPSTO, though without obtaining and verifying any evidence documents. A case where the non-recording of a change of ownership prior to initiating court proceeding amounted to lack of standing was not found most probably due to the fact that, as it was mentioned above, the USC does not connect the enforceability of patent rights and the need to record change of ownership. The proof of rights, when questioned during the court proceedings, is sufficient to have standing.

[159] *See* Section 33(1) UK PA. See also AIPPI UK Q190 'Contracts regarding Intellectual Property Rights (assignments and licenses) and third parties', p. 1.

[160] *See* Section 68 UK PA. *See* also AIPPI UK Q190, p. 1; Thorley *et. al.* (2006), supra n 50, point 10-21.

[161] *See* Section 30(3) PatG; R613-55 CPI. See also AIPPI Germany Q190 Contracts regarding Intellectual Property Rights (assignments and licenses) and third parties, p. 4; AIPPI France Q190 Contracts regarding Intellectual Property Rights (assignments and licenses) and third parties, p. 2.

This effectively means that the registered owner remains subject to rights and obligations, including the enforceability of patent rights, until the change of ownership is recorded. As aforementioned, most patent offices do not impose a strict time limit for the recordation and subsequent patent owners may potentially record the change at any time, for instance, prior to initiating a lawsuit. Despite the fact that the EPC does not specify any remedy for the non-recording of a change of applicant or owner, the EPO case law reveals that the patent office follows the similar logic as the INPI and DPMA. In particular, the non-recorded subsequent patent owner cannot defend its rights during proceedings at the EPO and the registered owner will be considered to be the legitimate party.[162] Moreover, the recordation of a change of ownership needs to be completed before the expiry of the period for filing the notice of appeal if the subsequent owner decides to appeal the decisions of the Receiving Section, Examining Divisions, Opposition Divisions or the Legal Division; otherwise the appeal filed by the non-recorded subsequent owner will be inadmissible.[163] With regard to the unitary patent, it can be assumed that the subsequent owner would also need to record her rights to be viewed as a legitimate party to the proceeding before the EPO or the Unified Patent Court(UPC).

The stronger enforcement mechanism is arguably established by the JPO. The JPO goes beyond the non-enforceability against third parties effect and provides that an assignment needs to be recorded with the patent office for it to take effect between the contracting parties (succession in law excluded).[164] However, the JPO does not specify

[162] *See* Decision of the Enlarged Board of Appeal of 25 May 2005 (EPO G 0002/04): The procedural status of the proprietor cannot be transferred without the substantive title; Interlocutory Decision of the Technical Board of Appeal 3.3.03 of 24 November 2005 (EPO T 0261/03): "A first condition to be met is that the competent organ of the EPO before which the opposition proceedings are pending be informed about the transfer of the relevant business. It follows from the established case law of the EPO that without such a notification the transferor of the business remains opponent and the transferee does not acquire opponent status", point 3.2.; Decision of the Technical Board of Appeal 3.4.01 of 10 December 2010 (EPO T 0128/10-3.4.01), point 2.2; Decision of the Technical Board of Appeal 3.4.01 of 1 December 2011 (EPO T 0960/08.4.01): The boards of appeal have consistently held that formal requirements have to be fulfilled for the opponent status to be considered transferred, point 2.2.

[163] In particular, it is stated that for a transferee of a patent to be entitled to appeal, the necessary documents establishing the transfer, the transfer application and the transfer fee pursuant the Rule 20 EPC [currently Rule 22 EPC] must be filed before the expiry of the period for appeal under Article 108 EPC [within 2 months]. Later recordal of the transfer does not retroactively validate the appeal (Decision of the Technical Board of Appeal 3.3.4 of 18 May 2001 (EPO T 656/98), headnote; see also Decision of the Technical Board of Appeal 3.4.01 of 10 December 2010 (EPO T 0128/10 3.4.01), point 3.8).

[164] *See* Art. 34(4) JPA; Art. 98 JPA; AIPPI Japan Q190 Contracts regarding Intellectual Property Rights (assignments and licenses) and third parties, p. 1; Doi (2007), supra n 50, p. 120.

the time limit for such recordation. In any case, if in practice the contractual obligation between contracting parties does not take effect unless it is recorded, a subsequent patent owner may be more motivated to record an assignment to ensure that the transaction is legitimate. In other patent office under study the legitimacy of the contractual transaction is not directly conditioned on the registration of the change of ownership. However, it is unclear whether this stronger remedy is strictly enforced. If the parties may register the transaction at any moment (e.g. prior to initiating a lawsuit) without any negative consequences, this remedy in practice would not be stronger than the one established by the USPTO. The only risk a subsequent patent owner undertakes is that the registered owner may assign the patent to another party in the meantime and the previous transaction would not be valid since it was unregistered.

Overall, it can be concluded that the potential repercussions for not recording a change of applicant or owner are generally not very strict, especially not when it comes to the EPO, the INPI and the DPMA where no time limits for the recordation are imposed and the repercussions of non-enforceability can be easily avoided. Similarly, the "subsequent purchaser" remedy may not be effective, for instance, when there is a low level of risk that the registered owner will reassign a patent (e.g. when there is high level of trust between the parties). Given that the repercussions are not severe, parties may not be motivated to record a change of ownership when it is executed but only record it when it is absolutely necessary, for instance, in order to enforce a patent. Moreover, in case of USPTO and UK IPO patents, the right to enforce a patent by the subsequent owner does not depend on the prior recordation. The subsequent owner of a UK IPO patent in case of non-recording within six months from the assignment, however, risks losing costs and expenses awarded during the litigation. In our view, this potential financial disadvantage may incentivize a subsequent owner to record a change of ownership.

3.5.3 The disclosure of changes of ownership to the public

Another important aspect to consider is whether patent offices transmit the acquired information related to the change of ownership to the public. As aforementioned, all patent offices under study maintain a register of interests in patents.[165] The changes of ownership are entered to the registries of all patent offices under study. The UK

[165] *See* 35 USC 261; Rule 143(w) EPC Regulations; 27(1)(i) JPA; R613-53 CPI; 30(3) PatG; 44(6) UK IPRs.

IPO specifies that the change "must be entered in the register as soon as practicable after it occurs (or, if later, when the application is published)."[166] No other patent office provides any reference to the timing of entrance of the collected information to the registry.

It can be concluded that, on the positive side, all patent offices under study installed a system allowing initial patent owners and/or their successors to record a change of ownership. However, the system has a lot of limitations. The major drawback, in our view, is that there is frequently no time pressure to register the change of ownership which indirectly allows the parties to do it when it is absolutely necessary. Moreover, not every patent office imposes a party requesting a change of ownership to be recorded to provide evidence documents, which may lead to errors.[167] In addition, there is a risk that some patent offices accept low quality evidence documents, such as employment agreements instead of assignment agreements, which constitute an obligation to assign the rights but do not prove that an assignment took place.[168]

Overall the procedure of requesting a recording seems to be relatively easy: parties need to submit a request, in some cases evidence documents, and pay fees. This narrow scope of the requirements, in our view, is not demanding and can be complied with. This view is also supported by the EPO which claims that "the procedure is particular simple and easy to comply with", "merely because the requirement is so simple to comply with, is no reason to ignore it".[169] Unfortunately, the simplicity of the process clearly does not encourage patent owners to record the change of ownership. On the contrary, it is

[166] *See* 44(6) UK PRs.

[167] *See* for instance In Gaia Technologies Inc. v. Reconversion Technologies, Inc., United States Court of Appeal, Federal Circuit. August, 1996 the appellant was registered as an owner in the UPSTO registry. The UPSTO made a recording of a change without obtaining the copy of assignment. However, the judge concluded, when assessing whether the appellant (registered owner) had standing in the proceedings, that the appellant did not have standing since she could not provide a document confirming the ownership. Thus, the changes of ownership registered at the USPTO may contain errors.

[168] This assumption follows from the Decision of the Legal Board of Appeal 3.1.1 of 24 January 2002 (EPO J 0012/003.1.1), where the Board rejected to record the change of ownership based on the Employee Confidentiality and Inventions Agreement and the provided by the appellant to prove her rights. The Board states that the documents "are both not equivalent to an assignment document" and that "these documents are only…a basis for further assignment" (point 7). The appellants disagreed and referred to the Decision of the Australian Patent Office which found the assignment legitimate and recorded the change of ownership. Thus, it is evident that there is a difference between the quality of the examination of provided documents between patent offices.

[169] *See* Decision of the Technical Board of Appeal 3.3.4 of 18 May 2001 (EPO T 656/98), point 3.4.

perceived as an extra administration burden (especially when the recording needs to be done in multiple patent offices) and a waste of financial resources. The potential need to translate relevant documents into national languages may also complicate the procedure and increase associated costs. The engagement into incurring extra expenses is only justifiable for some owners when there is a clear need to be identified, such as enforcement of patent rights in case of the EPO, INPI and DPMA patents. Not to mention that some owners strategically decide not to disclose their identity. This so-called "voluntarily" recordation of change of ownership significantly downgrades the quality of registries maintained by patent offices. A third party cannot be certain that the registered owner is an actual owner and would be forced to search for other means of obtaining this important piece of information.

3.6 Legislative Initiatives to Improve the Transparency of Patent Ownership

In response to executive actions announced by the White House on June 4^{th}, 2013 to "help bring about greater transparency to the patent system and level the playing field for innovators", the USPTO published a Notice on "Proposed Changes to Require Identification of Attributable Owner" on February 20^{th}, 2014. To the best of our knowledge, this notice represents the only attempt directly aimed at making patent ownership information more readily available to the public that has been initiated in the jurisdictions that we study. Despite the fact that the EPO and the European Commission also acknowledge flaws in the recordation of patent ownership changes[170], the USPTO Notice is not met by equivalent initiatives, including the on-going the Unitary Patent Package (UPP) initiative. The USPTO Notice proposes several modifications to 37 CFR Part 1 that relate to (i) which information needs to be provided to the USPTO when filing a notice, (ii) the occasions in which a notice that identifies a current owner needs to be provided and (iii) the consequences of non-compliance with the suggested rules.

[170] *See* Report of the Expert Group on patent aggregation, p. 57.

3.6.1 The identification of the attributable owner(s)

The notion of attributable owner

With the notion of 'attributable owner' the USPTO refers to two types of entities: (a) titleholders and (b) enforcement entities.[171] The titleholder is an entity that "exclusively or jointly has been assigned title to the patent or patent application".[172] The enforcement entity is an entity that is "necessary to be joined in a lawsuit in order to have standing to enforce the patent or any patent resulting from that application".[173] Information about these types of entities is currently not collected by the USPTO. However, since those entities are "real-parties-in-interest", having the right to enforce a patent[174], their identity should ideally also be publicly disclosed alongside the identity of titleholders.

Moreover, the Notice foresees the possibility that the actions of a titleholder or an enforcement entity may be controlled by another entity. For this reason attributable owner(s) would also need to provide information about the identity of the 'ultimate parent entity'.[175] An ultimate parent entity is defined as "an entity which is not controlled by any other entity".[176] To have the complete picture of 'who-owns-what' the USPTO would ideally obtain information with regard to so-called 'hidden beneficial owners'[177], referring to entities that are attempting to hide their identity by "temporarily divesting themselves of ownership rights through contractual or other arrangements".[178] The Notice further specifies what is understood by the term 'entity'. Primarily it can be "a natural person, corporation, company, partnership, joint venture, association, joint-stock company, trust, estate of a deceased natural person, foundation, fund, or institution,

171 *See* Federal Register 2014 79(16), p. 4109.
172 *See* 37 CFR 1.271(a)(1).
173 *See* 37 CFR 1.271(a)(2).
174 *See* Federal Register 2014 79(16), p. 4107.
175 *See* 37 CFR 1.247(b), Federal Register 2014 79(16), p. 4110.
176 *See* 16 CFR 801.1(a)(3).
177 *See* Federal Register 2014 79(16), p. 4110. In 37 CFR 1.271(c) the hidden beneficial owner is defined as "any entity that, directly or indirectly, creates or uses a trust, proxy, power of attorney, pooling agreement, or any other contract, arrangement, or device with the purpose or effect of temporarily divesting such entity of attributable ownership of a patent or application, or preventing the vesting of such attributable ownership of a patent of application".
178 *See* Federal Register 2014 79(16), p. 4110.

whether incorporated or not, wherever located and of whatever citizenship".[179]

The requirements for identifying the attributable owner(s)

In 37 CFR 1.271(f) the Notice specifies that an entity needs to provide to the USPTO in order to sufficiently identify the attributable owner. Different levels of information are required depending on the type of entity in question. A natural person is obliged to provide "the full legal name, residence and a correspondence".[180] If an attributable owner is a public company, its name, "stock symbol, and stock exchange where the company is listed" must be specified.[181] To identify a non-public company, its name, "place of incorporation, and address of the principle place of business" must be provided.[182] The identification of a partnership must include "the name of the partnership and address of the principle place of business".[183] With regard to any other entity the following information must be submitted: "its name, if organized under the laws of state, the name of the state or legal form of organization, and address of the principle place of business".[184]

3.6.2 Occasions for submitting information concerning the identity of the attributable owner(s)

There are in total six occasions listed in the Notice at which a patent applicant or owner is requested to provide information about the current attributable owner(s). Those six occasions can be grouped into two categories: (1) the identification of the attributable owner(s) in pending applications and (2) the identification of the attributable owner(s) in patents involved in proceedings before the office.

[179] *See* 37 CFR 1.271(d)(1). For more details on the term 'entity' see 37 CFR 1.271(d)(2)(3)(4). Additionally, in 37 CFR 1.271(e) the proposal specifies that the term 'entity' "does not include any foreign state, foreign government, or agency thereof (other than a corporation or unincorporated entity engaged in commerce), and also does not include the United States, any of the States thereof, or any political subdivision or agency of either (other than a corporation or unincorporated entity engage in commerce).
[180] *See* 37 CFR 1.271(f)(4).
[181] *See* 37 CFR 1.271(f)(1).
[182] *See* 37 CFR 1.271(f)(1).
[183] *See* 37 CFR 1.271(f)(3).
[184] *See* 37 CFR 1.271(f)(5).

The identification of the attributable owner(s) in pending applications

The first category includes three occasions at which the attributable owner needs to be identified: (i) during the filing stage of a patent application, (ii) in case of an ownership change during the patent prosecution stage and (iii) at the receipt of the notice of allowance. First, the attributable owner needs to be the first to be identified of all identified parties during the filing of a patent application, a reissue application and "each international application that commenced the national stage under 35 USC 371(b) or (f)".[185] It must be noted that the provision is only applicable to nonprovisional patent applications under 35 USC 111(a). The requirements do not apply to either provisional patent applications or international applications prior to the commencement of the national stage (35 USC 371(b) or (f)).[186]

Second, in case the attributable owner has changed during the prosecution of a nonprovisional application or during the pendency of an international application under 37 CFR 1.495(b), the Notice proposes to oblige a patent applicant to file a notice that identifies current attributable owner(s) within the three month period from the date of the change[187], whereby the three-month period cannot be extended.[188] Again, these requirements do not apply to provisional patent applications or international applications prior to the commencement of the national stage (35 USC 371(b) or (f)).[189]

Third, the USPTO suggests that once a patent applicant receives the notice of allowance[190], the applicant needs to file a notice that identifies the current attributable owner(s) to the office. This document must be sent within three months from the date that the notice of allowance has been sent.[191] As in the previous case, this time limit cannot be extended.[192] If there has been no change, the patent applicant is still obliged to send a notice and indicate that there has been no change of attributable owner(s).[193]

It should be noted that the failure to comply with identification requirements are dealt with differently depending on the occasion. If a nonprovisional patent applica-

185 *See* 37 CFR 1.273.
186 *See* Federal Register 2014 79(16), p. 4112.
187 *See* 37 CFR 1.275, Federal Register 2014 79(16), p. 4112.
188 *See* 37 CFR 1.275.
189 *See* Federal Register 2014 79(16), p. 4112.
190 *See* 37 CFR 1.311.
191 *See* 37 CFR 1.277.
192 *See* 37 CFR 1.277.
193 *See* 37 CFR 1.277.

tion has been accorded a filing date but the patent applicant failed to identify the attributable owner[194], the patent applicant will be notified about the failure and given a specified period of time to correct the deficiency.[195] In the Notice it is explained that the information needs to be sent within the period of two months which can potentially be extended up to eight months.[196] However, if the applicant fails to send the required document within this time frame, the patent application will be abandoned.[197] The patent application may result in abandonment also in case of failure to confirm that the recorded attributable owner information is accurate within a three-month period form the date of sending the notice of allowance.[198]

The identification of the attributable owner(s) involved in proceedings before the office

The second category also comprises three proposed occasions at which a patent owner is required to identify the current attributable owner(s): (i) the payment of maintenance fees, (ii) the initiation of patent trial and appeal board trial proceedings and (iii) the engagement in supplementary examination or re-examination proceedings. First, a notice needs to be sent prior to each payment of maintenance fees within the time period specified in 37 CFR 1.362(d)(e).[199] It should be noted that the period for payment is rather broadly defined, e.g. 3 to $3^1/_2$ years after grant for the first maintenance fee, 7 to $7^1/_2$ years after grant for the second maintenance fee, and 11 to $11^1/_2$ years after grant for the third maintenance fee.[200] Thus, an owner of a patent is required to file a notice of attributable ownership after every four year window up until the last maintenance payment. A notice also needs to be send if no change of attributable ownership has taken place.[201]

Second, the Notice suggests to require a patent owner to identify the attributable owner when any Patent Trial and Appeal Board Trial Proceedings is initiated for a patent

[194] As well as if an international application (complying with 37 CFR 1.495(b)) fails to identify the attributable owner (Federal Register 2014 79(16), p. 4112).
[195] *See* 37 CFR 1.273, Federal Register 2014 79(16), p. 4112.
[196] *See* Federal Register 2014 79(16), p. 4112.
[197] *See* 37 CFR 1.273.
[198] *See* 37 CFR 1.277, Federal Register 2014 79(16), p. 4112.
[199] *See* 37 CFR 1.381.
[200] *See* 37 CFR 1.362(d).
[201] *See* 37 CFR 1.381.

at stake. In such cases the notice identifying the current attributable owner needs to be submitted simultaneously with a mandatory notice required by 37 CFR 42.8(a)(**??**).[202] Moreover, if the attributable owner has changed during the trial proceedings, an additional notice needs to be submitted by the patent owner within 21 days from the date of the change of attributable owner.[203]

Third, the USPTO aims to oblige patent owners to accompany a request for supplementary examination (37 CFR 1.610), a request for ex parte reexamination (37 CFR 1.510) and a reply or any other paper filed by the patent office in an ex parte reexamination proceeding by a notice identifying the current attributable owner.[204] If the attributable owner changed during the reexamination proceedings, the notice needs to be filed within three months from the date of the change.[205]

