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The Strategic Management of Intellectual Property:

Patent Value and Acquisitions

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ABSTRACT

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In this dissertation I explore the role and importance of patent strategy for appropriating returns from innovation. In particular, I examine the mechanisms through which firms increase appropriability from patenting by employing complementary resources and capabilities and gauge their contribution to firm performance. To this end, I perform three empirical studies.

In the first study, I focus on measuring patent value and demonstrate that the importance of firm resources and capabilities is much higher than previously thought. I interpret these results as providing strong support for the view that the design of patent strategy is crucial for profiting from innovation.

In the second study, I look into a sample of technology acquisitions and examine under what circumstances firms profit from combining previously separate patent rights. I demonstrate that the merging of overlapping patent portfolios give rise to inimitable synergies, albeit only in complex technology industries. In addition, I find that firms are more likely to acquire targets with patents when their patent productivity is low, when they have a technologically diverse patent portfolio in complex technology industries and when they face an increased threat of being involved in patent suits.

In the third study, I explore the role of patent strategies in the non-technological domain. I demonstrate that recent regulatory changes enabling the patenting of business methods can help patentees capture value from business model and management innovations. Moreover, I find that patenting experience and access to complementary assets are both crucial elements of a patenting strategy aimed at increasing appropriability.

Taken together, these studies contribute towards bringing studies of patenting and the resource-based view of the firm closer together, to mutual advantage. This results in a better understanding of the effectiveness of patents at the firm-level and in a clearer operationalization of concepts of resources and resource interdependence.

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LIST OF ABBREVIATIONS

CAFC: Court of Appeals for the Federal Circuit

CAR: Cumulative abnormal returns

KBV: Knowledge-based view

M&A: Mergers and acquisitions

NBER: National Bureau of Economic Research

NOA: Notice of allowance

OLS: Ordinary least squares

RBV: Resource-based view

SIC: Standard Industrial Classification

TRIPS: Trade related aspects of intellectual property rights

USPTO: US Patent and Trademark Office

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The strategic management field is primarily concerned with explaining persistent differences in profitability across firms (Rumelt *et al.*, 1991). The resource-based view of the firm (RBV) has become increasingly influential in this pursuit by attributing performance differences to heterogeneity in resource endowments and the existence of isolating mechanisms that limit competition (Barney, 1991; Lippman *et al.*, 1982; Peteraf, 1993). RBV scholars focus particularly on knowledge and its protection as a source of competitive advantage (Eisenhardt *et al.*, 2002; Grant, 1996; Teece *et al.*, 1997). This is hardly surprising given that global competition is becoming increasingly reliant on intellectual capital and firms struggle to integrate disparate knowledge sources without risking expropriation (Pisano, 2006; Teece, 2000). Patent rights then are strategically important resources given their role in discouraging imitation. Penrose (1959:136), widely considered as the founder of RBV, explicitly acknowledges the role of patents for competitive advantage by suggesting that they are key devices to ward off competition, at least in the short term.

Economic theory similarly discusses the benefits derived from the ownership of patent rights but tends to emphasize their impact on inventors' incentives (Mansfield, 1968; Scherer, 1965). In particular, patents address a fundamental problem in information markets related to underinvestment in creating new knowledge: inventors have weak incentives to innovate as they are unable to appropriate their investments in R&D due to imitators, a situation commonly referred to as the ‘appropriability problem’ (Arrow, 1962; Winter, 2006). Patents explicitly address this problem by awarding inventors monopoly rights over the use of their inventions in exchange for the public disclosure of information necessary for the new product or process.

Nevertheless, the patent system does not guarantee strong appropriability. A number of studies have demonstrated that the effectiveness of patents varies considerably across sectors (Cohen, 2010; Cohen *et al.*, 2000; Levin *et al.*, 1987). For example, in the pharmaceutical industry patents are regularly reported to be the primary means of competition. In other industries though, such as metallurgy or communications equipment, they seem to be less important for profitability. Alternative strategies of appropriability (like secrecy or lead time) are found to confer more advantages to innovators.

The literature also suggests that patents are not always used as monopoly instruments as originally intended by the legislator. Patent holders are often unable to enforce their patent rights due to either poor monitoring or lack of managerial and financial resources required to litigate infringers (Lanjouw *et al.*, 2004b; Lerner, 1995). In addition, inventors need access to specialized complementary assets, such as marketing or manufacturing skills, in order to commercialize their invention (Teece, 1986). In so-called ‘complex’ technology industries, infringement of competitors’ technologies is the norm and patents are used as ‘bargaining chips’ in licensing and cross-licensing agreements (Grindley *et al.*, 1997; Hall *et al.*, 2001b). In addition, patentees often need to form patent 'thickets' or 'fences' in order to block certain parts of the technology space from competitors (Reitzig, 2004; Shapiro, 2001).

These findings suggest that the relationship between patenting and appropriability is a complex one and firms need to actively manage their patent portfolios in order to profit from their patented inventions. Hence, value appropriation through patenting should not be studied solely with reference to external conditions, like the nature of the patented technology or the strength of intellectual property rights regulation. Firm-specific choices and strategies are likely to influence the efficacy of patent rights as mechanisms of appropriability. As Bessen (2008:939) argues, patent value is, to a certain extent, endogenous to the efforts at patent refinement and enforcement undertaken by the assignee firm.

The strategic management of patent rights then, as opposed to simply owning patent rights, is likely to be crucial for profitability. Here I define the strategic management of patent rights, or patent strategy, as the actions undertaken by firms to employ resources and capabilities, in conjunction with patent rights, in order to increase appropriability (see also Somaya, 2012:1085-1087). Yet, with a few exceptions, the patenting literature pays little attention to the various facets of patenting strategy. For example, Reitzig *et al.* (2009) find that the level of cross-functional involvement across intellectual property management activities affects the speed with which assignees have their patents granted. In another study, Somaya *et al.* (2007) demonstrate that in-house expertise in patent law increases firm patent productivity. These studies are important in highlighting the role of firm strategy for patenting. Yet, there are a number of unanswered questions on the link between patent strategy and value appropriation. Examples of these include the following:

- What are the components of patent strategy and how do they relate to a firm's overall strategy?
- What are the means though which firms implement patenting strategy, i.e. how do firms acquire resources and develop capabilities aimed at increasing appropriability through patenting?
- What is the nature of interdependence developed between firm resources and patents rights that results in increased appropriability?