Despite the fact that the notice does not specify any punitive action in case of a failure to notify the attributable owner in the three described occasions, it is indicated that a failure to notify the USPTO by error "may be excused on petition accompanied by a showing of reason for the delay, error, or incompleteness and the petition fee".[206]

3.7 Recommendations for Improving the Transparency of Patent Ownership Changes

Although the USPTO has ultimately opted not to advance the Notice on "Proposed Changes to Require Identification of Attributable Owner", the provisions proposed by the notice and the comments submitted by stakeholders during public hearings thereupon provide a suitable starting point for a discussion of the 'minimal requirements' that future initiatives aiming to improve the transparency of patent ownership need to take into account. We present an overview of the comments submitted by public firms in Table 3.1 below.[207] In what follows we group these requirements together into

[202] *See* 37 CFR 1.383.
[203] *See* 37 CFR 1.383.
[204] *See* 37 CFR 1.385.
[205] *See* 37 CFR 1.385(c).
[206] *See* 37 CFR 1.387.
[207] The submitted comments on the proposed changes to require identification of attributable owner(s) were previously accessible at https://www.uspto.gov/patent/laws-and-regulations/comments-public/comments-changes-require-identification-attributable. We accessed and downloaded all documents containing submitted comments on March 10th, 2015. All documents are available upon request.

four categories; (i) requirements concerning the scope of ownership to be disclosed (the 'who-question'), (ii) requirements concerning the timing of the disclosure of ownership information (the 'when-question'), (iii) the type and extent of corrective action upon failure to meet requirements concerning the disclosure of ownership information (the 'what-if-question') and (iv) requirements concerning the recording and public disclosure of submitted ownership information (the 'how-question'). Our recommendations are based on the belief that the transparency of patent ownership is an essential part of patent notice and that patent notice is key to the functioning of markets for technology. The principle of transparency is one of the key principles of property law and can be divided into "passive transparency" and "active transparency".[208] Whereas the objective of passive transparency is to ensure that certain information is available and accessible the objective of active transparency is to ensure that information is not only available but also complete and useful. One of the means to achieve both passive and active transparency of property is to establish and maintain property registers. Hereby, one can distinguish between property registers that rely on the "voluntary" registration of ownership and those that rely on the "obligatory" registration of ownership.[209]Whereas the former registry system is based on 'positive enforcement' by providing property owners that register properties with certain privileges, the latter is based on 'negative enforcement' by inducing 'penalties' for not registering properties. In our comparative analysis of requirements for the establishment of patent owners we have essentially argued that whilst the registration of patent ownership changes is obligatory *de jure*, it is voluntary *de facto* in most jurisdictions under study. We argue that an active transparency of ownership can only be achieved if the registration of patent ownership changes shifts from a voluntary registry system towards a more obligatory one.

3.7.1 Requirements concerning the scope of ownership to be disclosed

We propose that the requirement to disclose information about the identity of the applicant/owner of a patent (application) should be confined to the name(s) and registered address of the exclusive or joint title holder(s) and her/their ultimate parent entity. Whilst the inclusion of a broad set of enforcement entities, defined as "any entity nec-

[208] *See* e.g. Peter Drahos, The Global Governance of Knowledge: Patent Offices and Their Clients (2010). See also Thomas Cottier and Michelangelo Temmerman, Transparency and IP Protection in International Law, in Bianchi, A. and Peters, A. (eds.) Transparency in International Law, (2013).

[209] *See* e.g. Alison Clarke and Paul Kohler, Property Law (2005).

Table 3.1: Submitted comments of firms to the USPTO Notice (part 1).

Appraisal/Criticism	Proposed Modifications
Cook Group (Manufacture of medical and dental instruments and supplies)	
• The costs of the proposed rules will be excessive to Cook and every operating company that collaborates with others to bring innovative products to market. • The required identification of the "entity necessary to be joined in a lawsuit in order to have standing" and the "ultimate parent entity" are vague and unnecessary. • Legal titleholder information is sufficient for the USPTO's purposes. • Abandonment is an excessive penalty under the proposed rules – a fee reduction for providing legal titleholder information is more appropriate and would spur innovation.	• Cook submits that if the proposed rules are finalized, they should be limited to requiring identification of legal titleholder information. When information is to be provided about other than natural persons, then corporate or partnership name, state of incorporation of creation, and business address for corporations or partnerships or the like is all that should be required, so that public and private corporations are placed on the same playing field. • Further, Cook submits that abandonment is a punitive sanction for non-compliance. Rather, stakeholders should be incentivized to comply with the proposal suggested by Cook, by way of a 10% reduction in the filing and issue fees, and a 10% reduction in maintenance fees if there is a sanction imposed surrounding identification at the time of maintenance fee payments.
Dell Inc. & Cisco Systems (Manufacture of computers and communication equipment)	
• The PTO's proposed rules will promote the notice function of patents and innovation. The PTO's proposed attributable ownership requirement will not only enhance the PTO's ability to carry out its operations but also will promote innovation by providing accurate information to the public. • Dell Inc. & Cisco Systems contend that the PTO's efforts to improve patent transparency will help all firms, large and small.	• The "who" question: Attributable owners for reporting purposes should be clarified to include a broader class of enforcement entities and should include entities that seek to hide their attributable ownership for more than a temporary period. • The "when" question: Attributable ownership by a patent assertion entity should be promptly recorded. • Confidential treatment of attributable ownership respecting patent applications should be limited to owners—not including patent assertion entities—who can assert a commercial justification for confidentiality.
GlaxoSmithKline (Manufacture of pharmaceutical preparations)	
• The burden estimate provided in the notice does not meet legal and regulatory requirements. • The office has not specifically identified why voluntarily recording assignments is not adequate. • It is unclear what is meant by "an entity necessary to be joined in a lawsuit in order to have standing to enforce the patent or any patent resulting from the application". • The attributable owner should be limited to the titleholder as set forth in a recorded assignment.	• In view of the shortcomings of the burden estimate provided in the Notice, GSK requests the Office to reissue the Notice of proposed rulemaking with a burden estimate that meets all of the legal and regulatory requirements and to reset the 60-day period for comment.

Table 3.1: Submitted comments of firms to the USPTO Notice (part 2).

• Times for identifying attributable owner should be limited to filing and, issuance, and start of post grant proceedings. • GSK believes that the titleholder can be identified on the application data sheet. • GSK believes it is adequate to identify the name of the legal entity and the registered place of business (e.g., city and state of incorporation). • The penalty for non-compliance is unclear in some instances.	
Hewlett-Packard Company (Manufacture of computers and peripheral equipment)	
• HP supports the disclosure of attributable owner information at key checkpoints during the lifecycle of a patent. • The Submission of attributable owner information would provide important benefits; • The effectiveness of the proposed rules in the Notice will turn on the precision of the definition of "attributable owner". The Notice defines several types of entities that are included within the scope of the term "attributable owner". • The rules requiring the submission of attributable owner information should be designed to minimize the burdens for submitting the information, while maximizing the accuracy of the information. Requiring a submission or confirmation of attributable owner information at key checkpoints during the life of a patent, as generally proposed in the Notice, would attain a reasonable balance between these competing considerations. Response to arguments against reporting attributable owner information; • Burdens of providing the information; in the majority of cases, disclosing the attributable owner information to the USPTO would simply be a matter of providing information that is already known or readily determined at a time when the party is already interacting with the USPTO. That being said, HP believes that the impact on entities with large portfolios will be proportionately greater than for small entities. • Proper tailoring of the proposed rules; HP believes that the problem goes well beyond the situations of demand letters and litigation, and as a result, the proposal will only fully capture the intended benefits if the USPTO requires attributable owner information for applications and patents, regardless of whether they are the subject of a demand letter or litigation.	• Although HP believes that the checkpoint-based approach would create an administrable framework, HP is mindful of the costs created by mandatory disclosures at each checkpoint. If the USPTO desires to reduce the costs of providing attributable owner information, the Office could instead modify the rules to only require disclosure of the information when it has changed. Although such a modification may increase the likelihood of unintentional noncompliance with the rules, this approach would reduce the need for parties to affirmatively confirm the information at each of the checkpoints during the process and potentially reduce the costs of compliance. • HP believes that the proposed rules would be greatly beneficial to the patent system as a whole. Nevertheless, HP encourages the USPTO to consider implementing the attributable ownership rules package in a phased approach by using a pilot program prior to final implementation. • HP strongly suggests that the Office considers expanding the proposed rules to include changes of ownership after the patent grants. • HP recommends modifying the proposed language from "prior to the date the maintenance fee is paid" to "prior to or concurrently with payment of the maintenance fee".

Table 3.1: Submitted comments of firms to the USPTO Notice (part 3).

IBM Corporation (Computer programming activities)	
• Improved ownership information will enhance the Office's ability to properly examine pending applications and to review issued patents; benefit the public in managing business affairs increasingly influenced by IP rights, and help fulfill the public notice function of the patent system by enabling members of the public to determine what areas of endeavor are covered by unlicensed patents and patent portfolios and what areas are not. The requirement to properly identify a patent owner also balances the existing requirement for challenges in inter partes patent proceedings to identify all their real parties in interest, thus levelling the playing field for challengers struggling to determine which patents warrant attention.	• IBM believes that changes must be made to the scope of the definition of "attributable owner" to collect useful information without hampering patenting and licensing. IBM supports identification of the exclusive or joint titleholder, opposes identification of entities necessary to be joined for standing to sue, supports identification of the ultimate parent entity in a way that does not burden applicants and owners, and opposes the requirements in subsection (d) regarding entities used to divest or prevent the vesting of title. • IBM believes it is reasonable to require disclosure of attributable owner information at filing, issuance, payment of maintenance fees, and at appropriate times during ex parte and inter partes post issuance proceedings. IBM is concerned, however, that the specific timing requirements proposed by the Office for updating attributable owner information during prosecution are overly burdensome. • IBM suggests inclusion of attributable owner information on the Application Data Sheet (ADS). • IBM supports the Office's suggestion regarding a tool for bulk processing of changes to attributable owner for patent portfolios. IBM generally supports the Office's efforts to provide a platform for voluntary disclosure of licensing information. Additional views on the Notice and Supplemental Notice: • IBM has grave concerns regarding the Office's proposed penalty of abandonment for failure to comply with the attributable owner disclosure requirements during patent prosecution (no penalty for post issuance failure is indicated in the proposed rules). The penalty of abandonment seems disproportionately harsh and inconsistent with the character of the requirement. • The penalty of abandonment is also disproportionate to the harm to the public of failure to disclose ownership information during prosecution, especially since it is easy to correct such harm. • IBM strongly encourages the Office to conduct a pilot program to determine the appropriate scope of the definition of "attributable owner" and the optimal means for reporting this information to the Office. A pilot program would allow the Office to evaluate compliance and impact on an experimental basis, and

Table 3.1: Submitted comments of firms to the USPTO Notice (part 4).

	avoid widespread misunderstandings or gaps created by unworkable elements of the overall system.
Intellectual Ventures (Other professional, scientific and technical activities)	
The Notice does not demonstrate that the proposed rules are necessary for; • Verifying the power of attorney. • Avoiding conflicts of interest. • Identifying commonly owned prior art and double patenting. • Post-issuance proceedings. • Improving the accuracy of public information. The proposed rules are overbroad and unduly burdensome. • The definition of attributable owner is broad and unworkable. • Determination of attributable ownership is beyond the skills of all patent agents and most patent attorneys. • Mandatory disclosure of attributable ownership impacts legitimate privacy and business interests. • The proposed rules potentially conflict with other legal requirements. The rules conflict with statute and other branches of government. The proposed rules are a significant regulatory action under Executive Order 12866. • Regulation costing more than $100 million require OMB approval. • The USPTO's $43.5 million estimate is based on erroneous assumptions. • Lessons from "small entity status" suggests higher costs. • Cost per application per patent are underestimated. • Total costs estimates are incorrect. • There are a number of additional considerations under Executive Order 12866.	• Intellectual Ventures recommends that the USPTO act within its current legal authority to improve the management and dissemination of information that it already possesses concerning titleholder, power of attorney, and terminal disclaimers. Cross-linking and modernizing the USPTO's existing databases is badly needed. • Intellectual Ventures also recommend that the USPTO convene an experts group to study solutions to the alleged problems identified in the Notice, including working with the USPTO's international partners to ensure that the USPTO's efforts promote, rather than impede, patent harmonization efforts through the IP5, Trilateral Offices, and Tegernsee Group.
Microsoft Corporation (Other software publishing)	
• Microsoft has been a vocal supporter of greater transparency in the patent system. On March 28, 2013, Microsoft launched a "Patent Tracker" tool that provides a list of all of the patents Microsoft owns and urged other companies to follow suit, as it firmly believes that greater transparency will yield tangible outcomes that enhance American competitiveness, create jobs and foster growth in nearly every sector of the U.S. economy. • Microsoft therefore applauds the USPTO for devoting attention to improving transparency by examining changes to "the rules of practice to	• With respect to the specific rule changes set out in the Proposed Rules, Microsoft supports the submission made by BSA|The Software Alliance.

Table 3.1: Submitted comments of firms to the USPTO Notice (part 5).

facilitate the examination or patent applications and to provide greater transparency concerning the ownership of patent applications and patents." 79 Fed. Reg. at 4105. One of the main functions of patents is to provide notice to the public of both the invention and who owns it. Disclosure of the real party in interest for a particular patent reduces the likelihood of opportunistic behavior and gamesmanship and helps to facilitate licensing and the dissemination of technology.	
Novartis AG. (Manufacture of pharmaceutical preparations)	
• The proposed attributable ownership rules are far broader than necessary to achieve their intended goals, and should be substantially narrowed to avoid unduly burdening legitimate users of the patent system. • The proposed attributable ownership disclosure rules have the potential to harm innovators and licensees, undermining many of the rules' stated goals. • The "purpose or effect" catch-all of §1.271(c) could harm innocent third parties. • The rules as proposed are unnecessarily burdensome and costly, and the proposed penalty is unduly severe.	• The goal of reducing risk abusive patent litigation should be addressed separately, through a set of rules that targets the source of that problem. • The remaining external goals an all internal goals can be achieved through the adoption of a mandatory patent assignment database. • Based on the concerns raised, Novartis urges the Office to consider removing exclusive licensees (an "entity necessary to be joined in a lawsuit in order to have standing to enforce the patent", 1.271(a)(2)) from the attributable ownership definition. Should the Office, despite these concerns, decided to maintain the current definition, Novartis requests that it at least considers limiting the application of this definition to disclosures related to the filing of a complaint, or at most, to the sending of a demand letter, as proposed in section IA of these comments. If the Office does not agree with either of these proposals, Novartis further asks that it considers implementing these rules only prospectively, limiting the attributable ownership disclosure requirement to patent applications filed after the effective day of any final rules, and patents and application exclusively licensed after that date. This would at least eliminate the risks relating to current license agreements that lack provisions to adequately address attributable ownership disclosure requirements, and provide licensing parties with fair notice of the risks that the rules pose to the confidentiality of their agreements. • Novartis respectfully submits that no attributable owner definition should contain a vague and uncertain catch-all category that includes subjective standards like "purpose or effect' such as proposed in 37 CFR 1271 (c). If the Office insists that such a category is necessary – for example, to achieve the goal of reducing the risk of abusive patent litigation – then it should be narrowly tailored to those

Table 3.1: Submitted comments of firms to the USPTO Notice (part 6).

	arrangements that are intended to mask a party from being identified or named in a legal action. As discussed in Section IA of these comments, it should also be narrowly applied to only those circumstances and entities where such litigation abuses are probable. • For the reasons previously discussed, even where a change has occurred, Novartis urges the Office to reconsider whether so many reporting events are truly necessary, where, as explained and proposed, narrower rules can achieve the same goals while reducing the burdens on patentees and applicants. Whether or not the Office maintains these reporting events for situations where the attributable ownership has changed, however, Novartis does not see justification for requiring reporting when all attributable owners have remained the same. • While the proposed rules make some effort to ameliorate the severity of the penalties by extending the reporting deadline for one event and allowing for corrections of certain error or omissions that occur for others, both of these provisions are, in Novartis' view problematic. For the deadline extension, if the rules are to include penalties as severe as abandonment, Novartis believes that the extension should be available for all reporting events, coupled perhaps by payment of a late fee, ideally without a requirement to file a petition, which seems unnecessary in most circumstances. Regarding the proposed correction procedure for other events, this procedure seems to apply only to cases where a "good faith effort" was made to comply with the rule, and it is not clear what this standard entails. If standard correction is required at all, Novartis proposes that the standard at least be consistent with that of 35 U.S.C 255, requiring only that the error be one made in good faith, rather than requiring a showing that "good faith efforts" were made to comply with the rules.
Ocean Tomo LLC (Other activities auxiliary to financial services, except insurance and pension funding)	
• Ocean Tomo supports USPTO Proposed Changes to Require Identification of Attributable Owner. It supports such disclosure not only at the time of initial filing but also with any change of assignment. It concurs with the proposition that such disclosure will further improve market efficiency for patent rights. • Intellectual property is taking up an increasingly large footprint on corporate balance sheets and is driving significant value for companies	• n/a

Table 3.1: Submitted comments of firms to the USPTO Notice (part 7).

investing in obtaining IP through R&D. Changes such as those described here will produce dividends to owners of IP through increased awareness of such assets as well as reduce transaction costs.	
Oracle Corp (Other software publishing)	
• Oracle supports the United States Patent and Trademark Office's efforts to adopt procedures designed to increase patent ownership transparency. It is in favor of enhanced ownership disclosure rules that will apply to both patent applications and issued patents, and commends the PTO's Proposed Rule as a significant step in the right direction. Oracle agrees with written comments submitted by the Coalition for Patent Fairness (of which Oracle is a member), and submits this brief additional comment to underscore its view that the disclosure requirements for issued patents outlined in the Proposed Rule should go further by requiring patent owners to file updated attributable ownership information at more frequent intervals.	• In its current form, the Proposed Rule requires filing updated post-issuance patent ownership information only when patent annuities are paid and when a patent has already become involved in a post-grant proceeding. The very long intervals between required filings of updated ownership information create significant gaps in the disclosure process that could be exploited by patent owners. Attributable ownership information could change, potentially many times, during the multi-year periods between required updates. For instance, under the Proposed Rule, a patent owner could wait until the third maintenance fee has been paid, and then transfer ownership of the patent to a shell company controlled by a different entity. The PTO and the public could be denied accurate attributable ownership information for the patent for years, unless and until the patent has become involved in a post-grant proceeding. Such long disclosure gaps undermine the very important transparency objectives that the Proposed Rule seeks to advance. In order to avoid this potential for abuse, in addition to obligations to file updated ownership information when patent annuities are paid and when a patent becomes involved in a post-issuance proceeding, Oracle respectfully suggests modification of the Proposed Rule to require reporting any change of attributable ownership within three months of such a change during the enforceable lifetime of an issued patent. This modification would bring the post-issuance reporting obligation in line with the reporting obligation that the Proposed Rule would apply during the pendency of a patent application and would avoid the long disclosure gaps discussed above.
Patentbooks Inc. (Other activities auxiliary to financial services, except insurance and pension funding)	
• Patentbooks Inc. (PBI) does not believe that the proposed rule, with the additional costs and drains on USPTO resources that administering the rule requires, is necessary or justified. • PBI supports a market-based system that will allow large-scale patent licensing for specific products on a utility basis for specific products	• n/a

Table 3.1: Submitted comments of firms to the USPTO Notice (part 8).