1.2 RESEARCH QUESTION

In this dissertation I contribute to the study of patent strategy by exploring the mechanisms through which firms increase appropriability from patenting by employing complementary resources and capabilities. This broad question is broken down into two themes. First, I evaluate the contribution of patent strategy to performance. We know from the literature that a host of factors affects appropriability, with complementary resources and capabilities being one of them. If the relative importance of patent strategy is low though, as compared to say the nature of the underlying technology, then maybe we shouldn't worry too much about it. Hence, it is important to first establish the significance (or not) of patent strategy for profiting from innovation.

Second, I focus on the constituent elements of a patent strategy. That is, what are the specific resources and capabilities that work synergistically with patent rights. Of course, this is unlikely to be an exhaustive list. However, additional insights will shed light on a somewhat underexplored territory. As Somaya (2012:1102) reports in a recent review of the literature, there are a number of interesting unanswered questions within the area of strategic patent management. He identifies the strategic logics behind patent trading and enforcement, as well as the links between strategy design and 'implementation-related issues' as particularly promising areas (Somaya, 2012).

Addressing these questions is crucial given the ever-increasing importance of patent rights in modern, technology-oriented economies. While traditional sources of competitive advantage are becoming obsolete, knowledge, and its effective management, are positioned at the core of value creation processes (Boisot *et al.*, 2004; Boisot, 1998). In the same vein, Teece (2000) observes that the development, deployment and utilization of intangible assets, including intellectual property rights, is fast becoming the fundamental basis of competitive advantage. Hence, it is important from both a theoretical and practical standpoint to understand the processes through which managers capture value from patenting.

Importantly, the design of patent strategy is likely to become more pertinent at a time when intellectual property rights are strengthened around the world. This process is underway in most advanced economies, where enforceability has strengthened and patentability has expanded over the last two decades (Bessen *et al.*, 2005a; Jaffe, 2000; Wagner, 2008). However, developing countries are following suit, in line with requirements set by the World Trade Organization's agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS). The strategic management of intellectual property then is likely to become a centerpiece of global competition and patenting expertise a critical source of competitive advantage. The recent wave of patent suits in the smartphone industry provides ample anecdotal evidence supporting this assessment.

Of course, the strategic implications of patent-based competition are also relevant to policymakers. The patent system is after all balancing the benefits resulting from increased incentives to innovate and the public disclosure of inventions with the costs introduced by granting monopoly rights. The boundaries of the patent system are somewhat blurred though and there is ample scope for calibrating its parameters. In the US, for example, there have been two major episodes of revamping the patent system in the last 12 years. Hence, a better understanding of the actual use of patent rights by corporations is bound to help establish a more productive and fairer patent system.

1.3 OVERVIEW OF THE DISSERTATION

In this dissertation I contribute to the study of appropriability by undertaking three empirical studies that provide unique insights into the nature and significance of patent strategy. I choose to focus on the relevance of patent strategy to firm performance and on the mechanisms through which firms implement patent strategies by acquiring resources and developing capabilities. In this way, I provide a more holistic account of how firms design and profit from patent strategies. The remainder of the dissertation is organized as follows:

In the next chapter, I provide a review of the literature and identify the benefits from bringing a resource-based logic to the study of patenting. I discuss mainly the RBV literature and studies of patenting in the law and economics literatures.

In chapter 3, I focus on measuring patent value. So far, the literature has primarily focused on heterogeneity in the effectiveness of patent rights across industries or technology sectors (Arora *et al.*, 2003a; Cohen, 2010; Cohen *et al.*, 2000; Levin *et al.*, 1987). The natural conclusion was that the use of patent rights, and their contribution to value capture, are largely driven by the characteristics of the underlying technology. Here, however, I provide evidence suggesting that a firm's collection of complementary resources and capabilities is in fact the key determinant of how much value is appropriated by firms through their patent rights. In particular, I track patent grants for a group of firms over a five-year period and identify the parameters that affect variance in patent valuation. I find that the majority of explained variance is attributed to firm characteristics, thus highlighting the importance of patent strategy for value appropriation.

In chapter 4, I look into a sample of technology acquisitions by US publicly listed firms over a twelve-year period and examine under what circumstances firms profit from combining previously separate patent rights. I demonstrate that technology acquisitions resulting in the merging of overlapping patent portfolios give rise to unique synergies, albeit only in complex technology industries. Hence, patent portfolio design and the combination of internal and external patent rights are found to be critical elements of patent strategy.

In addition, I explore the target selection strategies of acquirers in high tech sectors. I demonstrate that the selection of targets with patents (as opposed to targets without patents) is driven by strategic considerations related to minimizing the threat of being targeted in patent suits, addressing falling patent productivity and generating synergies with other patent rights. These results suggest that technology acquirers look into external technologies in order to complement a diminishing patenting output. In addition, the potential for creating synergies among patent rights is a strong motivation for targeting firms with patents. Finally, technology acquirers are actively trying to reduce their exposure to patent suits by strengthening their patent portfolios.

In chapter 5, I break with tradition and examine the efficacy of patent rights as mechanisms of appropriability in the non-technological domain. Although regulatory changes in the US enabled the patentability of management and business model innovations more than a decade ago, few studies have looked into how firms have responded to these changes. Here, I analyze a sample of business method patents awarded to US publicly listed companies and find that business method patents help firms capture value from their inventions. However, I find that patents for management innovations are less valuable than patents for business model innovations. Moreover, I identify patenting experience and access to complementary assets as the conditions that positively moderate the patent-performance relationship.

Finally, in chapter 6 I conclude by summarizing the findings of this thesis, and highlight key theoretical contributions and implications for policy and practice.

Chapter 2

Literature Review

2.1 INTRODUCTION

This chapter reviews the strategic management literature with a focus on RBV and the innovation literature with a focus on intellectual property management. In doing so, it identifies areas of overlap between the two fields and highlights the benefits of combining insights from these into developing a theory of strategic patent management. Patent strategy then is positioned as an application of resource-based logic to the study of appropriability, with the emphasis put on resource combinations that work synergistically with patent rights.

2.2 RESOURCE-BASED THEORIES OF STRATEGY

The strategic management field is primarily concerned with understanding performance heterogeneity among firms and tracks its origins in the work of consulting firms and 'business policy' professors in the early and mid 20th century. During this time, frameworks such as the learning curve, the strengths – weaknesses – opportunities – threats (SWOT) analysis and various portfolio analysis techniques were developed along with theories about the importance of clearly defined organizational goals and plans (Ghemawat, 2002). In parallel, economists were challenging the assumption that firms are unable to achieve abnormal profits in the long term (Bain, 1951; Mason, 1939). The emergent industrial organization economics essentially argued that industries differ in their underlying structural characteristics and, as a result, in their ability to support positive economic returns. This insight gave rise to the structure – conduct – performance paradigm which emphasized industry concentration and barriers to entry as the main drivers of firm profitability.

Building on this tradition, Porter (1980) developed a framework for analyzing industry attractiveness using 'five forces': the bargaining power of buyers, the bargaining power of suppliers, the threat of new entrants, the threat of substitutes and the level of industry rivalry. According to his framework, managers should target industries that are inherently attractive or manipulate these forces in order to increase profitability. Although initial evidence was supportive of Porter's framework (Schmalensee, 1985; Wernerfelt *et al.*, 1988), a limitation of this approach quickly became obvious: in many industries, there is substantial performance heterogeneity among industry participants. This observation was tested in a number of studies concluding that industry factors are not the main drivers of performance (McGahan *et al.*, 1997; Misangyi *et al.*, 2006; Rumelt, 1991). Instead, differences in performance across firms are, to a large extent, attributed to firm-specific characteristics.

The limited ability of industry analysis to explain firm performance helped give rise to resource-based theories of strategy. The resource-based view of the firm (RBV) is inspired by the work of Penrose (1959) who first conceptualized the firm as a collection of resources. Penrose argues that existing resources define a firm's 'productive opportunity set' (i.e. the opportunities available to managers) and, in turn, the patterns of firm growth. Nevertheless, the RBV did not emerge as a dominant theory of strategy until the notable contributions of Lippman and Rumelt (1982), Wernerfelt (1984), Barney (1991; 1986) and Dierickx and Cool (1989) to name a few. In attempting to explain under what circumstances resources can provide positive economic returns and be sources of competitive advantage, the RBV identifies four necessary conditions (Peteraf, 1993):

1. Resource heterogeneity
2. *Ex post* limits to competition
3. Imperfect resource mobility
4. *Ex ante* limits to competition

2.2.1 Resource Heterogeneity

The RBV departs from economic orthodoxy in assuming that firms are not characterized by identical production functions. In contrast, RBV theorists suggest that some resources are 'better' or more 'efficient' than others (Barney, 1991). These differences in firm resources give rise to economic rents which explain performance differences. In this context, economic rents are defined as return in excess of a resource owner's opportunity costs (Mahoney *et al.*, 1992). Traditionally, the strategy field has focused on 'Ricardian' rents, that is rents resulting from resources with differential productivity. Monopoly rents have received less attention as they are often the result of government protection or collusive practices. More recently, the importance of 'Schumpeterian' rents has been emphasized, especially with a focus on building dynamic capabilities (Makadok, 2001; Teece *et al.*, 1997). Schumpeterian rents are also labeled entrepreneurial rents as they are attributed to a firm's ability to identify opportunities in an uncertain environment (Mahoney *et al.*, 1992).

Although the concept of economic rent has been a mainstay of strategy research, it is important to note that its use has not gone unchallenged. In particular, Lippman and Rumelt (2003b) argue that it introduces a number of fallacies in reasoning about performance and value. They put forward a 'payments perspective' which identifies valuable resources by analyzing the sensitivity of a resource's (simple) rent generating potential to changes in demand (Lippman *et al.*, 2003a, 2003b).

2.2.2 *Ex post* Limits to Competition

Of course, resource heterogeneity is not enough for achieving competitive advantage when valuable resource positions can be replicated by competitors. Hence, valuable resources need to be imperfectly imitable and substitutable (Barney, 1991; Dierickx *et al.*, 1989). Lippman and Rumelt (1982) identify causal ambiguity as a key barrier to imitation. In this case, competitors are unable to disentangle the sources of superior performance due to the complexity associated with the design of systems of production. Other barriers to resource imitability and substitutability include property rights, switching costs, search costs or economies of scale (Rumelt, 1984).

Dierickx and Cool (1989) highlight additional barriers to resource imitability by observing that certain resource categories are not tradable in markets. Rather, these resources need to be developed or 'accumulated' internally. In such cases, time compression diseconomies, resource mass efficiencies, interconnectedness of resource stocks and resource erosion can limit competition.

2.2.3 Imperfect Resource Mobility

Imperfect resource mobility is used to describe limitations in resource trading arising from differences in valuation across firms (Peteraf, 1993). Asymmetric valuations can be attributed to switching costs (Montgomery *et al.*, 1988), asset cospecialization (Teece, 1986) or transaction costs (Williamson, 1985, 1991) and result in resources often being more valuable within the boundaries of the firm in which they are already deployed. This condition explains why resources become increasingly firm-specific and why there is a relative dearth of firms attempting to bid them away from their current employment (Chi, 1994).