(so that licensing patents will become as easy as obtaining water or electricity). Such a system will promote innovation by making available to intellectual property users multiple patents offering competing solutions, so that users may choose among these patents in developing their products or services. • The system PBI advocates also will provide for frequent regular payments directly into the accounts of patent owners from the pool of revenues provided by patent users. For this system to function effectively, it is important that patent owners provide the system administrator with their identity and the information necessary to meet financial and tax requirements (and that such information be updated periodically) so as to assure that the payments attributable to listed patents can be directed efficiently into the appropriate bank accounts. • Because the patent owners in this system will have a financial incentive to provide the types of patent ownership information the rule is seeking, PBI believes that its market-based solution will provide such information on a commercially driven basis at no direct cost to the government. Moreover, PBI is willing to share the ownership information that it gathers with government agencies needing such information (e.g., the USPTO and US Customs and Border Protection) for appropriate reasons. For this reason, PBI does not believe that the proposed rule, with the additional costs and drains on USPTO resources that administering the rule requires, is necessary or justified.	
Pfizer Inc. (Manufacture of pharmaceutical preparations)	
• The disclosure of "enforcement entities" and "hidden beneficial owners" is not necessary, effective or feasible and is premature, overly intrusive and burdensome. • Continuous updating of ownership information during prosecution and PTAB proceedings, particularly where there is no change in ultimate parent entity, is neither necessary nor feasible and would be unduly burdensome. • Automatic abandonment for failure to identify ownership information at the time of filing or failure to update such information at payment of the issue fee is unduly punitive. At the filing stage, inventors are already required to be listed and the initial POA must be signed by the applicant, so punishing the applicant for not providing the same information in another form is inappropriate. And the fact that a patent would be subject to an inequitable conduct claim	Pfizer believes that the following concepts should be eliminated from the PTO's proposed rules: • Any requirement to name "enforcement entities" or "hidden beneficial owners". • Any requirement to continuously update ownership during prosecution or other proceedings where no change in ultimate parent entity of legal title holder occurs. • Any automatic abandonment for failure to identify an assignee or ultimate parent entity. • Any requirement for a new reporting system and/or additional forms.

Table 3.1: Submitted comments of firms to the USPTO Notice (part 9).

if a party fails to provide or update other ownership information with intent to deceive and causes real harm to the PTO proceedings or a third party would be a sufficient deterrent to abusive behavior. • The PTO significantly underestimates the number and type of affected parties and the level of additional effort and cost needed to comply with its proposed rules.	
Toyota Motor Corporation (Manufacture of motor vehicles)	
• Toyota supports the general concept of transparency in the prosecution and enforcement of patent rights. Nevertheless, after a careful consideration of the proposed rules set forth in the Notice requiring identification of the attributable owner, Toyota opposes the proposed rules. • The proposed Section 1.271 of the Notice sets forth various definitions of the entity or entities that are covered by "attributable owner". Toyota particularly objects to the proposed definition of "ultimate parent entity". It is Toyota's view that the proposed definition of "ultimate parent entity" is burdensome and impractical as it relies, inter alia, on the ability to understand and apply such imprecise legal concepts as "control". Even if the definition of "ultimate parent entity" could be understood, ascertaining the ultimate parent entity can often be a difficult and complex process. Given the severe penalties imposed in proposed Section 1.279 for failure to notify the Office of the attributable owner, or a change to the attributable owner, considerable resources will need to be expended in order to ensure proper compliance with the proposed rules. This will necessarily increase the costs to applicant and patentees, and will be particularly burdensome for those patent holders who manage large portfolios. Accordingly, it is Toyota's view that any benefit that might be attributable to the proposed rules would be outweighed by the significant burden attendant with proper compliance with these rules.	• n/a.
Wayfinder Digital LLC (Other business support service activities)	
• Wayfinder Digital supports USPTO's effort to increase information transparency with respect to the attributable ownership of patents and patent applications. It believes that the patent compact through which inventors and titleholders are granted exclusive use of the patented invention in exchange for disclosure of the invention includes the disclosure of complete and accurate information on who owns a patent	• Adopt the legal entity identifier. • Require update of attributable ownership when there is a material change at any of the attributable owners of patents. • Do not exclude government entities from reporting when they own or have interest in a patent. • Adopt the us navy's patent information disclosure approach.

Table 3.1: Submitted comments of firms to the USPTO Notice (part 10).

or patent application and how to contact the attributable owners. This reporting does not introduce a burden on the patent owner and can be accomplished electronically at a minimal cost. The availability of this information is an essential element of a functioning patent system in today's global innovation economy. • The USPTO should use this opportunity to address "broken windows", the information asymmetry in the US patent system. The lack of information transparency is the broken window within the US patent system frustrating innovators, entrepreneurs and business owners. It facilitates aggressive patent monetization behavior, clandestine patent privateering pacts, the inability of firms to defend themselves against frivolous patent lawsuits and submarine infringement claims that coincide with the announcement of a new product or a new significant round of venture capital for science and technology-based firms. In the age of ubiquitous information disclosure, patent information remains inscrutable. Implementation of attributable ownership rules is an opportunity to improve information transparency in the US patent system across the board.	• Enhancing information on the competitive landscape for innovators. • Enhance the accuracy of address and geographic data. • Enable the public to identify bad data for correction. • Affirmatively identify abandoned patents. • Affirmatively identify expired patents.

essary to be joined in a lawsuit in order to have standing to enforce that patent or any patent resulting from the application" in the USPTO notice, may certainly limit the activities of entities that purposely seek to benefit from hiding their ownership, we contend that the disclosure of ownership of the title holder(s) and ultimate parent entity is sufficient to allow for an efficient functioning of markets for technology.[210] Furthermore, we believe that limiting the requirement for the disclosure of ownership information to these entity types strikes a fair balance between ensuring a consistent flow of information to the public and the potential of imposing unduly burdensome requirements that may negatively impact the legitimate confidentiality of business interests.[211] We contend that the disclosure of information on the identity of the title holder(s) and her/their parent entity is part of the quid pro quo through which inventors are granted exclusive rights to their invention and is readily available to parties

[210] *See* e.g. the comments submitted by the Cook Group and GlaxoSmithKline in Table 3.1.
[211] *See* e.g. the comments submitted by GlaxoSmithKline and Novartis AG. in Table 3.1.

required to submit this information to patent offices.

3.7.2 Requirements concerning the timing of the disclosure of ownership information

We propose that given that technology transactions can occur throughout the entire lifetime of patents, any future initiative should impose requirements to record changes of ownership regardless of when they occur during the patent lifecycle, within a reasonable time window after their occurrence.[212] The USPTO Notice imposes much stricter obligations to applicants during the patent application process than to owners post-grant. Whereas patent applicants are required to disclose the identity of the attributable owner(s) at the date of filing and notify the office of changes of attributable ownership during the patent application phase, once the patent is granted, the patent holders are only required to submit information about the identity of the attributable owner(s) upon payment of maintenance fees or during post-grant proceedings in front of the office. In jurisdictions where the payment of maintenance fees is due after short time intervals this requirement might be sufficient to provide a constant flow of accurate ownership information to the public. However, in the US patent system, where the payment of maintenance fees is due after three, seven and eleven years the long time-intervals between these events only allow for an occasional availability of ownership information. Given that the final maintenance fee for a US patent is due after eleven years, this entails that in the worst-case scenario changes of ownership that occur directly after the payment of this fee may not be observable for a period of up to nine years.

We also propose that ownership information should only be notified to a patent office when a change of ownership has effectively occurred. The USPTO Notice specifies that owners should give notice of the identity of the attributable owner(s) at specific moments during the patent life-cycle regardless of whether a change of attributable owner(s) has taken place. However, we support the arguments submitted by multiple stakeholders of the patent system during public hearings which indicate that this requirement may be unduly burdensome, given that the attributable ownership does not change at all during the lifetime of the far majority of patents.[213] We believe that requir-

[212] *See* e.g. the comments submitted by Hewlett-Packard Company and Oracle Corp. in Table 3.1.
[213] *See* e.g. the comments submitted by Novartis AG and Pfizer Inc. in Table 3.1.

ing the submission of attributable owner information only when an ownership change has occurred minimizes the burdens for submitting this information whilst maximizing its accuracy.

3.7.3 Corrective actions for non-compliance with requirements concerning the disclosure of ownership

We propose that any failure to comply with the disclosure requirement concerning the identity of the title holder(s) and her/their ultimate parent entity following any change of ownership should lead to punitive action in the form of abandonment of the patent (application) even though most stakeholders find this an excessive penalty [214] The USPTO Notice foresees such a penalty only in case of failure to meet this requirement during the pendency of a patent application and at the moment that a notice of allowance has been sent to the applicant and does not indicate penalties for failure to meet requirements post-issuance. Given that the primary motivation for initiating future initiatives aimed at improving the transparency of patent ownership is based on the conviction that a voluntary recordation system is insufficient to achieve a satisfactory level of such transparency, we believe that an effective enforcement of requirements must incorporate penalties for non-compliance that are administered consistently. We believe that the prospect of facing an abandonment of a patent (application) will incentivize parties to record ownership changes to a far greater extent than recordation on a voluntary basis. Given the severity of the penalty of abandonment, we suggest a sufficient time window for correcting errors made in good faith.

3.7.4 Platforms for recording and disclosing submitted ownership information

We propose that the potential burden and costs associated with the submission and retrieval of ownership information should be minimized by providing an on-line, easy to access and free-of-charge platform for submitting and retrieving such information. We believe that allowing parties to submit ownership information free-of charge on such a platform will greatly lower the burdens and costs that parties are currently facing when submitting ownership information to most patent offices. At present, the

[214] *See* e.g. the comments submitted by the Cook Group, IBM Corporation, Pfizer Inc. and GlaxoSmithKline in Table 3.1.

USPTO is the only patent office that offers the possibility to record patent assignments online without charges, although the retrieval of recorded assignment documents is only made possible upon written request against a fee of 25 dollars. We contend that making ownership information readily available to the public, free-of-charge through an on-line platform immediately after processing the submitted information (with the exception of ownership changes that involve patent applications that have not yet been published and are subject to secrecy requirements) is equally important as allowing parties to submit such information.[215] We believe that such an approach will allow a patent office to draw upon the public for the identification and communication of incorrect ownership information to the office, which will significantly improve the accuracy of such information.[216]

3.8 Concluding Remarks

In this chapter we aimed to highlight issues concerning the disclosure of patent ownership information which, rather than facilitating organizations' patent monetization activities, might instead act as a barrier to these activities. We have argued that the market for patent monetization relies to a great extent on the effectiveness of the patent system's notice function. The ability to know both the boundaries that define a claimed invention as well as the identity of the parties that hold rights to this invention is a primary requirement for the initiation of technology transactions. In particular, based on a comparative analysis of the patent provisions of six of the most active patent offices worldwide – the EPO, the USPTO, the JPO, the INPI, the DPMA and the UK IPO – we addressed recently expressed concerns that current provisions provide only limited opportunities for tracking changes of ownership. We find support for the legitimacy of these concerns, our analysis reveals that although all six patent offices under study impose strict requirements concerning the identification of the initial applicant(s) of a patent, they do not impose and/or enforce such strict requirements with respect to the disclosure of the identity of the new owner(s) following a change of ownership. Furthermore, there is generally no legal basis to impose punitive action following failure to report ownership changes. As a result, the disclosure of the identity of the new owner(s) following ownership changes is largely left to the discretion of the new owner(s) and

[215] *See* the comments submitted by IBM Corporation in Table 3.1.
[216] *See* the comments submitted by Patentbooks Inc. in Table 3.1.

takes place on a voluntary basis. Therefore, the likelihood of identifying the actual owner(s) of a patent may be significantly reduced following changes in the ownership of the patent.

Despite the potentially negative implications of a limited transparency of patent ownership for technology markets, we are only aware of one initiative that aims specifically to address the flaws of current patent provisions, the USPTO's Notice on "Changes to Require Identification of Attributable Owner". Although the USPTO has ultimately decided not to advance the proposed provisions, we have drawn upon these provisions as a basis for proposing recommendations for future initiatives. Based on the conviction that the disclosure of information on the identity of parties holding rights to a patent is part of the quid pro quo of granting exclusive rights to a claimed invention to these parties, we propose four minimal requirements that future initiatives by patent offices should impose to warrant a more adequate, accurate and timely disclosure of patent ownership information. Firstly, we suggest that the requirement to disclose information about the identity of the applicant/owner of a patent (application) should be confined to the name(s) and registered address of the exclusive or joint titleholder(s) and its/their ultimate parent entity. Secondly, we suggest that future initiatives should impose requirements to record changes of ownership regardless of when they occur during the patent lifecycle, within a reasonable time window after their occurrence. Thirdly, we suggest that any failure to comply with the disclosure requirement concerning the identity of the title holder(s) and its/their ultimate parent entity following any change of ownership should lead to punitive action in the form of abandonment of the patent (application). Lastly, we suggest that the potential burden and costs associated with the submission and retrieval of ownership information should be minimized by providing for an on-line, easy to access and free-of-charge platform for submitting and retrieving such information.

We believe that our recommendations strike a fair balance between ensuring a consistent flow of information that allows technology markets to function efficiently and the potential of imposing unduly burdensome requirements that may negatively impact the legitimate confidentiality of business interests. We hope that this chapter will inspire academics and policy makers to actively engage in combined efforts to find solutions that improve the transparency of patent ownership.

Chapter 4

When Does It Pay Off to Participate in Markets for Technology?

The Interplay Between the Mode of Technology Acquisition, Absorptive Capacity and the Nature of Technology[1]

4.1 Introduction

External technology is universally recognized as an important source of technological inputs for firms in high-tech industries (Laursen and Salter, 2006; Arora *et. al.*, 2014; Stettner and Lavie, 2014). Because the knowledge sources for innovation are nowadays more widely distributed than ever before, even the largest and most technologically advanced firms cannot rely solely on internally developed technology. They must also tap into complementary knowledge sources situated beyond their boundaries when developing their innovations (Chesbrough, 2003; Cassiman and Veugelers, 2006). In view of this there is an extensive scholarship on the different modes that firms can rely upon to access external technology. Although this scholarship has considerably advanced our understanding of firms' 'make, buy or ally' decisions, it is predominantly confined to mergers and acquisitions (M&As) (*i.a.* Hitt *et. al.*, 1996; Ahuja and Katila,

[1] This chapter is based on a single-authored working paper.

2001; Puranam and Srikanth, 2007), R&D alliances (*i.a.* Robertson and Gatignon, 1998; Wang and Zajac, 2007; Yin and Shanley, 2008) and technology licensing (Arora *et. al.*, 2001; Arora and Ceccagnoli, 2006; Agrawal *et. al.*, 2015). As a result, another obvious and potentially more favorable mode of technology acquisition – the outright purchase of standalone technology – has so far been overlooked in existing literature. This is surprising given the large amount of attention that has been devoted to 'markets for technology' in recent times in both scholarly and academic circles (*i.a.* Federal Trade Commission, 2011).

Analyzing firms' activities on markets for technology is important for at least three reasons. First, even though historic accounts of 'markets for technology' – where trading activity refers to intermediate technological outputs that are disembodied from goods and services – date back to the late 19^{th} century (Lamoreaux & Sokoloff, 1998; Burhop, 2010), recent studies suggest that they have rapidly expanded since the beginning of the 1990s (Arora *et. al.*, 2001). Their growth is not only manifested in increased levels of technology trade, but also in the economic rents that such trade generates. For example, in 2011 Google Inc. acquired Motorola LLC for a reported $12.5 billion to, in the words of CEO Larry Page *"...strengthen its patent portfolio and to enable it to better protect Android from anti-competitive threats from Microsoft, Apple and other companies..."*.[2] Similarly, Microsoft Inc. purchased a portfolio of 800 patents from AOL in 2012 for $1.1 billion which amounts to a lofty price of $1.3 million per patent.[3] Whereas in the past patents were primarily acquired by specialist patent firms, these examples indicate that large firms are increasingly involved in technology trade and are willing to spend big amounts on the acquisition of technology. Furthermore, these examples illustrate that firms rely on multiple modes to acquire external technology. Whereas Google Inc. acquired an entire firm to leverage that firm's technology portfolio, Microsoft Inc. directly acquired a specific bundle of patents.

Second, markets for technology are relevant phenomena from a policy perspective because they have the potential to generate positive welfare effects. Essentially, these markets allow for a division of labor between the entities that invent and the entities that manufacture most efficiently (Allain *et. al*, 2016; De Marco *et. al.*, 2017). By pro-

[2] https://www.reuters.com/article/industry-us-media-motorolapatents/behind-googles-12-5-billion-motorola-gamble-patents-idUSTRE77F00O20110816, accessed on January 25th, 2019.

[3] https://www.nytimes.com/2012/04/10/technology/microsoft-to-buy-aol-patents-for-more-than-1-billion.html, accessed on January 25th, 2019.

viding a viable pathway for invention without commercialization, such specialization renders incentives to inventors who do not have access to the complementary assets required to manufacture, market and distribute their inventions (Teece, 1986). Lower entry barriers not only result in a greater supply of technology to be further developed and incorporated into products, but also to a greater level of competition among these technologies (Federal Trade Commission 2011). This competition in turn benefits consumers by speeding up the rate of innovation and resulting in better and cheaper products. In addition to shaping innovation incentives, efficient markets for technology also limit duplicative R&D investments (Gans and Stern, 2003) and costly patent litigation cases (Galasso *et. al.*, 2013).