A related concept is that of complementarity, used to describe resources that generate surplus value over and above the amounts they could create independently (Adegbesan, 2009:463; Milgrom *et al.*, 1995). Hence, in the presence of complementarity with other resources in a firm's portfolio, there will be fewer opportunities for profitable trades in resource markets. The excess value resulting from cospecialization, complementarity etc has also been defined as 'appropriable quasi-rents', which are distinct and independent from either Ricardian or monopoly rents (Klein *et al.*, 1978).

2.2.4 *Ex ante* Limits to Competition

The last component of a resource-based theory of competitive advantage is the existence of imperfections in the markets for trading resources, or ‘strategic factor markets’ (Barney, 1986). Barney (1986) argues that there is little room for performance differentials unless firms can exploit imperfections in strategic factor markets by essentially underpaying for the future value of resources. In this context, Barney’s central insight was that the sole non-stochastic way of achieving above normal returns is to have consistently superior (i.e. more accurate) expectations regarding the future value of resources. Superior profitability is then linked to investments in information acquisition, the optimal level of which is a function of resource rarity, inimitability and the level of uncertainty about resource valuation (Makadok *et al.*, 2001).

2.2.5 RBV Extensions

A number of theoretical approaches are based on or inspired by a RBV of strategy (Newbert, 2007; Peteraf *et al.*, 2003). Here, I discuss the ‘capability-view’ of the firm and the knowledge-based view (KBV) of the firm largely due to their importance and impact on strategy research and practice. Although there is an ongoing debate about whether these are qualitatively different theories of strategy, it is hard to draw any definite conclusions given the vagueness of RBV in defining resources (Barney, 2001; Eisenhardt *et al.*, 2002; Kraaijenbrink *et al.*, 2010). In any case, both approaches discuss central issues related to competitive advantage and deserve more attention.

Capability theories

The capability literature emphasizes resource 'deployment' as opposed to RBV's original focus on resource selection. Hence, capabilities are seen as firm-specific, non-transferable resources developed over time through complex interactions among the firm's resources and whose purpose is to improve the productivity of the other resources possessed by the firm (Amit *et al.*, 1993; Makadok, 2001:398). This concept goes back to Richardson (1972) who defined capabilities as the ability of a firm to combine 'complementary but not similar' activities through the skills and knowledge it possesses. From a similar standpoint, Prahalad and Hamel (1990) introduced the concept of core competences to describe a firm's ability to make a significant contribution to the perceived customer benefits and is difficult for competitors to imitate. In general, RBV scholars pay increased attention to the notion of capabilities due to their favorable candidacy for causally ambiguous and imperfectly mobile sources of firm heterogeneity.

A number of authors prefer to associate capabilities with organizational routines and see them as outcomes of evolutionary processes (Nelson *et al.*, 1982; Zollo *et al.*, 2002). Path dependency is a central concept in this tradition as it highlights the importance of past choices in a firm's repertoire of available options (Teece *et al.*, 1997). In fact, capability development is often paralleled to a lifecycle trajectory, following distinct stages of evolution and renewal (Helfat *et al.*, 2003).

An important distinction in the literature is between 'operational' and 'dynamic' capabilities. Winter (2003:991) defines operational, or 'zero-level' capabilities as a high-level routine (or collection of routines) that, together with its implementing input flows, confers upon an organization's management a set of decision options for producing significant outputs of a particular type. These are contrasted with dynamic capabilities, defined as a firm's ability to adapt, integrate and reconfigure internal and external organizational skills, resources and functional competences to match the requirements of a changing environment (Teece *et al.*, 1997:515). The main distinction between the two is that while operational capabilities are pertinent to current profitability, dynamic capabilities enable firms to renew operational capabilities and increase profitability in the future.

The notions of 'dynamic managerial capabilities' and 'resource orchestration' are often seen as bridges between RBV and capability theories (Adner *et al.*, 2003; Sirmon *et al.*, 2007). These concepts essentially emphasize the interaction between resource investment – RBV – and resource deployment – capabilities – and suggest that a fit between the two can have important performance implications (Sirmon *et al.*, 2009). The emphasis here is more on managers' actions and on how to effectively manage resource portfolios by synchronizing the processes of obtaining, bundling and leveraging resources (Sirmon *et al.*, 2007).

Knowledge-based view of the firm

The knowledge-based view of the firm focuses specifically on knowledge and suggests that firms exist because they do better than markets in sharing, transferring and integrating knowledge (Grant, 1996). Hence, organizational knowledge is seen as a crucial ingredient for achieving competitive advantage. The principles of this approach were set by Polanyi (1966), who first identified that the existence of tacit knowledge can have important implications for understanding and explaining organizations. Contrary to Arrow's view of firms as quasi markets, KBV suggests that firms organize activity in a nonmarket-like fashion through learning and internal technology transfer (Teece *et al.*, 1997). This allows them to take advantage of lower communication and coordination costs resulting from the higher-order principles and shared identity created within an organizational context (Kogut *et al.*, 1992, 1996).

Two somewhat distinct approaches can be identified in this tradition. The first understands knowledge as an organizational property and views the organization as the entity which creates and deploys knowledge (Spender, 1996). This is clearly represented in models where knowledge is created by interactions between tacit and explicit knowledge shared by organizational members (Nonaka, 1994; Nonaka *et al.*, 2000). On the other hand, knowledge creation is seen as an individual activity with the focus put on the role of individuals in creating and storing knowledge (Grant, 1996). This view is more in line with an evolutionary theory of the firm where knowledge accumulation is seen as originating from organizational members and then encoded into routines that guide behavior (March, 1991; Simon, 1991).

2.2.6 RBV Critiques

Partly reflecting its importance to the strategic management field, the RBV has not gone unchallenged. Scholars from various strands of research have criticized RBV for its lack of clarity, definitional ambiguity, tautological nature etc (Foss *et al.*, 2003; Hoopes *et al.*, 2003; Priem *et al.*, 2001). Kraaijenbrink *et al.* (2010:351) do a good job in summarizing RBV critiques into the following eight categories:

1. The RBV has no managerial implications
2. The RBV implies infinite regress
3. The RBV's applicability is too limited
4. Sustainable competitive advantage is not achievable
5. The RBV is not a theory of the firm
6. Valuable, rare, inimitable, non-substitutable are neither necessary nor sufficient for sustainable competitive advantage
7. The value of a resource is too indeterminate to provide for useful theory
8. The definition of resource is unworkable

Although some of these are less important than others, a key weakness of RBV related to the above critiques seems to be the lack of strong empirical support and the problematic operationalization of key variables (Armstrong *et al.*, 2007; Newbert, 2007). Based on a meta-analysis of published studies, Newbert (2007:136) finds that the RBV has received only marginal support while there is considerable variation depending on the theoretical approach employed. From a similar standpoint, Armstrong *et al.* (2007) argue that RBV is characterized by poor operationalization of key variables due to difficulties in observing resources and inability to isolate the effect of resources from other confounding factors.

This is indeed concerning given that RBV is currently the dominant lenses through which we understand strategic decision-making. If RBV is a theory with little empirical support or a theory with non-testable predictions then this poses a serious threat to the foundations of strategy research. Therefore, empirical tests of RBV are required in order to assess the relevance, boundaries and predictive power of RBV. According to Arend (2006:410), a good test of RBV must meet four criteria:

1. The test must measure the benefit predicted by RBV theory
2. The test must adjust the benefit by the cost of the focal resources
3. The test must assess the VRIO (valuable – rare – inimitable – non-substitutable) of the focal resources
4. The test must control for the influence of higher-level resources on benefits

This list captures some of the most common problems in the operationalization of RBV. Different measures of resources are often not informative about the mechanism through which performance heterogeneity is achieved or about the costs associated with resource acquisition (Arend, 2006; Collis, 1994; Peteraf, 1993). In addition, it is often difficult to identify measures of resource value and performance that are independent of each other and are thus addressing the tautology critique (Armstrong *et al.*, 2007; Priem *et al.*, 2001). Finally, RBV's focus on difficult to imitate and observe resources introduces significant challenges for empirical researchers as those resources that can be measured are unlikely to be the sources of performance differences (Godfrey *et al.*, 1995; Lockett *et al.*, 2009). A common conclusion then shared by an increasing number of scholars is that RBV would benefit from good quality empirical testing.

2.3 RBV AND INNOVATION

The RBV as originally formulated did not pay much attention to issues related to innovation and technological change. The dynamic capability literature has, at least partially, addressed this concern by emphasizing the need to understand the processes through which firms renew their portfolio of resources and capabilities (Eisenhardt *et al.*, 2000; Teece *et al.*, 1997). Nevertheless, the study of innovation sits comfortably within the RBV paradigm (Lieberman *et al.*, 1998). Given that strategic factor markets are unlikely to provide all required resources, innovation can be seen as a case of developing new resources not available in strategic factor markets (Dierickx *et al.*, 1989; Sirmon *et al.*, 2007). In fact, the internal development of resources is likely to increase the effectiveness of the various isolating mechanisms, such as causal ambiguity, resource interconnectedness, time compression diseconomies etc, required for competitive advantage (Dierickx *et al.*, 1989; Thomke *et al.*, 2002). So, the link between RBV and innovation is the former's focus on the sort of resources (and organization routines) that are conducive to innovative activities.

Of course, every new resource does not count as innovation. According to most definitions, innovation is seen as the generation of new knowledge that can be commercially applied to new products or processes (Mansfield, 1968; Teece, 2000). Hence, a firm's investment in building reputational capital would hardly qualify as innovative activity. On the contrary, R&D activity is the textbook example of inventive output.

2.3.1 Generating Innovation

Schumpeter (1950) famously suggested that innovation and perfect competition are incompatible. This claim implies that firm size should be a good predictor of innovative activity as large corporations are better equipped to invest in risky innovations projects, spread R&D costs and appropriate the associated returns. Yet, empirical evidence in favor of this assertion is not conclusive as there is no statistically significant relationship between industry concentration and technological change (Mansfield, 1968; Teece, 2006). Cohen (2010:140) points out though that there is clear, robust results indicating that R&D expenditures are closely linked to business unit size. His review is based on studies employing more fine-grained data, often at the project or business unit level. For example, Henderson and Cockburn (1996) find strong scale economies in R&D activity in the pharmaceutical industry.

Other firm characteristics explain innovative activity. According to some estimates, 50% of the variance in R&D intensity is explained by fixed firm effects (Scott, 1984). One of the most robust findings in the literature is the positive relationship between available cash flows and R&D investment (Cohen, 2010). There is also evidence that the degree of diversification positively contributes to R&D spending although results are somewhat mixed (Cohen, 2010; Henderson *et al.*, 1996). This is likely due to reverse causality and confounding industry-level variables.

Consistent with a resource-based logic, the managerial literature is focusing more on differences across firms in innovation productivity. For example, the importance of cross-functional links has been highlighted in a number of studies (Teece, 1986, 1992). In addition, task subdivision, development phase coordination, project leader autonomy and the links between product development and applied research have all been found to improve R&D capability in a number of industries (Iansiti, 1995; West *et al.*, 2003). Focusing specifically on the pharmaceutical industry, Cockburn *et al.* (1998; 1994) find that a firm's R&D productivity increases with domain expertise, i.e. disciplinary-based knowledge, and with a firm's ability to use and integrate knowledge across disciplines. Yet, Teece (1996, 2000) notes that different organizational forms or arrangements are better suited for different types of innovation, e.g. autonomous versus systemic.

External resource acquisition and innovation

Prior research has shown that external resource acquisition can improve firm innovative performance. Specifically, technology acquisitions provide technological input to the acquiring firm enabling it to avoid the uncertain process of internal technology development and to leverage the target's knowledge base and capabilities (Ahuja *et al.*, 2001; Puranam *et al.*, 2007). The acquisition of small, technology-intensive firms is a major source of growth and renewal in industries with rapid rates of technological change (Karim *et al.*, 2000). In fact, there is evidence that internal R&D and external knowledge acquisition complement each other (Cassiman *et al.*, 2006).