Third, the study of markets for technology is also meaningful from a private perspective in the sense that the standalone acquisition of technology may, albeit only under specific circumstances, have distinct benefits over other modes of technology sourcing. To the extent that these markets are efficient and hence transaction costs are low, the acquisition of a single or small bundle of technologies may in principle be faster, cheaper and less risky than the acquisition of an entire firm whilst simultaneously offering a higher degree of control over the technology than R&D alliances and licensing. Markets for technology provide firms with the option to selectively choose the technologies they need, without facing the challenges associated with integrating entire firms and the potential contractual hazards of dealing with alliance partners and licensors. Although these potential benefits are certainly compelling in theory, to the best of our knowledge, no study has empirically examined firms' ability to realize them in practice.

In fact, empirical studies of markets for technology have traditionally been hampered by the lack of comprehensive datasets on technology transactions and their contractual terms. The limited number of studies that have empirically explored standalone technology acquisitions mainly focus on: (i) the characteristics of technologies, buyers and sellers that determine the likelihood that a transaction materializes (Serrano, 2010; Caviggioli and Ughetto, 2013; De Marco *et. al.*, 2017), (ii) theoretically model the gains from trading patented inventions (Serrano, 2018) or (iii) study patents as collateral in business financing (Hochberg *et. al.*, 2018). Whilst generating valuable insights with respect to the dynamics of technology trade, these studies leave unanswered the important question of whether, to what extent and under which conditions firms can profit from standalone technology transactions.

It is the pursuit of these questions that motivates this chapter. By exploiting a novel firm-level dataset, we explore whether and under which conditions firms benefit from both outright purchases of standalone technology – *disembodied technology acquisition* – and the acquisition of entire firms – *embodied technology acquisition*. We propose that firms can benefit from both acquisition modes, but that their ability to do so depends on the presence of absorptive capacity as well as the nature of the acquired technology. In an important advance to the existing literature, we construct a consolidated panel of 682 publicly traded US-firms that allows us to distinguish between (i) the stock of patented inventions developed by the focal firm and its subsidiaries, (ii) the stock of patented inventions acquired by the focal firm and its subsidiaries through M&As and (iii) the stock of patented inventions acquired by the focal firm and its subsidiaries via standalone technology acquisitions. Our setup also makes it possible to identify and disregard transactions – both embodied and disembodied – between entities that are part of the same parent firm at the date of acquisition. It turns out that such 'intra-firm' transactions make up a large share of all technology acquisitions and may therefore have significantly influenced the results of existing studies of technology transactions.

Our findings both confirm and extend the findings of existing scholarship. First, we find that the mode of technology acquisition by itself is an important determinant of firms' ability to benefit from external technology. Whereas embodied technology acquisition positively contributes to firms' market value there is an overall negative association between market value and disembodied technology acquisition. Second, we find that internal R&D positively moderates the contribution of both modes of technology acquisition to market value. Our results clearly indicate that the contribution of both modes is only positive for firms that possess a stock of internally developed technology that exceeds a certain minimum threshold, with this threshold being significantly higher for the disembodied mode. Whereas the top-40% of firms in terms of internally developed stock can benefit from embodied technology acquisition, the same only holds for the top-20% in case of disembodied technology acquisition. Thus, although absorptive capacity aids both the acquisition of entire firms and the acquisition of standalone technology, it is more critical to the success of the latter activity than it is for the former. Lastly, we find that the relationship between both modes of technology acquisition and market value also depends on the nature of the acquired technology. Surprisingly, only the acquisition of familiar technology via the embodied mode is as-

sociated with higher market values. There is no association between market value and the acquisition of novel technology via the embodied mode nor the acquisition of familiar technology via the disembodied mode whereas we find a negative association between market value and the acquisition of novel technology via the disembodied mode. Combined, our results suggest that the benefits of technology acquisition are most likely to be realized by firms having large internally developed knowledge stocks that acquire familiar technology by buying entire firms rather than standalone technology. Although our empirical setting does not allow us to establish a particular causal structure, we believe that our study provides a first step towards a richer understanding of the performance implications of embodied and disembodied technology acquisition by highlighting previously unexplored relationships.

4.2 Theory and Hypotheses

4.2.1 Background

Scholarship has generally advanced two sets of arguments to explain why firms increasingly rely on external sources of technology. A first set of arguments is based on the premise that a single firm *cannot* develop its entire technology portfolio internally. In this scenario the acquisition of technology from external sources is thus *inevitable*. On the one hand, scholars suggest that the cross-sectoral nature of novel technologies and the interwovenness of scientific disciplines and technological fields requires firms to integrate an increasingly wide range of knowledge components (Hagedoorn, 1993; Laursen and Salter, 2006). On the other hand, it is well-established in the organizational behavior literature that organizational learning is path-dependent and confines firms' expertise to a limited number of technological fields (Rosenkopf and Nerkar, 2001). Furthermore, the capabilities needed to develop technology are less likely to be co-located with the capabilities needed to commercialize them (Teece, 1986). It is, therefore, more and more unlikely for even the largest and most diversified of firms to develop all their technologies internally (Cassiman and Veugelers, 2006).

As firms mature, they naturally develop a greater expertise in certain technological domains than in others. And once they become more familiar with a set of technologies, developing an even deeper expertise in these technologies is more likely to yield immediate returns than exploring new ones because organizational learning happens via a

virtuous cycle that exists between gaining experience with a technology and becoming competent with that technology (Ahuja and Lampert, 2001; Argote and Miron-Spektor, 2011). As experience and competence in a specific set of technologies accrue, successful routines for solving specific problems solidify (Henderson and Clark, 1990). Over time these routines can become increasingly rigid and inert to an extent that solutions for specific problems evolve into dominant solutions to all problems (Leonard-Barton, 1992). However, a given set of routines and competences can only be effective in addressing a limited number of problems. A continuous dependence on familiar technologies biases firms towards favoring incremental improvements and sub-optimal solutions at the expense of exploring unfamiliar, yet potentially more promising, technological opportunities (Levinthal and March, 1993; Rosenkopf and Nerkar, 2001). Given that there is ample empirical evidence suggesting that firms develop more impactful technologies when they (re)combine technological components from otherwise decoupled knowledge domains, a fixation on familiar technologies may be detrimental to firms' sustained competitive advantage (Fleming, 2001; Yayavaram and Ahuja, 2008).

A second set of arguments conveys that even if a single firm could hypothetically develop all its technologies internally, it *should not* do so. In this scenario the acquisition of technology is a matter of *choice* and is an *attractive alternative* to internal technology development. First, sourcing technologies from external entities may enable firms to exploit technologies faster. In industries characterized by a high degree of technological change and frequently changing customer needs, current technological competences can quickly become obsolete whilst the development of new ones requires a depth of experience and cumulative knowledge that cannot be quickly nurtured internally (Dierickx and Cool, 1989); Uotila *et. al.*, 2009; Wu *et. al.*, 2014). Access to technologies developed by entities that already have these competences in place can, therefore, significantly shorten the time-to-market of firms' products. Second, acquiring technologies externally may be cheaper than developing them internally, especially when the supply of such technology is large, the technology is general-purpose rather than specific and legal appropriation mechanisms are effective (Teece, 1986; Arora *et al.*, 2001). To the extent that they function efficiently, markets for technology allow for a specialization of inventive activity that results in significant gains to be made from the trade of technology (Arora and Nandkumar, 2012). Third, the alternative to acquire technologies externally mitigates the risk of firms not being able to recoup their sunk cost

investments when new technologies appear. It provides them with the option to spot promising technological opportunities in an early stage whilst committing financial resources only at a later stage (Kogut and Zander, 1992; McGrath and Nerkar, 2004).

4.2.2 The relevance of the mode of technology acquisition

Although the benefits ascribed to external technology acquisition are universal in nature, it is well-established that there is considerable variation in firms' ability to realize these benefits in practice. A key aspect that has received a great deal of attention from both economic and managerial scholars in this respect is the choice of technology acquisition mode. Whereas the traditional transaction cost literature has portrayed firms' technology sourcing decisions as a dichotomous choice between making and buying, more recent contributions have extended this view by adding collaborative R&D arrangements to the mix of viable sourcing modes (*i.a.* Robertson and Gatignon, 1998; Van de Vrande, 2013; Stettner and Lavie, 2014; Lungeanu *et al.*, 2016). Rather than focusing on the choice between 'make, buy or ally', we focus exclusively on the choice between two variants of 'buy'; (*i*) *embodied technology acquisition* – the acquisition of technology that is embedded in an asset – and (*ii*) *disembodied technology acquisition* – the acquisition of standalone technology. More specifically, we define embodied technology acquisition as the acquisition of an entire firm via an M&A-deal and disembodied technology acquisition as the outright acquisition of a single technology or a small bundle of technologies.[4] We argue that firms can benefit from both modes, whilst recognizing that both modes have their own distinct benefits that make them more suitable over the other mode under certain conditions.

Although embodied technology acquisitions can be motivated by a variety of considerations other than the acquisition of technology – *e.g.* (i) to increase market power, (ii)

[4] Most studies of markets for technology have focused exclusively on the licensing of technology and have overlooked the acquisition of standalone technology. The main difference between licensing and acquiring a technology is that in a license, the owner of the technology (the licensor) grants permission to 'utilize' the technology to another entity (the licensee) whilst retaining ownership of the technology being licensed, whilst in an acquisition the owner of the technology (the assignor) transfers all of his rights to the technology to another entity (the assignee). Whereas licensing comprises a long-term, exclusive or non-exclusive contractual agreement between licensor and licensee that may be limited to fields of use, acquisition involves an irrevocable and permanent transfer of ownership from assignor to assignee. The acquisition of standalone technology thus shows a greater resemblance to a traditional seller-buyer market relationship than licensing.

to enter new geographic and/or product markets, (iii) to achieve synergies, economies of scale and economies of scope and (iv) to get access to valuable complementary assets – empirical evidence suggests that the great majority of such acquisitions in high-tech industries is inspired by technological motives (Ahuja and Katila, 2001; Choi and McNamara, 2018). Pharmaceutical firms regularly acquire small biotechnology ventures to gain access to their drug compounds, machinery and/or key personnel (Higgins and Rodriguez, 2006; Allain *et. al.*, 2016) and some of the world's largest semiconductor firms have expanded their technology portfolio almost exclusively via M&As (Grindley and Teece, 1997; Kapoor and Lim, 2007). By acquiring an entire target firm, the acquiring firm not only gains access to all the technologies of the target, but also to the unique capabilities that the target relied on to develop them. These capabilities are often embedded in the tacit and socially complex knowledge of target firms' individual and collective human capital and are therefore difficult to transfer via disembodied technology acquisition (Ranft and Lord, 2000). At the core, embodied technology acquisition enables an acquiring firm to leverage both what the target firm *knows* – its knowledge base – and what the target firm *does* – its capabilities (Puranam and Srikanth, 2007). Whereas a target's knowledge base can serve as an input to the innovative process of the acquiring firm, its capabilities can function as an independent source of ongoing future innovation.

In contrast, when a firm acquires technology via the disembodied route, it only gains ownership of a single technology or a small bundle of technologies without getting access to the seller's capabilities and resources. It can thus only leverage that part of the seller's knowledge base that is embedded within the acquired technology. In essence, the choice between embodied and disembodied technology acquisition comes down to a trade-off between the need for *commitment* and *coordination* on the one hand and *flexibility* on the other hand. Compared to disembodied technology acquisition, a firm can tap into a larger pool of external knowledge and has a greater potential to leverage this knowledge via embodied technology acquisition because it acquires the entirety of another firm's knowledge sources, including the holders of tacit knowledge. At the same time, acquiring and leveraging a larger pool of external knowledge is more costly and time-consuming than acquiring standalone technology. Even if the acquired firm operates as an independent unit of the acquiring firm, leveraging its knowledge requires a degree of communication and coordination between the acquiring firm and the

new unit that requires a high-level of commitment. Furthermore, by acquiring an entire firm, the acquiring firm might not only be paying for the acquisition of knowledge and capabilities that it values but also for those that it doesn't.

In comparison to embodied technology acquisition, disembodied technology acquisition requires less commitment from the acquiring firm. Although it is prone to substantial transaction costs stemming from the search of external technology and the negotiation, execution and enforcement of agreements between buyers and sellers, these costs are likely to be lower on average than the costs associated with acquiring and integrating an entire organization. Furthermore, because there is less knowledge that needs to be leveraged, disembodied technology acquisition is arguably a faster means to ensure access to a certain technology than the acquisition of an entire firm. At the same time, leveraging knowledge might be more challenging via disembodied knowledge acquisition because there is no transfer of knowledge sources, such as key R&D personnel, that the acquiring firm can learn from.

In sum, embodied technology acquisition presents firms with more options than disembodied technology acquisition but this comes at a greater cost. It is thus not obvious whether one mode is universally more profitable than the other. At this stage, we therefore posit that firms can benefit from both embodied- and disembodied technology acquisition and hypothesize that:

H_1: *The acquisition of technology contributes positively to firms' market value both via embodied- and disembodied technology acquisition.*

4.2.3 The relevance of internal technology development

Although we expect an overall positive effect of both embodied- and disembodied technology acquisition on firms' financial performance, there is a rich body of literature suggesting that firms vary greatly in their potential to recognize the value of external knowledge, assimilate it and apply it to commercial ends. This potential is known as *absorptive capacity* and is based on the believe that, like individuals, firms require a stock of prior related knowledge to be able to assimilate and use new knowledge (Cohen and Levinthal, 1989). Firms' ability to identify, screen, transform and integrate external knowledge is dependent upon the richness of their pre-existing knowledge base in the sense that organizational learning is more straightforward when the object of learning is related to what is already known (Cohen and Levinthal, 1990, Lane and Lubatkin,

1998). Considering that firms' knowledge base is mostly a product of their internal R&D activities, these activities are important sources of absorptive capacity. As noted by Rosenberg (1990) *"... it requires a substantial research capability to understand, interpret and to appraise knowledge... whether basic or applied"* and *"... the cost of maintaining this capability is high..." (p. 171)*.

Whereas external technology sourcing has almost exclusively been described as a substitute for internal R&D investment in the classic make-or-buy literature, more recent studies emphasize that firms' internal and external R&D activities are *complementary* in nature. Most notably, Veugelers and Cassiman (1999) formally deduce that firms' creation of internal knowledge increases their marginal return to external knowledge acquisition and provide empirical evidence for a complementarity between the two activities. They find this complementarity to be context-specific in the sense that the extent of firms' activities that is directly related to basic research positively affects the complementarity between internal and external R&D. Rothaermel and Alexandre (2009) extend these findings by quantifying the 'optimal' technology sourcing mix. They derive that the best-performing firms in terms of financial performance are the ones that balance internal development and external sourcing in a 60-to-40 percent ratio.

Firms' ongoing investments in internal R&D contribute to the development of absorptive capacity in two ways. First, by investing a substantial amount in internal R&D, firms create a stock of specific knowledge that allows them to be more sensitive to opportunities that present themselves in their technological environments (Rothaermel and Alexandre, 2009; Stettner and Lavie, 2014). Second, higher levels of R&D investment also enable firms to be more proactive in exploiting the spillovers between internal and external sources of knowledge. In this regard, it is not only the size of firms' knowledge base that determines the degree of absorptive capacity but also its diversity. As stated by Cohen and Levinthal (1990) *"... a diverse background provides a more robust basis for learning because it increases the prospect that incoming information will relate to what is already known..." (p. 131)*. A higher knowledge diversity allows firms to make more novel and fruitful associations between internal and external knowledge because the variety of knowledge components increases the number of possible new (re)combinations (Rosenkopf and Nerkar, 2001; Fleming, 2001).

Whilst the above arguments suggest that absorptive capacity, as an important by-

product of internal technology development, increases firms' ability to benefit from both embodied- and disembodied technology acquisition, we propose that absorptive capacity is more important for disembodied technology acquisition than it is for embodied technology acquisition. Whereas the capability to scan the external environment for technological opportunities is important for both technology acquisition modes, the capability to integrate acquired knowledge may only be important for disembodied technology acquisition. Leveraging external knowledge acquired via disembodied technology acquisition requires that the acquiring firm integrates this knowledge with its internally developed knowledge base, whilst this is not the case for knowledge acquired via the embodied mode. Although leveraging knowledge acquired via embodied technology acquisition requires a degree of coordination between the acquiring firm and the acquired firm on the organizational level, this does not imply per se that the acquired knowledge needs to be integrated within the acquiring firm. Hence, in case of disembodied technology acquisition, the acquired knowledge *needs* to be exploited within the confines of the acquiring firm, whereas in case of embodied technology acquisition the acquired knowledge can also be exploited within the confines of the acquired firm. In line with this reasoning we hypothesize that:

H_2: *The contribution of embodied and disembodied technology acquisition to firms' market value depends on the size of their internal knowledge stock, whereby the presence (absence) of internally developed knowledge is most crucial for disembodied technology acquisition.*

4.2.4 The relevance of the nature of technology

In case of embodied technology acquisition, an acquiring firm's ability to successfully leverage the knowledge base of the target depends to a large extent on how *familiar* the acquiring firm is with the technological domain(s) in which the target is active. The consensus in the strategic management literature is that acquiring firms are more likely to realize positive post-acquisition innovation outcomes when their and their targets' knowledge bases are *sufficiently different* to expose them to novel and diverse knowledge, yet sufficiently related to provide ample opportunities for learning (Kapoor and Lim, 2007; Sears and Hoetker, 2014). The intuition is that a high degree of relatedness between the acquiring and target firm's technology portfolio makes it easier to identify and integrate technology developed by the target, but that a too high degree of

relatedness limits the exposure to new knowledge domains and thus the potential for recombination and cross-fertilization. The middle ground is thus a moderate level of technological relatedness which is achieved when the acquiring and target firm focus on different narrowly defined knowledge domains that are situated within a broader core knowledge domain that they have in common (Rosenkopf and Almeida, 2003; Makri *et. al.*, 2010; Phene *et. al.*, 2012).

Familiarity with the target's technology is of lesser importance when the main objective of an M&A is to leverage the target firms' capabilities to generate future technologies rather than leveraging its existing knowledge base. Recent studies indicate that the exploitation of known and exploration of novel technologies are distinct activities that should be balanced across rather than within technology sourcing modes (Phene *et. al.*, 2012; Stettner and Lavie, 2014). When such a balance exists, exploration enhances firms' performance more via M&As than via internal development because *"…acquisitions enable a firm to gain immediate control of knowledge that is entirely different from its internal knowledge without calling for relatedness, resemblance or combination of knowledge…" (Stettner and Lavie, 2014, p. 191)*. In other words, M&As permit the separation of exploitation and exploration activities, because it is not necessary and often not even desirable for an acquiring firm to fully integrate a target firm whose business is only remotely related to its own business.