Most studies of technology acquisitions focus on their impact on the innovative capability of acquiring firms. In one of the first studies in the field, Hitt *et al.* (1991) found that acquisitions negatively affect R&D investment, providing support for the view that acquisitions are seen by managers as substitutes to innovation. Focusing on the output side, Ahuja *et al.* (2001) demonstrated that the absolute size of the acquired knowledge base positively affects acquirers' innovative output while relative size reduces innovative output. Valentini (2012) provided a more fine-grained analysis, finding that acquisitions have a positive effect on patenting output but a negative effect on patent impact, originality and generality.

The decision of whether to integrate the acquired entity into the organizational structure of the acquiring firm or to preserve its organizational autonomy has received a lot of attention in the literature. In particular, this decision imposes an inherent trade-off to the acquiring firm as structural integration enhances its ability to use the target's knowledge base but reduces its ability to leverage the target's innovative capabilities (Puranam *et al.*, 2007). In addition, the benefits of structural integration are time-variant, with structural integration being more beneficial when it does not coincide with exploration-intensive phases along the acquired firm's technological trajectory (Puranam *et al.*, 2006). From a similar standpoint, other scholars have explored the impact of acquisitions on inventors' productivity and incentives as well as the mediating role of structural integration (Kapoor *et al.*, 2007; Paruchuri *et al.*, 2006).

Alternatively, external resource acquisition can take the form of corporate venture capital investments or even alliances and joint ventures. For example, alliance activity has been found to increase innovative performance and survival for startups (Baum *et al.*, 2000) while Eisenhardt *et al.* (1996) find that alliances help firms pursue pioneering technologies. Nevertheless, Joshi *et al.* (2011:1141) demonstrate that technology alliances, in the form of patent pools, lead to substantial and significant decrease in both the quality and quality of patents subsequently generated. Corporate venture capital is regularly seen as a mechanism for reducing uncertainty related to the R&D activities, with Dushnitsky et al. (2005) and Wadhwa et al. (2006) providing evidence consistent with this claim.

More recently, the interaction between the various forms of external knowledge acquisition has been explored. Hagedoorn *et al.* (2002) show that the characteristics of the technological environment play an important role in explaining the selection between alliance and acquisition. Firm idiosyncrasies are also found to be important though as Wang *et al.* (2007) demonstrate that experience in both alliance and acquisition activity as well as partner-specific knowledge affect the choice between alliance and acquisition. Keil *et al.* (2008) analyzed simultaneously firms' portfolio of external resource acquisition activities, i.e. mergers and acquisitions, alliances, joint ventures and corporate venture capital investments, but only found a positive association between joint ventures and innovative performance. They identify technological relatedness between the two firms as an important mediating factor.

2.3.2 Profiting from Innovation

Inventive processes and R&D activity are interesting to RBV scholars to the extent they contribute to firm performance and competitive advantage. Although a number of studies confirm that innovation increases firm survival, profitability etc (Cefis *et al.*, 2005; Hee-Jae *et al.*, 2005; Roberts, 1999; Robinson *et al.*, 1988), the link between innovation and performance is not straightforward. The management literature has an abundance of examples to offer where innovators failed to capture the economic returns on their innovations (Teece, 1986). A classic case is that of EMI and its discovery of the CAT scanner. While EMI's CAT scanner was a massive technological advance, it ended up being of limited commercial benefit to EMI. It is tempting to attribute such failures to Schumpeterian 'creative destruction', Pisano (2006:1123) explains though that there is ample variance in the phenomenon: there are many cases where first or early movers captured and sustained significant competitive advantage over time.

Appropriability

Schumpeter's (1950) note that innovation is hardly conceivable with perfect competition and Arrow's (1962) discussion about the 'fundamental paradox' of information markets set the basis for understanding the problem of appropriating returns from innovation. Put simply, the appropriability problem refers to an innovator's inability to fully capture the value created from the introduction of a novel product or process. Teece's (1986) classical contribution provides a comprehensive and analytically powerful approach to understanding the problem of appropriability by linking a firm's ability to profit from innovation with its contractual conditions and the prevailing institutional/technological environment. Specifically, Teece (1986) argues that the appropriability regime, complementary assets and the dominant design paradigm are the key sets of variables that explain the distribution of profits resulting from innovation. These are defined by Teece (1986:287; 2000) as follows:

- Appropriability regime refers to the environmental factors, excluding firm and market structure, that govern an innovator's ability to capture profits generated by an innovation. The most important dimensions of this are the nature of the technology and the efficacy of legal mechanism of protection.
- Complementary are the assets necessary for the successful commercialization of an innovation, such as marketing knowledge, manufacturing capabilities etc. These are often specialized (or cospecialized) as there is unilateral (or bilateral) dependence between the innovation and the complementary assets.
- Dominant is the design emerging after considerable experimentation in the marketplace and becomes the de facto standard for a particular product or process.

A key insight of this framework is that strategy formulation is highly dependent on the effectiveness of intellectual property protection mechanisms and the inherent replicability of the technology. Weak intellectual property rights and easily codified knowledge suggest a weak regime of appropriability where imitation is relatively easy. In such cases, the owners of complementary assets are likely to capture a large share of the profits resulting from innovation. In contrast, strong intellectual property rights and tacit knowledge indicate strong appropriability. Innovators then are likely to keep a larger share of the value, especially when complementary assets are not specialized.

There is strong empirical evidence in support of Teece's (1986) framework. For example, Ceccagnoli (2009:82) finds that ownership of specialized complementary assets, has a large, positive and significant impact on a firm's economic performance. Rothaermel (2001) studied incumbents' strategies facing radical technological change in the pharmaceutical industry and found that those exploiting complementary assets outperformed those exploring new technologies. Similarly, Tripsas (1997) finds that complementary assets allowed incumbent firms to survive various waves of disruptive technologies in the typesetter industry.