Although the acquisition of standalone technology gives the acquirer more rights and thus a higher degree of control than licensing, it offers less opportunities for learning. Via acquisition the assignee only gets access to the knowledge that is embedded in, and thus specific to, the acquired technology whereas via licensing the licensee can negotiate access to additional know-how that is not embedded in the technology per se. Evidently, the opportunities for learning via standalone technology acquisition are even more limited when compared to embodied technology acquisition as the latter provides access to a target firm's entire knowledge base and all of its resources and capabilities. Given the minimal opportunities for learning that the acquisition of standalone technology offers, it is more likely to provide benefits when the acquiring firm is familiar with the acquired technology than when it is not. As noted by Karim and Mitchell (2000), when obtaining tacit resources, such as know-how, is an objective of the acquisition, 'the market for firms' may be more robust than 'the market for discrete exchange'. The exchange of tacit resources often fails in the market for discrete exchange because these

resources are not codifiable and are subject to appropriability concerns. This view is confirmed by Figueroa and Serrano (2018) who find that a patented invention is more likely to be acquired by entities that have patented in the same technological domain(s) as the selling entity prior to the acquisition.

Hence, embodied technology acquisition can be a viable strategy for the acquiring firm to leverage both technology it is familiar with and technology it is unfamiliar with. The acquisition of another firm not only provides the acquiring firm access to this firm's knowledge base and intellectual property but also presents the acquiring firm with an additional unit that has the capabilities to produce future technologies by itself. On the contrary, disembodied technology acquisition is only beneficial towards the exploitation of familiar technology and not towards the exploration of unfamiliar technology. In line with this reasoning we therefore hypothesize that:

H_3: *Via the embodied mode, both the acquisition of familiar and novel technology contributes positively to market value, whereas via the disembodied mode only the acquisition of familiar technology contributes positively to market value.*

4.3 Data and Methods

4.3.1 Sample

Our dataset comprises information on 682 publicly traded US-firms, representing nine industries: (i) Pharmaceuticals & Biotechnology, (ii) Chemicals, (iii) IT-Hardware, (iv) Electronics & Electrical Machinery, (v) Engineering & General Machinery, (vi) Software, (vii) Automotive & Other Vehicles, (viii) Other Manufacturing and (ix) Other Industries (we refer to Table 4.1 for a breakdown of industries according to NACE-REV.2 codes). These firms are drawn from the 2016-edition of the European Commission's World-wide R&D Scoreboard, which lists the top 2,500 firms that spend the most on R&D activities worldwide. We selected all firms from this list that were incorporated in the US, are the ultimate owner of their corporate group and have been publicly traded for a minimum of three years between 2000 and 2016. For these firms we constructed a panel dataset comprising 7,827 firm-year observations for the period 2000-2016 by combining ownership-, accounting- and patent information from several sources. Specifically, we retrieve (i) ownership information from 10-K filings at the Securities and Exchange

Table 4.1: An overview of sample industries according to NACE-REV.2 codes.

Industry	Tag	NACE Code	NACE Code Description	#Firms	#Observations
Automotive & other vehicles	AUTH	29	Manufacture of motor vehicles, trailers and semi-trailers.	45	575
		30	Manufacture of other transport equipment.		
Chemicals	CHEM	01	Crop and animal production, hunting and related service activities.	58	787
		19	Manufacture of coke and refined petroleum products.		
		20	Manufacture of chemicals and chemical products.		
		22	Manufacture of rubber and plastic products.		
Electronics & electrical machinery	ELEC	27	Manufacture of electrical equipment.	28	351
Engineering & general machinery	ENGI	28	Manufacture of machinery and equipment nec.	46	644
It-hardware	ITHW	26	Manufacture of computer, electronic and optical products.	137	1,769
Other manufacturing	OTHM	17	Manufacture of paper and paper products.	53	659
		23	Manufacture of other non-metallic mineral products.		
		24	Manufacture of basic metals.		
		25	Manufacture of fabricated metal products, except machinery and equipment.		
		31	Manufacture of furniture.		
		32	Other manufacturing.		
Pharmaceuticals & biotech	PHAR	21	Manufacture of basic pharmaceutical products and pharmaceutical preparations.	86	819
Software	SOFT	58	Publishing activities.	79	793
		62	Computer programming, consultancy and related activities.		
		63	Information service activities.		
Other industries	OTHI	06	Extraction of crude petroleum and natural gas.	150	1,430
		07	Mining of metal ores.		
		08	Other mining & quarrying.		
		09	Mining support service activities.		
		10	Manufacture of food products.		
		11	Manufacture of beverages.		
		12	Manufacture of tobacco products.		
		13	Manufacture of textiles.		
		14	Manufacture of wearing apparel.		
		15	Manufacture of leather and related products.		
		35	Electricity, gas, steam and air conditioning supply.		
		38	Waste collection, treatment and disposal activities; materials recovery.		
		41	Construction of buildings.		
		42	Civil engineering.		

Table 4.1: An overview of sample industries according to NACE-REV.2 codes (continued).

Industry	Tag	NACE Code	NACE Code Description	#Firms	#Observations
Other industries	OTHI	45	Wholesale and retail trade and repair of motor vehicles and motorcycles.	150	1,430
		46	Wholesale trade, except of motor vehicles and motorcycles.		
		47	Retail trade, except of motor vehicles and motorcycles.		
		49	Land transport and transport via pipelines		
		51	Air transport.		
		52	Warehousing and support activities for transportation.		
		53	Postal and courier activities.		
		55	Accommodation.		
		56	Food and beverage service activities.		
		59	Motion picture, video and television programme production, sound recording and music publishing activities.		
		60	Programming and broadcasting activities.		
		61	Telecommunications.		
		64	Financial service activities, except insurance and pension funding.		
		65	Insurance, reinsurance and pension funding, except compulsory social security.		
		66	Activities auxiliary to financial services and insurance activities.		
		68	Real estate activities.		
		71	Architectural and engineering activities; technical testing and analysis.		
		72	Scientific research and development.		
		73	Advertising and market research.		
		74	Other professional, scientific and technical activities.		
		77	Rental and leasing activities.		
		78	Employment activities.		
		79	Travel agency, tour operator reservation service and related activities.		
		82	Office administrative, office support and other business support activities.		
		85	Education.		
		86	Human health activities.		
		93	Sports activities and amusement and recreation activities.		
		94	Activities of membership organisations.		
		96	Other personal service activities.		
Full sample				**682**	**7,827**

Commission (SEC), (ii) information on M&As from Thomson Reuters' EIKON database (previously known as SDC Platinum), (iii) patent information from the United States Patent and Trademark Office's (USPTO) Historical Patent Data Files and the 2018 Spring

Edition of PATSTAT, (iv) patent assignment information from the USPTO Patent Assignment Data File and (v) accounting information from COMPUSTAT.

For our 682 sample firms we obtained the names of all subsidiaries listed in Exhibit-21 of yearly 10-K filings at the SEC for all years between 2000 and 2016. Pursuant to item 601(b)(21) of Regulation S-K of the SEC, public firms are required to list all of their subsidiaries which, considered in the aggregate or as a single subsidiary, constitute a significant subsidiary as defined in Rule 1-02(w) of Regulation S-X.[5] We retrieved a total of 131,389 unique subsidiaries which amounts to an average of 193 subsidiaries per firm. To identify M&As and divestments, we complemented the subsidiary information from SEC-filings with records of M&A deals from EIKON that list the corporate name of sample firms as 'ultimate acquirer' or 'ultimate target'. We identified and dropped records of 'intra-firm' deals between entities that were part of the same corporate group at the time the deal was finalized. Our sample firms were listed as ultimate acquirer in 15,801 M&A deals and as ultimate target in 7,623 divestments during the sample period. The compilation of parent names, subsidiary names, names of acquired entities and names of divested entities allows us to track changes in the ownership structure of firms over time, which is an important first step towards distinguishing between technologies developed internally and technologies acquired via M&As.

To identify the patents held by sample firms we matched the yearly lists of entity names as they appear in SEC-filings and EIKON to the names of assignees as they appear on publications of patent applications published by the USPTO. We retrieved the names of patent assignees from the USPTO Historical Patent Data Files and PATSTAT 2018 and applied several name cleaning procedures to standardize them. Subsequently, we developed an algorithm, that computes the similarity between the names of firms and assignees, based on a weighted function of (i) the number of overlapping characters, (ii) the sequence of characters and (iii) string length, to denote the similarity between

[5] Under rule 1-02(w) of Regulation S-X, a significant subsidiary is one that meets any of the following conditions; (i) The value of the investments in and advances to the subsidiary by its parent and the parent's other subsidiaries, if any exceed 10 percent of the value of the assets of the parent or, if a consolidated balance sheet is filed, the value of the assets of the parent and its consolidated subsidiaries. (ii) The total investment income of the subsidiary or, in the case of a non-investment company subsidiary, the net income exceeds 10 percent of the total investment income of the parent or, if consolidated statements are filed, 10 percent of the total investment income of the parent and its consolidated subsidiaries. (iii) The subsidiary is the parent of one or more subsidiaries and, together with such subsidiaries would, if considered in the aggregate, constitute a significant subsidiary.

pairs of text strings. After a manual validation of a random sample of potential name-matches we set the threshold for 'correct' matches such that it would limit both the number of false positives and false negatives.

To account for changes in the ownership structure of firms, we only retrieved patent records for the years in which matched entity names were part of a sample firm. For example, if Subsidiary A has been part of Firm B between 2001 and 2006, we only retrieved patent applications having earliest filing years between 2001 and 2006. In case of acquired entities, we assigned all patents filed prior to the acquisition date to the stock of acquired patents and assigned those filed thereafter to the stock of patents developed internally by the acquired firm. To illustrate, if Firm B acquires a Target Firm C on 01/01/2001 we consider all patents filed by Target Firm C prior to 01/01/2001 as being acquired by Firm B and all patents filed after that day as being developed by Firm B. This logic is reversed for divestments, in these cases we assign patents filed prior to the divestment date to the stock of internally developed patents and consider patents filed thereafter as being developed by the new owner of the divested entity.

We rely on patent assignment records from the USPTO Patent Assignment Database (UPAD) to identify technologies acquired via the disembodied mode. [6] A patent assignment is a transfer by a party of all or part of its right, title and interest in a patent or patent application for which an application to register has been filed. For an assignment to take place, the transfer to another party must include the entirety of the bundle of rights that is associated with the ownership rights. A patent assignment is in effect thus an acquisition of a patented invention by a designated assignee from a designated assignor. We retrieved all patent assignment records from UPAD that list our sample firms or their subsidiaries as assignees by using the same name-matching approach that we used to link parent-, subsidiary- and acquired firms' names to patent records.

Recognizing that patent assignments can be the result of M&As – the acquiring firm can decide to assign all or some of the patents of the acquired entity to its own name – we identified and dropped all assignment records involving patents that we assigned in the previous step to the stock of patents that were acquired via M&As. Furthermore, we disregarded all 'intra-firm' assignment records that have a listed assignor and assignee that were both part of the same corporate group at the execution date of the assignment. Lastly, we followed the procedure described by Marco *et. al.* (2015) to drop assignments

[6] See Marco *et. al.* (2015) for an elaborate description of the USPTO Patent Assignment Dataset.

whereby the assignor is an inventor-employee of the assignee.[7]

Ultimately, we matched at total of 1,915,752 patent applications filed at the USPTO to our 682 sample firms. Of these patents 1,697,533 were developed internally by sample firms of which 645,063 were developed by 15,595 subsidiaries, 81,101 were acquired via 3,449 M&A deals and 137,118 were acquired via 34,678 patent assignments deals. These numbers highlight that establishing the ownership structure of firms over time is essential for understanding the entirety of firms' technological activities. First, without taking into account the subsidiaries of firms, we would miss out on about 38% of patents that were filed under subsidiary name variants rather than corporate name variants. An even greater concern is that there are stark differences between industries with respect to the allocation of patent ownership. As shown by Figure 4.1 below, in some industries, such as Pharmaceuticals & Biotechnology, the majority of patents is filed under subsidiary names whereas in other industries such as Electronics & Electrical Machinery and Engineering & General Machinery more than 90% of patents are filed under corporate name variants. Second, by not taking into account the ownership structure of firms, we would not have been able to identify and disregard technology transactions between entities belonging to the same corporate group. As it turns out, about 78% of all assignments listing our sample firms or their subsidiaries as beneficiary of a patent assignment happen within rather than across firm boundaries. As illustrated by Figure 4.2, this finding is pretty consistent across industries. Without consolidation we would thus vastly overestimate the prominence of disembodied technology acquisition.

[7] This issue exists because *"…for all applications filed before September 16, 2012, the patent must issue to a human inventor, requiring a legal assignment to an employer-owner. Inventor-employees are typically under some contractual obligation to transfer ownership of an application or resulting patent to their employers. Thus, before the recent enactment of the America Invents Act (AIA), in order to take action in a patent matter, an assignee had to establish ownership of the patent or patent application in compliance with 37 CFR 373 (pre-AIA), which generally required submitting or specifying the location of documentary evidence of a chain of title from the inventor to the assignee in the assignment records of the Office…" (Marco et. al., 2015, p. 7).* Marco *et. al.* (2015) classify an assignment record as "employer assignment" when the record meets the following conditions: (i) the record is the earliest transaction recorded for the property, (ii) the property was transferred alone, (iii) the execution date is prior to the patent application disposal date and (iv) keyword searching identifies the conveyance text as an "assignment".

Figure 4.1: The share of corporate and subsidiary patents per industry.

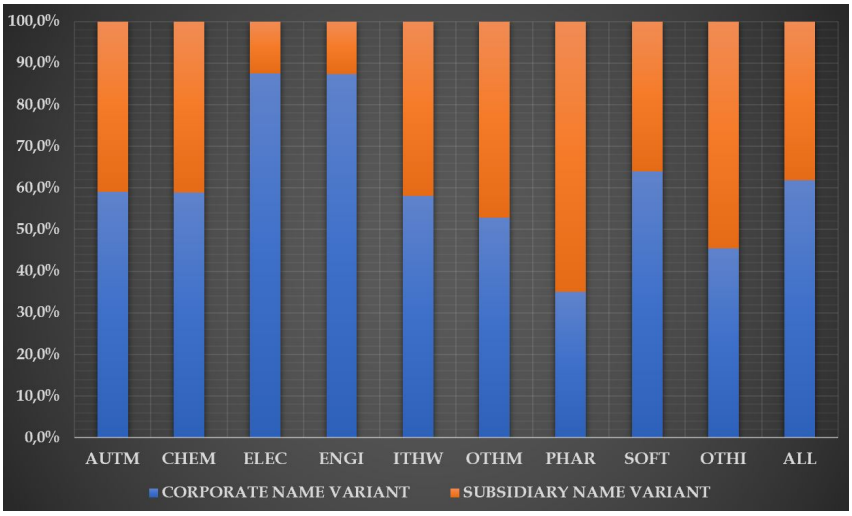
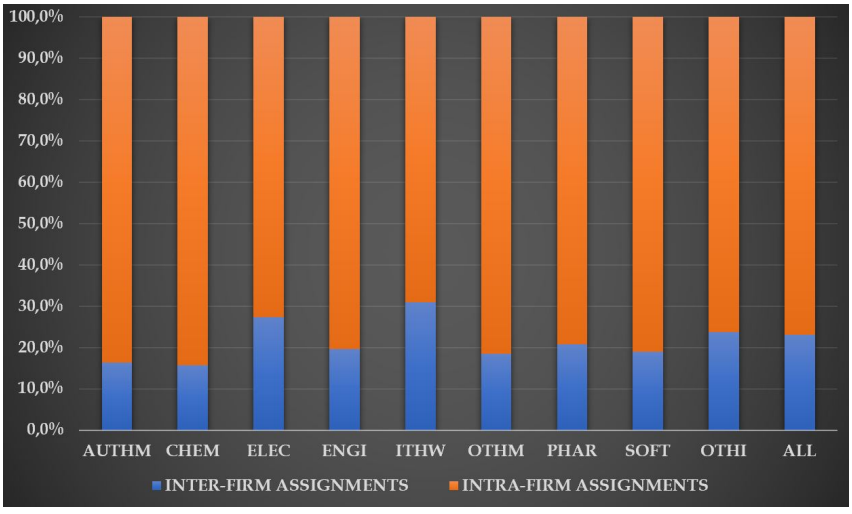


Figure 4.2: The share of intra-firm and inter-firm assignments per industry.



4.3.2 Variables

Dependent Variable

The dependent variable in our analyses is the annual financial performance of firms, reflected by their market value at the end of each fiscal year. In line with a longstanding tradition in the economics of innovation literature we compute market value as the sum of common stock, preferred stock and total debt minus current assets whereby the book value of current assets includes net plant, property and equipment, inventories and investments in unconsolidated subsidiaries (*i.a.* Hall *et. al.*, 2005; Czarnitzki *et. al.*, 2006; Arora *et. al.*, 2014). The main rationale for using market value is that it is a far sighted measure of financial performance. Existing studies that use market value as dependent variable implicitly assume that firms' stock price at any point in time fully reflects all information available to the market up to that point (Fama, 1998; Borah and Tellis, 2014). Every announcement of a new decision by a focal firm provides new information to the market that may affect its stock price positively or negatively. Fluctuations in the stock price reflect the discounted cash flows that the market anticipates as a result of the decision, thereby considering the focal firm's past performance and its future potential.

Pursuant to this logic, we assume that the stock market returns to different technology acquisition strategies reflect their discounted expected returns in the future. Analyzing these returns, then permits us to assess the payoff from embodied and disembodied technology acquisitions as well as the factors that drive this payoff. This forward-looking feature of market value is paramount to our study, given that the returns from firms' technological activities often become apparent only several years after they ensued (*i.a.* Czarnitzki *et. al.*, 2006; Belderbos *et. al.*, 2010). An additional advantage of relying on market value as our dependent variable is that it makes our results comparable to the results of existing studies (e.g. Hall *et. al.*, 2005; Arora *et. al.*, 2014). We collected all relevant accounting information to compute the market value from COMPUSTAT. The market value is given by:

$$MARKETVALUE_{i,t} = CSHO_{i,t} * PRCC_F_{i,t} + PSTKL_{i,t} + LCT_{i,t} + DLTT_{i,t} - PPEGT_{i,t} - INVT_{i,t} - ESUB_{i,t}$$

where $MV_{i,t}$ is the market value of firm i at the end of fiscal year t, $CSHO_{i,t}$ is the number of outstanding common shares, $PRCC_F_{i,t}$ is the share price at the end of the fiscal year, $PSTKL_{i,t}$ is the preferred stock at liquidating value, $LCT_{i,t}$ is the sum of current liabilities, $DLTT_{i,t}$ is the sum of long-term debt, $PPEGT_{i,t}$ is the total book value of property, plant and equipment, $INVT_{i,t}$ is the total book value of inventory and $ESUB_{i,t}$ is the total investment in unconsolidated subsidiaries.