The emergence of a dominant design has also been shown to affect technological development and performance (Anderson *et al.*, 1990; Suarez *et al.*, 1995). This issue is often approached in conjunction with questions about the existence (or not) of first-mover advantage. Although first movers are more likely to enforce their design as dominant, especially in the presence of path dependencies (Arthur, 1989; David, 1985), there is a host of additional factors that need to be considered. First-movers enjoy technological leadership, preempt competitors by capturing important asset positions and benefit from increasing buyer switching costs (Lieberman *et al.*, 1988, 1998). At the same time though, late-movers can free ride on first-mover investments and take advantage of reduced technological and market uncertainty (Lieberman *et al.*, 1988, 1998). Suarez *et al.* (2007) add to these the pace of market and technology evolution as important moderating factors.

Finally, economists have paid a lot of attention to differences in regimes of appropriability across countries and sectors (Cohen, 2010; Cohen *et al.*, 2000; Levin *et al.*, 1987). In the next section I focus specifically on intellectual property rights and their role in appropriating returns from innovation.

2.4 INTELLECTUAL PROPERTY RIGHTS[1]

Patents, trade secrets, copyrights and trademarks are the main instruments through which the legislator protects creative and inventive work in the economy. To begin with, patent law protects inventions and other industrial know-how by granting inventors the right to exclude anyone else from the production or use of a specific new device, apparatus, or process for a stated number of years, 20 in the US and most other countries in the world (Griliches, 1990:1662). Inventions must meet the three statutory criteria of novelty, utility and nonobviousness in order to be eligible for patent protection. According to title 35 of the US Code (sections 101, 102, 103)

[1] The focus of this chapter is on US law as the following chapters use patent and financial data from the US. Nevertheless, there are no major differences in the basic principles of intellectual property protection between the US and other advanced economies.

novelty requires the applicant to be first to invent the claimed invention, utility requires the invention to work and serve a minimal human need and nonobviousness requires the invention not to have been obvious to a person having ordinary skill in the art to which the subject matter pertains at the time the invention was made.

Trade secrets also protect inventions and industrial know-how but have important differences with patents. In particular, it is easier to obtain trade secret than patent protection as its definition is much more inclusive. According to the Uniform Trade Secrets Act (section 1.2) a trade secret is defined as information, including a formula, pattern, compilation, program, device, method, technique, or process, that (i) derives independent economic value, actual or potential, from not being generally known to, and not being readily ascertainable by proper means by, other persons who can obtain economic value from its disclosure or use, and (ii) is the subject of efforts that are reasonable under the circumstances to maintain its secrecy. Nevertheless, trade secret protection is less robust as the owner has no protection against independent discovery, reverse engineering or when the information becomes widely known (Blair *et al.*, 2005).

Copyrights protect all original works of authorship, including literary, musical, dramatic, choreographic as well as sound recordings and their duration is significantly longer, currently spanning the life of the author plus seventy years (see title 17 of the US Code). Importantly, the copyright owner has the exclusive right to prepare derivative work but ideas and facts are not subject to copyright protection (Blair *et al.*, 2005).

Lastly, trademarks are awarded to the first person to make a lawful, commercial use of a symbol to identify her product or service (Blair *et al.*, 2005). Trademark protection is valid for as long as the association between mark and product persists, although owners need to renew the registration of their trademarks regularly. There are two main benefits from holding trademarks. First, the owner can exclude others from the commercial use of a mark. Second, the owner can, in some cases, prevent trademark dilution, that is the lessening of the capacity of a mark to identify a unique product or service (see title 15 of the US Code).

2.4.1 Patent Rights and Innovation

The patent system is particularly important to innovation as it is designed to address the market failure associated with information markets (Arrow, 1962). Because new knowledge is both nonrival and nonexcludable, imitators are able to free ride on investments in new knowledge. This reduces innovators' *ex ante* incentives to create knowledge as, *ex post*, they will be unable to recoup their investment. In addition, Arrow (1962:615) pointed out the fundamental paradox of information markets: the value for the purchaser is not known until she has the information, but then she has in effect acquired it without cost. This results in suboptimal production and allocation of knowledge.

Patents address these concerns by increasing incentives to innovate and by promoting the public disclosure of innovation. However, there is a cost. Patent holders enjoy monopoly over their inventions, introducing a deadweight loss for society. Besides that, the cost of running the patent system and enforcing patent rights is substantial (Bessen *et al.*, 2005a; Jaffe, 2000). Then, there is evidence that the patent system increases costs in areas where innovation is cumulative in nature (Hall, 2003, 2009a). This has been termed as the 'tragedy of the anticommons', describing cases where people underuse resources because narrowly defined property rights block each other (Heller *et al.*, 1998). Overall, it is not *a priori* clear whether the benefits of the patent system outweigh the costs it introduces.

2.4.2 Patent Enforcement

As explained before, the grant of a patent does not guarantee the monopolistic use of the patented invention. All it does is provide the patent holder with the right to sue infringers. When infringement is suspected, the patent assignee can ask the court to impose a temporary injunction against the use of the patented technology by the infringer. The likelihood of having a temporary injunction granted depends on (1) whether the plaintiff faces the threat of irreparable harm if the injunction is denied, (2) the balance between this harm and the injury that granting the injunction would inflict on the defendant, (3) the evidence that the plaintiff will win the case on the merits, and (4) the public interest (Lanjouw *et al.*, 2001a:577).

If infringement is identified, the injunction becomes permanent and infringers are ordered by court to compensate the patent holder for the damage incurred. There are no clear guidelines for calculating the patent holder's lost revenue, although two methods have been used in US courts. The first compares the patent owner's revenue before and after the infringement to infer the damage (Blair *et al.*, 2005). The second method proxies lost revenue using the defendant's actual sales of the infringing product (Blair *et al.*, 2005). The US Court of Appeals for the Federal Circuit (CAFC) is the specialized court that hears all appeals in patent cases. It is generally considered pro-patent as it uses the "but-for" standard to calculate damage awards: the patent owner is entitled to recover whatever profits she would have earned but for infringement (Blair *et al.*, 2005).