Patent Stocks

There are two opposing views with regards to the computation of patent stocks that have dominated the economics of innovation literature. On the hand, there are scholars who take the view that the economically relevant lifetime of a patent exceeds its legal lifetime. Most notably, Cantwell and Andersen (1996) and Cantwell and Piscitello (1998) calculate patent stocks over a 30-year period and use a straight-line depreciation method that resembles those included in vintage capital models. The underlying rationale is that new technological knowledge is embodied, at least in part, in capital equipment that has an average age of 30 years and depreciates steadily over time. On the other hand, there are scholars who contend that the economically relevant lifetime of a patent is much shorter than the maximum legal age of 20 years. These scholars generally employ a perpetual inventory method and use constant annual depreciation rates that vary between a conservative 15%, which corresponds to an average patent age of 6.6 years (*i.a.* Gambardella and Torrisi, 2000; Hall *et. al.*, 2005), and a more progressive 30%, alluding to an average patent age of 3.3. years (*i.a.* Cockburn and Griliches, 1988; Blundell *et. al.*, 1999).

We adopt the latter view and apply a constant annual depreciation rate of 15% in all our calculations of patent stocks. To account for differences in observation periods between sample firms, we follow the approach outlined by Jungmittag (2004) and compute patent stocks in a moving six-year time-window using the perpetual inventory method. We also account for the heterogeneity in the quality of patents by computing citation-weighted patent counts as introduced by Hall *et. al.* (2005). Specifically, we count the number of citations that a focal patent receives in a fixed time-window of three years after its earliest publication date and normalize this count by the average number of citations received in the same period by patents that are classified into the same technology classes and have the same earliest filing year as the focal patent. As

an example, consider a focal patent that is classified simultaneously into technology classes 'A61B', 'A18G' and 'C12F' and has been filed in 2005. For this patent we derive the number of citations that it receives in a three-year period and divide this number by the average number of citations in the same time window received by all patents classified simultaneously into technology classes 'A61B', 'A18G' and 'C12F' that were filed in 2005.

We compute patent stocks based on patent information from the USPTO Historical Patent Data Files, PATSTAT and UPAD. The generic formula for patent stocks is given by:

$$PATENT\ STOCK_{i,t} = \sum_{\tau=t-5}^{t} (1-\delta)^{(t-\tau)}\ PATENT\ COUNT_{i,\tau}$$

where $PATENT\ STOCK_{i,t}$ is the patent stock of firm i at the end of fiscal year t, δ is the annual depreciation rate of 15% and $PATENT\ COUNT_{i,\tau}$ is the count of citation-weighted and normalized patent applications with earliest filing year τ. To test our hypotheses, we disaggregate firms' overall patent stock into several parts. To test Hypotheses 1 and 2 we distinguish between the stock of patents that have been filed by firm i and its subsidiaries, the $INTERNAL\ STOCK_{i,t}$, the stock of patents that firm i has acquired either via M&As, the $EMBODIED\ STOCK_{i,t}$ and the stock of patents that firm i has acquired via patent assignments, the $DISEMBODIED\ STOCK_{i,t}$. All three stocks are computed via the generic formula as defined above. To test hypotheses 3a and 3b we develop measures that indicate how familiar a firm is with the acquired technology. To this end, we apply the 'novelty in recombination' indicator developed by Verhoeven *et. al.* (2016) to the firm-level.

Verhoeven *et. al.* (2016) propose that an invention has novelty in recombination if the combination of components and principles applied to serve its purpose are different from those embodied in previous technologies. They operationalize this intuition by relying on the International Patent Classification (IPC) system and identify patents that are the first to make a combination of IPC-4 classes as those having novelty in recombination. This means, for example, that only the first patent that is classified into both class A61B and A18G will 'score' on the novelty in recombination indicator. We apply the same logic to the firm level and impose a fixed time window of ten years. For every patent that a focal firm acquires via M&As and patent assignments, we derive all combinations of IPC4-classes listed on the patent and check whether these combinations are present on patents filed by the focal firm or its subsidiaries

in the ten years prior to the acquisition date. If an acquired patent makes at least one combination of IPC4-classes that is not present on any of the patents filed by the focal firm or one of its subsidiaries, we classify this patent as 'novel' and otherwise as 'familiar'. This allows us to distinguish between the stock of patents acquired via M&As that is novel to the focal firm, the $EMBODIED\ STOCK(novel)_{i,t}$, and the stock that is not novel, the $EMBODIED\ STOCK\ (familiar)_{i,t}$. Likewise we can make the same distinction between the stock of patents acquired via assignments that is novel, the $DISEMBODIED\ STOCK(novel)_{i,t}$, and the stock that is not novel, the $DISEMBODIED\ STOCK\ (familiar)_{i,t}$.

Ultimately, our approach allows us to delineate the technology sourcing mix of sample firms over time. To illustrate, Figure 4.3 presents the profiles of three sample firms – Apple Inc., Comtech Telecommunications Corporation and Twitter Inc. – to highlight markedly different technology sourcing mixes. From the figure it can be observed that Apple Inc. developed the vast majority of its technologies internally and filed most patents under its parent name, Comtech Telecommunications Corporation acquired the majority of its patent portfolio via the embodied route – primarily the acquisition of Telecommunications Systems Inc. in 2015 – and Twitter Inc. acquired the bulk of its technologies via the disembodied route – primarily a patent assignment deal with IBM Corporation in 2014. To illustrate that the technology sourcing mix of firms can be subject to considerable changes over time, consider the technology sourcing mix of Twitter Inc. prior to 2014, presented in Figure 4.4. It is clear that prior to the patent assignment deal with IBM Corporation, the majority of Twitter Inc.'s patent portfolio was developed internally. It is the effect of changes such as this in the technology sourcing strategies of firms on their market value that is the focal point of our analysis.

Control Variables

We introduce several variables that may be correlated with firms' market value as control variables in our analysis. First, we include the total assets of a firm – $ASSETS_{i,t}$ – to account for the fact that market values may vary considerable between firms of different sizes. Second, it is well-established in the economics of innovation literature that the stock market value of firms is related to the size of their investments into R&D *(i.a.* Blundell *et. al.*, 1999; Hall *et. al.*, 2005). Therefore, we include the R&D expenditures of firms as a control variable. To be consistent with our computation of patent

Figure 4.3: The technology sourcing mix of Apple Inc. (top), Comtech Telecommunications Corporation (middle) and Twitter Inc. (bottom).

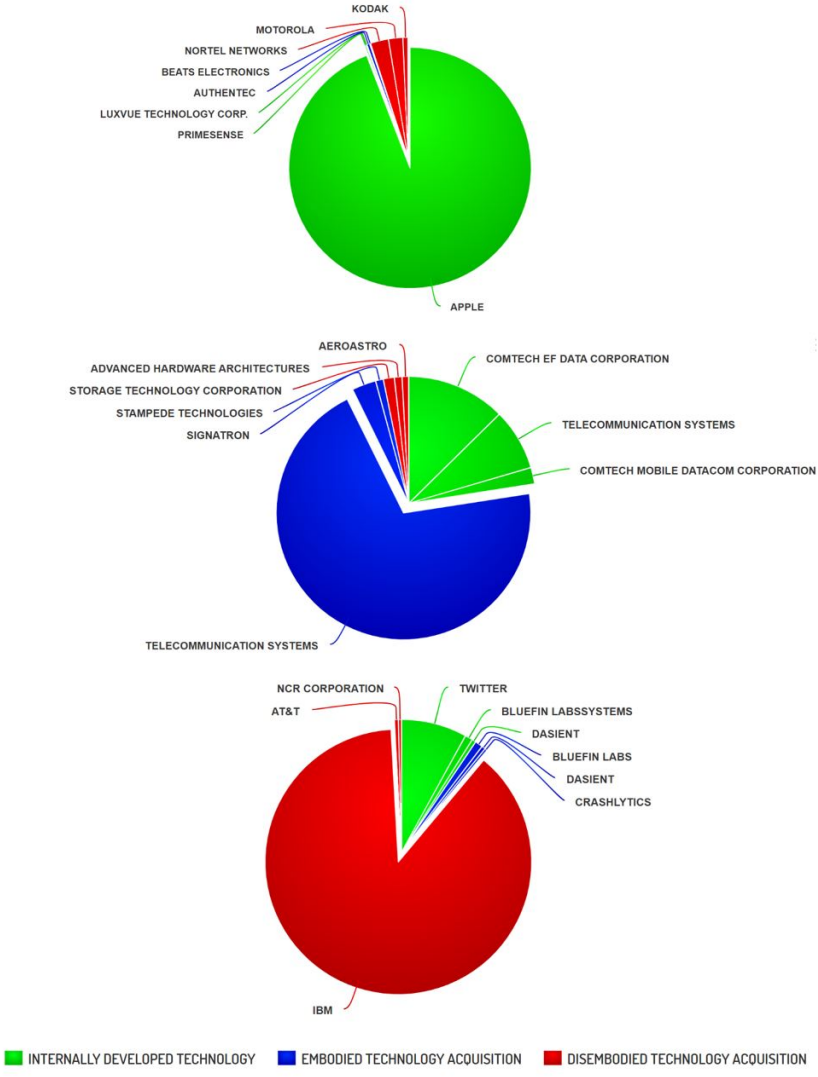
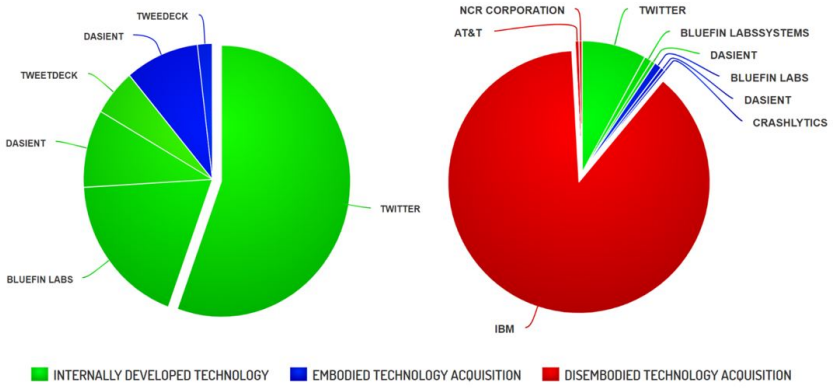


Figure 4.4: The technology sourcing mix of Twitter Inc. prior to (left) and after 2014 (right).



stock variables, we compute the stock of R&D expenditures using a perpetual inventory method with a constant 15% annual discount rate in a fixed six-year window. Relying on accounting information from COMPUSTAT, the R&D stock is given by:

$$R\&D\ STOCK_{i,t} = \sum_{\tau=t-5}^{t} (1-\delta)^{(t-\tau)}\ XRD_{i,\tau}$$

where $R\&D\ STOCK_{i,t}$ is the stock of R&D expenditures of firm i in fiscal year t, δ is the annual depreciation rate of 15% and $XRD_{i,\tau}$ is the amount of R&D expenditures in millions in year τ. Lastly, we include time fixed effects to control for differences in macroeconomic trends across time and include industry fixed effects to account for differences in market value across industries. Hence, firms in different industries may face different competitive pressures and opportunities, which may ultimately translate into performance differences across industries.

We do not include firm fixed effects for multiple reasons. First, analyses of variance indicate that most of the variation in our measures of interest is between firms rather than over time within firms. The between-firm variation of *PATENT STOCK*, *INTERNAL STOCK*, *EXTERNAL STOCK*, *EMBODIED STOCK* and *DISEMBODIED STOCK* accounts to 86, 87, 83, 82 and 79 percent of the variation respectively. This observation

is in line with existing studies that use patent stock measures in a firm-level setting (Arora *et. al.*, 2014). Second, by construction our stock-variables change slowly over time which implies that *"... even small amounts of measurement error may lead to a substantial downward bias in the coefficient estimates when differenced estimators are used..."*, *(Hall et. al., 2005, p. 26)*. Lastly, 'fixing' differences across firms may not be sensible in the sense that firms are likely to adapt their strategies in response to changing market conditions (Hall *et. al.*, 2005).

4.3.3 Estimation

We estimate a multiplicative and non-linear relationship between market value and our patent-stock variables because we have reason to believe that both dependent and independent variables of interest exhibit the characteristics of exponential growth over time. Under these circumstances, multiplicative models have been shown to produce substantially improved statistical specifications compared to additive models. Most notably, a recent study by Falta and Willett (2013) that estimates the relationship between market value and a large set of accounting variables in a panel of US-firms over a 50-year period, suggests that most accounting variables – including our model variables market value, total assets and R&D-expenditures – exert exponential growth over time. The study also highlights the importance of giving recognition to time lags when estimating a 'market-accounting' relationship because the effects of most accounting variables are long-run rather than short run. Following this logic, we estimate the following base regression equation:

$$ln(Y)_{i,t} = \alpha + \beta ln(X)_{i,t-1)} + \epsilon_i$$

In the resulting models, coefficients should be interpreted as an elasticity in the sense that the effect of a one-unit change in X on Y refers to a percentage change rather than an absolute one. In the above equation, β, thus, refers to the percentage increase in $ln(Y)_{i,t}$ for every 1% increase in $ln(X)_{i,t}$. Our approach is in line with recent studies that estimate the contribution of firms' R&D activities on their market value, most notably the study of Arora *et. al.* (2014), which makes our results directly comparable with their results.

4.4 Results

4.4.1 Nonparametric Analysis

We present summary statistics for our core constructs in Table 4.2. From the table we can observe that the average market value of firms in our sample is $13.8 billion of which $11.8 billion is vested in physical assets. On average, sample firms spend $351 million on R&D and have a patent stock of 516 patents. At the firm level, an average of 85 percent of the patent stock is developed internally by parent firms and their subsidiaries, whilst 15 percent is acquired externally. Of the externally acquired patents, 40 percent is acquired via the embodied route and 60 percent is acquired via the disembodied route, which amounts to 6 percent and 9 percent respectively out of the total patent stock. Our sample firms thus acquire a greater number of patents via patent assignments than via the acquisition of firms. On average, the share of novel patents within firms' patent stock is 9 percent, although there is a notably difference between the share of novel patents in the internally and externally developed stocks. Whereas the share of novel patents is 9 percent for the internally developed stock, it amounts to 14 percent for the externally developed stock, with only a 1 percent difference between the embodied and disembodied stocks. This suggests that sample firms are more likely to acquire technologies that belong to technological domains they are not familiar with than to develop these technologies internally.

Table 4.3 breaks downs the descriptive statistics by industry to highlight key differences in average values of core constructs across industries. From the table it can be observed that the average market value of sample firms is the greatest in the *Chemical* and *Pharmaceutical & Biotech* industries, with the value of assets being the greatest in the *Electronics & Electrical Machinery* and *Automotive & Other Vehicles* industries. Not surprisingly, the most R&D intensive firms are active in the *Pharmaceutical & Biotech*, *Software* and *IT-Hardware* industries. *Pharmaceutical & Biotech* firms spend a whopping 57 percent of the value of their assets on R&D, which is more than five times the sample average of 11 percent. Also in line with expectations, firms in manufacturing industries generate the most patents on average. An average firm in *Engineering & General Machinery*, *IT-Hardware* and *Automotive & Other Vehicles* has a patent stock of 978, 782 and 715 patents respectively.

Interestingly, there are stark differences across industries with respect to the rela-

Table 4.2: Summary statistics for main constructs.

	#Observations	#Firms	Mean	S.D.	Distribution				
					Min	10th perc.	50th perc.	90th perc.	Max
Market value ($m)	7,827	682	13,782	40,029	0.04	236	2,165	30,176	626,550
Assets ($m)	7,827	682	11,781	42,949	0.10	167	1,738	23,818	797,769
R&D expenditures ($m)	7,827	682	351	1,102	0	2	52	654	16,085
R&D stock ($m)	7,827	682	1,301	4,042	0	9	189	2,406	46,903
Sales ($m)	7,827	682	10,000	31,795	0	101	1,462	19,616	483,521
Number of employees	7,827	682	28,694	104,025	2	341	5,550	66,663	2,300,000
Patent stock	7,827	682	516	1,725	0	2	77	1,016	31,789
R&D expenditures/assets	7,827	682	0.11	51.95	0	0.002	0.04	0.19	93.09
Patent stock/R&D stock	7,827	682	0.71	1.01	0	0.047	0.40	1.66	19.69
Internal stock	7,827	682	438	1,560	0	1	59	889	30,922
External stock	7,827	682	77	373	0	0	9	146	10,581.
Embodied stock	7,827	682	31	236	0	0	0	38	8,534
Disembodied stock	7,827	682	46	270	0	0	5	99	10,379
Share internal stock	7,827	682	0.85	0.23	0	0.446	0.89	1	1
Share external stock	7,827	682	0.15	0.23	0	0	0.11	0.55	1
Share embodied stock	7,827	682	0.06	0.16	0	0	0.0028	0.24	1
Shared disembodied stock	7,827	682	0.09	0.18	0	0	0.0547	0.37	1
Patent stock (familiar)	7,827	682	467	1,650	0	0.73	59	928	31,288
Patent stock (novel)	7,827	682	49	106	0	0.52	16	111	1,622
Internal stock (familiar)	7,827	682	401	1,501	0	0.52	45	818	30,423
Internal stock (novel)	7,827	682	38	83	0	0	12	88	967
External stock (familiar)	7,827	682	66	342	0	0	6	121	9,490
External stock (novel)	7,827	682	11	43	0	0	2	25	1,251
Embodied stock (familiar)	7,827	682	26	213	0	0	0	30	8,108
Embodied stock (novel)	7,827	682	5	33	0	0	0	8	1,243
Disembodied stock (familiar)	7,827	682	40	248	0	0	3	83	9,319
Disembodied stock (novel)	7,827	682	6	25	0	0	1	16	1,060
Share novel in patent stock	7,827	682	0.09	0.20	0	0.048	0.19	0.48	1
Share novel in internal stock	7,827	682	0.09	0.19	0	0.042	0.17	0.45	1
Share novel in external stock	7,827	682	0.14	0.26	0	0	0.21	0.64	1
Share novel in embodied stock	7,827	682	0.15	0.31	0	0	0.20	0.78	1
Share novel in disembodied stock	7,827	682	0.14	0.27	0	0	0.17	0.63	1

Table 4.3: Summary statistics for main constructs broken down per industry.

	AUTM	CHEM	ELEC	ENGI	ITHW	OTHM	PHAR	SOFT	OTHI	ALL
#Observations	575	787	351	644	1,769	659	819	793	1,430	7,827
#Firms	45	58	28	46	137	53	86	79	150	682
Market value ($m)	10,708	22,676	15,528	9,506	10,170	8,375	19,156	10,738	17,191	13,782
Assets ($m)	22,572	19,070	32,292	8,560	6,189	6,008	9,903	5,049	14,235	11,781
R&D expenditures ($m)	687	219	217	290	387	173	839	342	110	351
R&D stock ($m)	2,747	867	818	1,123	1,434	658	3,046	1,149	361	1,301
Sales ($m)	17,978	18,594	8,966	7,084	4,621	4,681	4,843	2,413	19,898	10,000
Number of employees	45,023	19,821	25,980	25,858	12,583	15,875	9,562	7,727	77,376	28,694
Patent stock	716	454	582	978	782	432	291	361	168	516
R&D expenditures / assets	0.04	0.02	0.04	0.04	0.10	0.05	0.57	0.11	0.03	0.11
Patent stock / R&D stock	0.80	0.81	0.99	0.97	0.81	0.99	0.27	0.26	0.65	0.71
Internal stock	655	383	523	920	635	374	226	252	155	438
External stock	60	71	59	58	148	58	64	109	13	77
Embodied stock	16	42	18	21	52	17	37	56	3	31
Disembodied stock	44	29	41	37	96	41	27	53	10	46
Share internal stock	0.92	0.84	0.90	0.94	0.81	0.87	0.78	0.70	0.92	0.85
Share external stock	0.08	0.16	0.10	0.06	0.19	0.13	0.22	0.30	0.08	0.15
Share embodied stock	0.02	0.09	0.03	0.02	0.07	0.04	0.13	0.15	0.02	0.06
Share disembodied stock	0.06	0.06	0.07	0.04	0.12	0.10	0.09	0.15	0.06	0.09
Patent stock (familiar)	611	398	512	907	715	383	272	337	152	467
Patent stock (novel)	105	56	70	71	67	49	19	24	16	49
Internal stock (familiar)	565	339	463	863	587	334	213	238	142	401
Internal stock (novel)	91	45	60	58	48	40	13	14	13	38
External stock (familiar)	46	60	48	45	128	49	59	99	10	66
External stock (novel)	14	11	11	14	20	9	6	10	3	11
Embodied stock (familiar)	11	37	14	16	43	14	34	52	2	26
Embodied stock (novel)	5	5	5	5	9	3	3	4	1	5
Disembodied stock (familiar)	35	23	35	28	85	35	25	47	8	40
Disembodied stock (novel)	9	6	6	9	11	6	2	6	2	6
Share novel in patent stock	0.15	0.12	0.12	0.07	0.09	0.11	0.06	0.07	0.09	0.09
Share novel in internal stock	0.14	0.12	0.11	0.06	0.07	0.11	0.06	0.06	0.08	0.09
Share novel in external stock	0.24	0.16	0.18	0.23	0.13	0.15	0.09	0.09	0.22	0.14
Share novel in embodied stock	0.34	0.12	0.25	0.22	0.18	0.15	0.08	0.07	0.32	0.15
Share novel in disembodied stock	0.20	0.21	0.15	0.24	0.11	0.15	0.09	0.12	0.18	0.14

tive shares of internally developed and externally acquired technologies. The share of externally acquired patents is the largest in the *Software*, *Pharmaceuticals & Biotech* and *IT-Hardware* industries, whilst being the lowest in the *Engineering & General Machinery* and *Automotive & Other Vehicles* industries. The share of externally acquired patents amounts to 30 percent for an average *Software* firm, which is twice the sample average of 15 percent, whilst amounting to only 6 percent for an average *Engineering & General Machinery* firm, which is less than half of the sample average. Except for the *Chemical*, *Pharmaceutical & Biotech* and *Software* industries, sample firms acquire a larger share of patents via patent assignments than via M&As. For firms in these industries the share of externally acquired technologies via M&As far exceeds the sample average of 6 percent. The standalone acquisition of technology is especially prominent in the *Software*, *IT-Hardware* and *Other Manufacturing* industries.

The differences between industries are also apparent when it comes to the share of novel technologies within the internally developed and externally acquired stock of patents. With respect to the entire patent stock it is notable that firms in the *Automotive & Other Vehicles*, *Chemical*, *Electronics & Electrical Machinery* and *Other Manufacturing* industries have the largest share of novel patents on average. It is also the firms in these industries that both develop the largest share of novel patents internally and acquire the largest share of novel patents externally. Lastly, firms in the *Automotive & Other Vehicles* and *Electronics & Electrical Machinery* and *Engineering & General Machinery* have the highest novelty shares within the stocks of patents acquired via both the embodied and disembodied mode.

4.4.2 Parametric Analysis

The results of the regression models estimating the contribution of different technology acquisition strategies to the market value of firms are presented in Table 4.4. We begin with a baseline regression in Model 1 that estimates the contribution of firms' assets, cumulative R&D investments and internal technology development efforts to their market value. As expected, the signs of *ASSETS* , *R&D STOCK* and *INTERNAL STOCK* are all positive and highly significant. Furthermore, the high value of the R-squared indicates that the control variables account for a large share of the variation in *MARKET VALUE*. To test Hypothesis 1, we include the *EMBODIED STOCK* and *DISEMBODIED STOCK* in Model 2. Interestingly, we find that the coefficient of *EMBODIED STOCK*

Table 4.4: Regression results: contributions from internal, embodied and disembodied stocks to market value.

	Dependent Variable: ln(Market value)				
	(1)	(2)	(3)	(4)	(5)
ln(*ASSETS*)$_{t-1}$	0.825***	0.829***	0.833***	0.822***	0.830***
	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
ln(*R&D STOCK*) $_{t-1}$	0.020***	0.022***	0.025***	0.021***	0.019**
	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
ln(*INTERNAL STOCK*) $_{t-1}$	0.085***	0.095***	0.097***	0.077***	0.092***
	(0.006)	(0.007)	(0.007)	(0.008)	(0.009)
ln(*EMBODIED STOCK*) $_{t-1}$		0.015**		-0.082***	
		(0.007)		(0.018)	
ln(*DISEMBODIED STOCK*) $_{t-1}$		-0.035***		-0.064***	
		(0.007)		(0.016)	
ln(*EXTERNAL STOCK*) $_{t-1}$			-0.013*		
			(0.007)		
ln(*INTERNAL STOCK # EMBODIED STOCK*) $_{t-1}$				0.017***	
				(0.003)	
ln(*INTERNAL STOCK # DISEMBODIED STOCK*) $_{t-1}$				0.005*	
				(0.003)	
ln(*EMBODIED STOCK FAMILIAR*) $_{t-1}$					0.026***
					(0.010)
ln(*EMBODIED STOCK NOVEL*) $_{t-1}$					-0.020
					(0.014)
ln(*DISEMBODIED STOCK FAMILIAR*) $_{t-1}$					0.002
					(0.010)
ln(*DISEMBODIED STOCK NOVEL*) $_{t-1}$					-0.063***
					(0.014)
Constant		0.581***	0.546***	0.732***	0.567***
		(0.078)	(0.077)	(0.082)	(0.080)
#Observations	7,827	7,827	7,827	7,827	7,827
#Firms	682	682	682	682	682
R-squared	0.822	0.826	0.826	0.828	0.825
Industry Dummies	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes

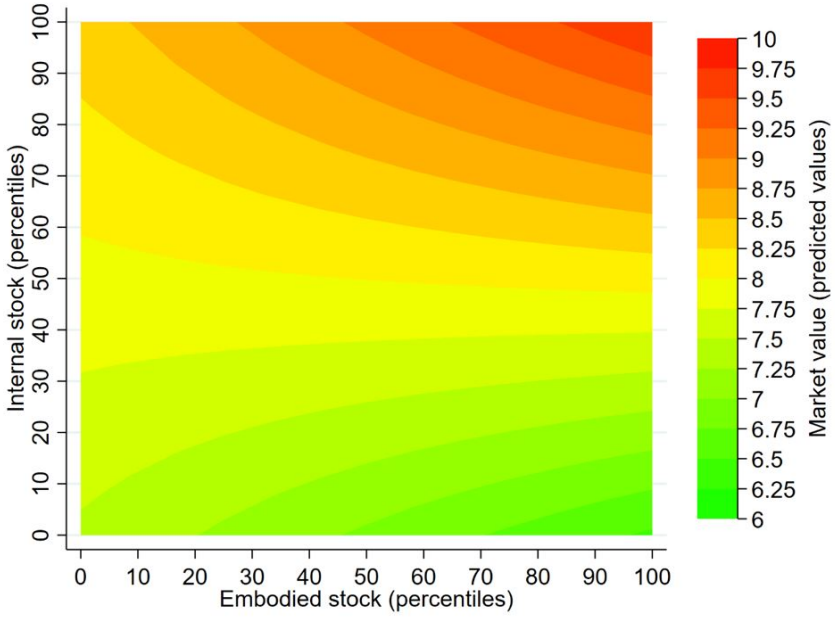
Standard errors are robust to arbitrary heteroskedasticity and allow for serial correlation via clustering on the firm-level.
*** p<0.01, ** p<0.05, * p<0.1.

is positive and significant whilst the coefficient of *DISEMBODIED STOCK* is negative and significant. The results, thus, suggest a positive contribution to market value of technology acquired via the embodied mode whilst revealing a negative relationship between market value and technology acquired via the disembodied mode. This finding not only rejects Hypothesis 1, but also highlights the importance of disentangling different modes of technology acquisition. To further illustrate this point, we include the sum of *EMBODIED STOCK* and *DISEMBODIED STOCK* in Model 4 instead of including both stocks separately. The coefficient of *EXTERNAL STOCK* is negative and significant, albeit only at the 10%-level. This means that we would have found an overall negative relationship between technology acquisition and market value without explicitly distinguishing between the different modes of technology acquisition.

To explore whether the contribution of the two modes of technology acquisition to market value differs across different levels of internal technology development, we include the interaction term of *INTERNAL STOCK* and *EMBODIED STOCK* and the interaction term of *INTERNAL STOCK* and *DISEMBODIED STOCK* respectively in Model 4. Both interaction terms are positive and significant, albeit only at the 10%-percent level for the interaction between *INTERNAL STOCK* and *DISEMBODIED STOCK*, but are difficult to interpret because the coefficients of *EMBODIED STOCK* and *DISEMBODIED STOCK* are negative whilst the coefficient of *INTERNAL STOCK* is positive. This signals that the direction of the relationship between *EMBODIED STOCK* and *MARKET VALUE* and *DISEMBODIED STOCK* and *MARKET VALUE* differs across levels of *INTERNAL STOCK*.

To get a clearer view of the interaction between *INTERNAL STOCK* and the two modes of technology acquisition we visualize the predicted values of *MARKET VALUE* across the distribution of *INTERNAL STOCK* and *EMBODIED STOCK* in Figure 4.5 and across the distribution of *INTERNAL STOCK* and *DISEMBODIED STOCK* in Figure 4.6. The interaction between *INTERNAL STOCK* and *EMBODIED STOCK* is apparent in the curvature of the contour lines in the figure. This curvature clearly shows that the relationship between *EMBODIED STOCK* and *MARKET VALUE* differs across levels of *INTERNAL STOCK*. Hence, if this would not be the case the contour lines in the figure would all be straight. The presence of both upward and downward curves confirms that for part of the distribution of *INTERNAL STOCK* the relationship between *EMBODIED STOCK* and *MARKET VALUE* is negative whereas for another part it is positive. More

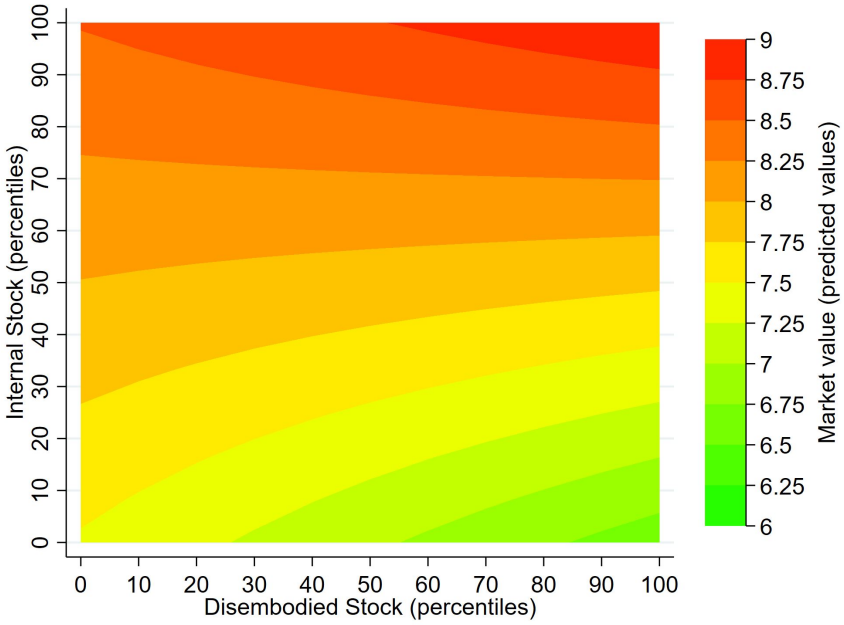
Figure 4.5: Predicted values of market value across the distribution of internal and embodied stocks.



specifically, we can observe a clear pattern whereby (i) up to the 30^{th} percentile of the distribution of *INTERNAL STOCK*, firms acquiring even a low volume of technology via the embodied mode have a lower market value on average than firms that do not acquire any technology, (ii) between the 30^{th} and 60^{th} percentile of the distribution of *INTERNAL STOCK*, there is no significant difference between the market value of firms acquiring any level of technology and firms acquiring no technology at all and (iii) above the 60^{th} percentile of the distribution of *INTERNAL STOCK*, firms acquiring any level of technology have a higher market value on average than firms acquiring no technology. This suggests that the acquisition of technology via the embodied mode only contributes positively to market value for firms having the top-40% largest stocks of internally developed technologies.

The interpretation of figure 4.6 is analogous to the interpretation of Figure 4.5. The

Figure 4.6: Predicted values of market value across the distribution of internal and disembodied stocks.



overall pattern in Figure 4.6 is similar to the one in Figure 4.5, although the threshold of *INTERNAL STOCK* at which higher levels of *DISEMBODIED STOCK* are associated with higher values of *MARKET VALUE* is considerably greater than the threshold of *INTERNAL STOCK* at which higher levels of *EMBODIED STOCK* are associated with higher values of *MARKET VALUE* in Figure 4.5. Interestingly, this indicates that acquiring technologies via M&As contributes positively to the market value of a larger share of firms than acquiring technologies via standalone acquisitions. In sum, the patterns in Figures 4.5 and 4.6 suggest that the size of firms' internally developed knowledge stock positively moderates the relationship between market value and both modes of technology acquisition. At the same time a comparison of both patterns suggests that absorptive capacity is more important for acquiring technology via the disembodied route than via the embodied route. This is conform the predictions of Hypothesis 2.

In a final specification in Model 5 we further disaggregate the embodied and disembodied stocks into stocks of patents that the acquiring firm is familiar with and those that are novel to the acquiring firm. The coefficient of *EMBODIED STOCK FAMILIAR* is positive and significant whilst the coefficient of *EMBODIED STOCK NOVEL* is not significant. These results suggest that there is a positive relationship between embodied technology acquisition and market value for acquired technologies that are familiar to the acquiring firm but not for the technologies that the acquiring firm is unfamiliar with. This finding rejects the prediction of Hypothesis 3a that acquiring technology from external sources via embodied technology acquisition is positively associated with firms' financial performance, regardless of whether the acquiring firm is familiar or unfamiliar with the acquired technology. The results suggest that for acquisitions via M&As it does matter whether firms are familiar with the technologies that they acquire. Interestingly, the coefficient of *DISEMBODIED STOCK FAMILIAR* is not significant whilst the coefficient for *DISEMBODIED STOCK NOVEL* is negative and significant. These results signal that there is no contribution of familiar technology acquired via standalone acquisition to market value but that there is a negative appraisal of the market of novel technology acquired via the disembodied route. We can thus reject Hypothesis 3b which predicted that the acquisition of technology via the disembodied mode has a positive effect on firms' financial performance, only when the acquiring firm is familiar with the acquired technology. Our results suggest that there is no positive contribution of technology acquired via the disembodied mode, regardless of whether the acquiring firm is familiar with the technology or not.

4.5 Discussion

4.5.1 Main Findings

To the best of our knowledge, our study is the first to consider the performance implications of standalone technology acquisitions on the firm-level. As a result, our findings extend the existing scholarship on the sourcing of external technology in multiple ways. First, our findings clearly suggest that the mode of technology acquisition is a key determinant of firms' ability to generate value from technology developed outside their boundaries. We find that whilst the acquisition of technology via the embodied mode is associated with higher market values the same does not hold for technology acquired

via the disembodied mode. In fact, our findings point to a negative relationship between market value and the acquisition of standalone technology. This implies, that despite all the benefits that are ascribed to the acquisition of standalone technology in the literature on markets for technology, the acquisition of technology alone does not necessarily translate into value creation on the firm-level, at least not in the eyes of the stock market.

Second, our findings strongly emphasize that absorptive capacity is a requisite for firms to derive value from technologies acquired via both embodied- and disembodied technology acquisition. We find that the size of firms' internally developed knowledge stock positively moderates the relationship between market value and both modes of technology acquisition respectively. We thus find support for the notion that firms can only be 'good buyers' when they are also 'good makers', irrespective of the mode of acquisition. For firms that develop little to no technology themselves buying even the lowest volumes of technology is associated with lower market values on average whilst firms having large internal knowledge stocks can derive additional value from acquiring large volumes of external technology. Although we do not formally test for it, these findings hint at a complementary rather than substitutive relationship between internal technology development and external technology acquisition. Furthermore, they seem to suggest that above a certain threshold of internal knowledge production, the marginal cost of identifying, screening, assimilating, integrating and exploiting technology is likely to decrease whilst the opportunities for the fruitful recombination of internal and external knowledge are likely to increase. Interestingly, our analyses reveal that this threshold is considerably higher for the acquisition of technology via the disembodied mode than via the embodied mode. This implies that firms require a greater absorptive capacity to generate value from external technology if technology is the only thing they acquire.

Third, our findings highlight that the nature of technology shapes firms' ability to benefit from technology acquired via both modes, albeit in different ways. The distinction between the acquisition of technologies that firms have prior experience with and those that are novel to them reveals that firms are most likely to benefit from the acquisition of familiar technology via the embodied mode. Although we find a positive relationship between market value and the acquisition of familiar technology via the embodied mode, we do not find any relationship between market value and the

acquisition of novel technology via this mode. This suggests that the positive overall contribution of embodied technology acquisition that we reported above is mainly attributable to the acquisition of technology that is related to what the acquiring firm already knows. Interestingly, we find a negative relationship between market value and the acquisition of novel technology via the disembodied mode whilst finding no effect for the acquisition of familiar technology via this mode. On the one hand, this suggests that it is challenging to derive value from technology that is new to a firm, even if this firm acquires the entire firm that developed this technology. On the other hand, it implies that acquiring technology only may not be sufficient to leverage external technology even if this technology is related to what the acquiring firm already knows.

4.5.2 Implications

Although our finding of a negative association between the acquisition of standalone technology and market value is somewhat surprising, given that it goes against all the arguments provided in favor of markets for technology, other studies have reported negative stock market responses to firms' buying decisions. Most notably, in an event study of stock market reactions to firms general 'make, buy and ally' decisions, Borah and Tellis (2014) find that make and ally decisions generally provoke a positive stock market reaction, whilst buy decisions generally prompt a significant negative reaction. This finding is robust even after controlling for a variety of confounding variables, applying different estimation methods and testing for both pure and mixed strategies. As an explanation for the negative stock market reaction towards buying, Borah and Tellis advance that, when buying firms often incur high financial, management and reputation costs that outweigh its benefits in large part because buying often involves a bidding game with rivals that results in a price that exceeds the 'real' value of the object of purchase. Although their study is not specifically concerned with making or buying technology, Borah and Tellis' explanations may also hold in our setting.

Another explanation, that is more specific to the setting of technology acquisition, relates to the inefficiency of markets for technology in overcoming the information asymmetry between buyers and sellers of technology. Although most market exchanges are subject to a level of information asymmetry, the level of information asymmetry is greater for intangible assets than for tangible assets because intangibles exert the characteristics of a public good. Whereas a buyer requires a certain level of detail about

a technology in order to decide whether to acquire it or not, a seller does not have an incentive to provide such a level of detail because doing so would *de facto* result in a transfer of the technology without any financial compensation. As a result, there is considerable uncertainty about the potential applications and, hence value of a technology, and there may be high costs associated with negotiating, executing and enforcing agreements between buyers and sellers. These costs are likely to be especially high for technologies that the acquiring firm is not familiar with. This might explain, at least in part, why the negative relationship between disembodied technology acquisition pertains to technologies that acquiring firms are not familiar with. An acquiring firm simply knows less about the potential applications of technologies that it has no experience with than it knows about the applications of technologies that it has experience with. As a result, it faces higher uncertainty and transaction costs when acquiring novel technology than it faces when acquiring familiar technology.

Alternatively, the negative association between standalone technology acquisition and market value might also be explained by the fact that the acquisition of standalone technology signals strategic motives that the stock market perceives as negative. Whereas the acquisition of an entire firm might be perceived by the stock market as a signal that the acquiring firm is serious about expanding its stock of technologies, resources and/or capabilities, the acquisition of a bundle of patents might be perceived as a signal that the acquiring firm is facing some kind of adversity. For example, Facebook Inc.'s acquisition of 750 patents from IBM Corporation in 2012 was perceived by analysts as a signal that the firm was preparing itself for a major patent litigation battle with Yahoo!. As a result, the stock market reaction to Facebook Inc.'s announcement of the patent acquisition deal was negative.[8] At the same time though, Twitter Inc.'s acquisition of 943 patents from IBM Corporation for $36 million was perceived as a bargain to avoid litigation with IBM Corporation, resulting in a positive stock market reaction following the announcement.[9] It is likely that there is a great deal of heterogeneity among disembodied technology acquisition deals with some provoking negative and others provoking positive stock market responses.

[8]https://www.reuters.com/article/us-facebook-ibm-patents/facebook-buys-750-patents-from-ibm-source-idUSBRE82L13O20120322, accessed on February 11th, 2019.

[9]https://www.bloomberg.com/news/articles/2014-03-06/twitter-paid-36-million-for-900-ibm-patents-to-build-portfolio, accessed on February 11th, 2019.

4.5.3 Limitations

Our study is subject to a number of noteworthy limitations that can serve to highlight fruitful avenues for future research. First, although we took great caution in retrieving and combining information from several publicly available data sources to establish firms' ownership structure and technology sourcing strategies, we should note that firms may have strategic motives for not disclosing information pertaining to their ownership of other companies and their ownership of intellectual property. A study by Gramlich and Whiteaker-Poe (2013), for example, reveals that in 2010 Oracle Corporation and Google Inc. disclosed significantly less subsidiaries in SEC-filings than in the years prior, with the list of Google Inc.'s subsidiaries going down from 118 to two and the list of subsidiaries of Oracle Corporation going down from 428 to six from 2009 to 2010. Another study by Ewing and Feldman (2012) found that the mass patent aggregator Intellectual Ventures has made use of over 1,000 shell companies to conduct its intellectual property acquisitions. Furthermore, the limitations of relying on publicly available patent assignment records as highlighted in Chapters 2 and 3 of this dissertation certainly apply. To the extent that existing regulations do not warrant the adequate disclosure of changes in patent ownership rights, we may only selectively observe firms' disembodied technology acquisition activities. Although we rely on inventory measures that moderate sudden fluctuations in patent stocks, we cannot rule out that our results are biased due to the fact the we may not observe the full extent of intellectual property ownership by our sample firms.

Second, it is important to note that we simply observe mere counts of patents acquired via M&As and patent assignment deals without observing the terms of these deals. Most notably, we do not observe the amount of transaction costs that our sample firms incurred to acquire firms and standalone technologies. Clearly, the price paid to acquire technologies via both M&As and patent assignment deals is likely to be an important, if not the most important, determinant of how the stock market reacts to such deals. Although we attempt to partially capture the value of internally developed and externally acquired technologies by weighing patents by the number of forward citations that they receive – which is in line with several existing studies that suggest that forward citations are associated with economic value (see for example Hall *et. al.*, 2005 and Kogan *et. al.*, 2017) – it is very likely that the contribution of technology acquisition deals to market value is attributable to the specific terms of these deals rather than the

occurrence of deals themselves. Any future research endeavor that would incorporate the cost of acquiring technology into the analysis would undoubtedly be a valuable addition to existing scholarship.

Third, in addition to not observing the terms of M&A and patent assignment deals we also know little to nothing about the motivations for completing such deals. Although we implicitly assume that M&As and patent assignments are at least partly motivated by technological considerations, we cannot rule out that these considerations are not the main motive to conduct such deals. M&As might, for example, primarily be an entry mechanism to access new geographic and/or product markets and patent assignments may be a means to initiate or fend off patent litigation cases. As a result, we also know little about the choices that firms face when deciding between M&As and standalone technology acquisitions and between patent assignments and technology licensing. A better understanding of the motives underlying different modes of technology acquisition is arguably the most important advance towards a richer understanding of the dynamics of firms' technology acquisition strategies.

Finally, whilst our empirical strategy allows us to generate new insights on the relationship between different technology sourcing strategies and firms' market value, it does not allow us to establish a particular causal structure. Although we believe that our study provides a valuable first step towards a richer understanding of the performance implications of embodied and disembodied technology acquisition, we acknowledge the need for future causal explorations of the proposed relationships.

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General Conclusion

Research Objectives

Although historic accounts of markets for technology date back to the late 19th century, there is increasing evidence that these markets have expanded considerably since the beginning of the 1990s. Their growth is not only demonstrated by larger volumes of technology trade but also by the ever-increasing monetary streams that this trade generates. Markets for technology are relevant phenomena for corporate managers and policy makers alike because they can be a source of both private and social value. There is a large stream of literature under the umbrella of 'open innovation' suggesting that firms should not develop all their technologies internally. Greater competitive pressures in combination with the increasing complexity of technology make that even the largest and most technologically advanced firms cannot rely solely on internally developed technology when developing their innovations but must tap into knowledge sources that are located outside their boundaries to complement their internal knowledge stocks. On the societal level, markets for technology have the potential to generate positive welfare effects for consumers by enabling a division of labor between actors that invent and actors that commercialize most efficiently. By providing a viable pathway for invention without commercialization, they enable a level of specialization that creates incentives to inventors who do not possess the downstream resources and capabilities needed to manufacture, market and distribute their inventions. This results in a larger supply of and competition among technologies that not only creates welfare gains for consumers but also enables gains from the trade of technology. Specialist providers of technology can often develop technologies faster and cheaper than a focal firm, which makes external technology acquisition a viable alternative to internal technology development.

Notwithstanding the potential private and social benefits of markets for technology,

there is consensus amongst academics, policy makers and industry representatives that these benefits are not fully realized due to a number of imperfections that define such markets. Most notably, technology markets are subject to information asymmetries between buyers and sellers that are attributable to the intangible nature of knowledge assets. These information asymmetries result in high transactions costs from negotiating, executing and enforcing contractual agreements between buyers and sellers. Legal appropriation mechanisms can remedy this imperfection not only by offering protection from misappropriation by third parties but also by encouraging inventors to disclose relevant technological information that they would otherwise keep secret. Patents are thus not only an important mechanism for getting inventions developed but are arguably even more important as a vehicle for getting these inventions put to the right use. It is not surprising, therefore, that empirical analyses of markets for technology are almost exclusively based on patent-based indicators. Whereas the earliest of these analyses have been limited by a lack of large-scale systematic data sets on patent licensing deals, more recent empirical literature has started to employ data on patent assignments – publicly disclosed transfers of patent ownership rights – in an attempt to provide a more comprehensive understanding of the dynamics of technology trade.

Although these studies have undeniably contributed to our understanding of markets for technology, they leave important questions with respect to the application of patent assignment data unanswered. First, they neglect or significantly downplay existing concerns that federal regulations may not be effective in motivating the beneficiaries of patent assignments to publicly disclose these deals, even though this concern casts serious doubt on the consistency and accuracy of publicly available records of patent ownership changes. Second, existing studies lack a number of methodological advances that are fundamental to realize the full potential of assignment data on the firm-level. In particular, they do not distinguish between (i) inter-firm and intra-firm transactions and (ii) transactions that involve standalone technology and transactions that are part of a larger M&A deal. As a result, existing applications of patent assignment records provide only a limited understanding of the implications of firms' activities on markets for technology. This dissertation aims to provide such an understanding by (i) systematically examining the reliability and consistency of publicly available records of patent ownership changes and (ii) applying these records to study the performance effects of firms' activities on markets for technology. In doing so, it bridges economic, managerial

and legal scholarship on markets for technology, open innovation and patent monetization in order to contribute to existing debates concerning the functioning of technology markets, the applicability of patent assignments as indicator of technology trade and the public notice function of the patent system.

Main Findings and Implications

There is a need to exercise caution when interpreting the results of studies that rely on publicly available records of patent assignments to measure activity on markets for technology.

The main implication of the findings of Chapter 2 is without a doubt that caution is warranted in the interpretation of studies relying on publicly available patent assignment records. The validation of assignment records from the USPTO Patent Assignment Database (UPAD) not only reveals that a significant share of patent assignment deals is not recorded with the USPTO but also that the non-recording of assignments is related to characteristics on both the patent- and assignee-levels that have been associated with greater levels of activity on technology markets by existing empirical studies. The comparison of the names of assignees listed on issued patent documents with the names of plaintiffs and defendants in patent suits, reveals that a chain of ownership cannot be established via records in UPAD in more than half of the cases in which the plaintiff or defendant is not listed as assignee on the issued patent document. Intriguingly, the rate of recording increases over time, which implies that empirical studies reporting a trend towards greater activity on technology markets may, at least in part, pick up a trend in recording rather than a trend in actual activity. The analyses furthermore reveal significant differences in recording patterns across technology classes, patent value indicators and types of assignees, which points to the existence of biases in such patterns that are not randomly distributed. In addition to Chapter 2, the consolidation exercise in Chapter 4 highlights that the great majority of patents that are assigned, are assigned to firms that are part of the same corporate groups as the assignor. This implies that existing studies that describe a trend towards greater activity on markets for technology may pick up a trend in the reallocation of patents within firm boundaries rather than a trend in inter-firm transactions.

Policy changes aimed at improving the 'active transparency' of patent ownership are much needed to improve both the functioning of markets for technology and the notice function of the patent system.

As a follow-up on the analyses of Chapter 2, the main implication of Chapter 3 is that there is a need for policy change aimed at improving the transparency of patent ownership. In the chapter we argue that transparent ownership information is not only part of the 'quid pro quo' logic that underlines the utilitarian justification of the patent system but is also crucial for the efficient functioning of markets for technology. A comparative analysis of the six largest patent offices worldwide reveals that existing provisions provide only limited opportunities for tracking changes of ownership over time. Although all six patent offices under study impose strict requirements concerning the identification of the initial applicant(s) of a patent, they do not impose and/or enforce such strict requirements with respect to the disclosure of the identity of the new owner(s) following a change of ownership. As a result, the disclosure of the identity of the new owner(s) following ownership changes is largely left to the discretion of the new owner(s) and happens on a voluntary basis. These findings call for policy initiatives that aim to promote active transparency instead of passive transparency. We argue that this can be achieved by installing minimal requirements with respect to (i) the scope of ownership to be disclosed, (ii) the timing of the disclosure of ownership information, (iii) the type and extent of corrective action upon failure to meet requirements concerning the disclosure of ownership information (iv) the recording and public disclosure of submitted ownership information.

Firms' ability to derive value from external technology acquisition is shaped by the interplay between the mode of technology acquisition, their degree of absorptive capacity and the nature of the acquired technology. Although firms can benefit from both embodied and disembodied technology acquisition, they are more likely to generate value from the acquisition of technology via the embodied mode.

The application of consolidated assignment records in an analysis of the performance implications of different technology acquisition strategies in Chapter 4 contributes to existing scholarship in several ways. First, the analyses reveal that the mode of technol-

ogy acquisition is a key determinant of firms' ability to generate value from technology developed outside their boundaries. Whereas the acquisition of technology via M&A deals is associated with higher market values, the same does not hold for the acquisition of standalone technology. In fact, the findings point to a negative relationship between market value and the acquisition of technology only. This implies, that despite all the benefits that are ascribed to the acquisition of standalone technology in the literature on markets for technology, the acquisition of technology alone does not necessarily translate into value creation on the firm-level. Second, the analyses also reveal that a minimum degree of absorptive capacity is a requisite for firms to derive value from both technologies acquired via M&A deals and technologies acquired solitarily. This suggests that firms can only be 'good buyers' when they are also 'good makers', irrespective of the mode of technology acquisition. At the same time, the analyses also indicate that firms require a greater degree of absorptive capacity to generate value from external technology if technology is the only thing they acquire. Lastly, the analyses also reveal that the nature of technology shapes firms' ability to benefit from technology acquired via both modes, albeit in different ways. The distinction between the acquisition of technologies that firms have prior experience with and those that are novel to them highlights that firms are most likely to benefit from the acquisition of familiar technology via the embodied mode.

Limitations and Avenues for Future Research

The analyses presented in this dissertation are inevitably subject to a number of noteworthy limitations that may inspire fruitful avenues for future research. First, although we observe the behaviors of firms in terms of recording patent ownership changes in Chapter 2, and in terms of their acquisition of technology via M&As and stand-alone deals in Chapter 4, we do not observe the motivations underlying these behaviors. With regards to the analysis of recording patterns in Chapter 2, this implies that we cannot determine whether and to what extent non-recording is motivated by a deliberate act to gain a certain strategic advantage or whether it is motivate by other considerations other than attempting to hide patent ownership. With regards to the analysis of firms' technology acquisition strategies in Chapter 4, we know little to nothing about the motivations of technology acquisition deals. Although we implicitly assume that M&As and patent assignments are at least partly motivated by technological considerations,

we cannot rule out that these deals are not motivated by technological considerations. M&As might for example function as an entry mechanism to access new geographic and/or product markets and patent assignments may be a means to prepare for or fend off patent litigation suits. As a result, our analyses provide us with only a limited understanding of the choices that firms face when acquiring technology.

Second, in the firm-level analysis presented in Chapter 4, we only observe mere counts of patents acquired via M&As and standalone deals and do not observe the terms of these deals. This is an important limitation given that it is very likely that the contribution of technology acquisition deals to market value is determined in large part by the specific terms of these deals. In particular, we do not observe the transaction costs that firms have to make to complete both M&A deals and patent assignments, although the price paid to acquire technology via both acquisition modes is undoubtedly a key determinant of how the stock market responds to such deals. Any future research endeavor that finds a way to reliably estimate and incorporate the price of technology into the analysis of technology acquisition deals would be a valuable addition to existing scholarship. In addition to not having information on the price paid for the acquisition of a firm or standalone technology, we also do not observe other important terms that are relevant for our analysis. For example, key staff members may not always be part of an M&A deal and patent assignment deals may be accompanied by transfers of key staff members from the 'selling' firm to the 'buying' one. In other words, in practice M&A deals may not always be as embodied and patent assignments may not be as disembodied as we assume in our analysis in Chapter 4. Linking information from various data sources in order to develop a better understanding of what exactly is transferred in technology acquisition deals is thus an important avenue for future research.

Third, our analyses are also limited in terms of scope and coverage in several ways. With the exception of the comparative analysis of regulations for the disclosure of patent ownership in Chapter 3, all analyses are confined to the US-setting in the sense that we rely exclusively on patent assignment records that are collected and disclosed by the USPTO. This means, for example, that our findings with regards to the dynamics of recording patterns in Chapter 2 may not be generalizable to settings outside the US. Although our comparative analysis of the regulations for disclosing patent ownership information in Chapter 3 suggests that the regulations in other jurisdictions are similar to those in the US, this does not necessarily imply that the same holds for actual

recording patterns. Likewise, our analysis of the performance implications of different acquisition strategies in Chapter 4 is confined to US patents held by US firms. As a direct consequence, some of the largest firms in terms of both R&D expenditures and patent stocks worldwide are not included in our analysis. In addition to being limited in 'geographic' scope, our analysis in Chapter 4 only covers two distinct modes of technology acquisition – M&As and patent assignments – and does not consider other prominent modes such as licensing and R&D alliances. As a result, we might only capture a fraction of firms' technology sourcing activities in our analyses. Taking into account the entire portfolio of technology sourcing modes and assessing the complementarity between these modes is, therefore, yet another promising avenue for future research.

Lastly, although we believe that our analyses advance the understanding of firms' activity on markets for technology by highlighting previously unexplored relationships, it should be noted that our empirical strategy does not allow us to establish a particular causal structure. We, therefore, acknowledge the need for causal explorations of the proposed relationships in future studies.

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