It is important to note though, that identifying infringers is not an automatic and cost-free process (Crampes *et al.*, 2002). Patent holders need to invest in monitoring and build a reputation for enforcement in order to discourage infringement (Agarwal *et al.*, 2009; Bessen *et al.*, 2005b). An increased likelihood of being discovered reduces incentives to infringe as competitors are keen avoid unprofitable suits (Crampes *et al.*, 2002). Yet, infringement is not necessarily *a priori* clear. According to title 35 of the US code (section 282), the grant of a patent does no more than confer a patent right that is 'presumed valid'. The final responsibility for settling patent disputes lies with the courts, usually CAFC. This introduces considerable uncertainty to the patent system that makes patent suits inevitable (Choi, 1998).

Bessen *et al.* (2005b) calculate that the average firm engages in 11.8 suits per 1000 patents as patentee litigant while the average firm expects 2.5 suits as alleged infringer per $ billion spent on R&D. These figures are close to estimates by Lanjouw *et al.* (2004b) who report a rate of 1.04% lawsuits per patent[2]. A more detailed look at the data reveals that the probability of a patent suit between two firms increases with the scale of the firms, the number of patents held by prospective plaintiffs, the R&D performed by prospective defendants, the capital intensity of the parties and technological closeness (Bessen *et al.*, 2005b:24).

The uncertainty regarding patent validity would not be important but for the considerable cost attached to patent litigation. According to a 2003 survey by the American Intellectual Property Law Association, for patent suits with $1-$25 million at risk, the median estimated cost of discovery is $1 million and the median estimated total litigation cost is $2 million; for suits with more than $25 million at risk, the median estimated cost of discovery is $2.5 million and the median estimated total litigation cost is $3.9 million.

Importantly, the costs of monitoring and patent enforcement affect small firms disproportionately. The likelihood of engaging in a patent suit as patentee litigant increases fourfold for small firms (less than 500 employees) while the number of expected suits per $ billion of R&D spent increases almost sixfold compared to larger firms (Bessen *et al.*, 2005b). Small firms are less likely to rely on repeated interaction with other firms in intellectual property or product markets in order to induce cooperative behavior (Lanjouw *et al.*, 2004b). In addition, small firms have less managerial and financial resources available to deal with patent suits. Consistent with

[2] Both figures are based on public firms

these suggestions, Lerner (1995) finds that small firms avoid technology areas where the threat of litigation from larger firms is high.

2.4.3 Sectoral Heterogeneity

A broad discussion on the use and benefits of patent rights masks important differences across industries. In a series of surveys targeting R&D managers, patents were found to be differentially effective as mechanisms of appropriability across sectors (Cohen *et al.*, 2000; Levin *et al.*, 1987; Mansfield, 1986). The so-called 'Yale survey' found that patents are considered effective only in a minority of business lines, primarily in drugs, organic chemicals and pesticides (Levin *et al.*, 1987). These results were later confirmed by the 'Carnegie survey' (Cohen *et al.*, 2000). Other strategies, such as secrecy and lead time advantages, were considered more effective in most industries examined (Cohen *et al.*, 2000; Levin *et al.*, 1987).

The 'Carnegie survey' also found that the motives for patenting are quite diverse across sectors. For example, when innovation is cumulative patents are regularly used as negotiating tools and are not always intended to ensure the monopolistic use of the invention (Cohen *et al.*, 2000). In industries like electronics or semiconductors, patents are used as bargaining chips as firms rely on cross-licensing agreements to ensure their freedom to operate (Grindley *et al.*, 1997). Hall *et al.* (2001b) confirmed these findings in their study of semiconductor firms. In particular, Hall *et al.* (2001b) explored the so-called 'patent paradox': firms suggest that they do not rely heavily on patents to appropriate returns to R&D, while, at the same time, exhibit dramatic increases in their patent propensity. They find that firms are engaged in 'patent portfolio races' in order to negotiate access to external technologies on more favorable terms (Hall *et al.*, 2001b).

A related feature of industries where innovation is cumulative, or 'complex-technology' industries, is 'defensive patenting'. Firms amass patent portfolios so as to avoid patent suits and reduce concerns about being held up by competitors (Gallini, 2002; Hall *et al.*, 2001b). Defensive patenting also helps firms navigate 'patent thickets', defined as overlapping sets of patent rights requiring those seeking to commercialize new technology to obtain license from multiple patentees (Shapiro, 2001:119). Patent thickets reinforce the hold up problem as any patent holder can potentially seek a temporary injunction when her patent is infringed. Hence, failure to negotiate access to external technologies can lead to significant production disruptions.

Complex-technology industries are contrasted to 'discrete-technology' industries (Merges *et al.*, 1990). Patents work quite differently in these sectors as there is little overlap between patent rights. Examples of such industries include pharmaceuticals or chemicals (Reitzig, 2004). Not surprisingly, R&D surveys find that prevention of copying is the main motive behind patenting in such industries (Cohen *et al.*, 2000; Levin *et al.*, 1987). Patents then are used primarily as monopoly instruments.

2.4.4 Patent Licensing

A distinct option available to innovators is to license their patented technologies. Although this might sound counterintuitive, given that the idea behind the patent system is to reward inventors with monopolistic use of their inventions, patent holders can derive a number of benefits from such agreements. Teece (2000:147) groups these in four categories:

1. Efficient commercialization. When innovators lack access to the complementary assets required to commercialize their inventions, licensing provides an alternative channel for effective commercialization of technology (Teece, 1986). Arora *et al.* (2006) provide evidence consistent with this logic as they find that increases in the effectiveness of patent protection increase licensing propensity but only for those firm lacking specialized complementary assets. In contrast, firms with specialized complementary assets license less when the effectiveness of patent protection increases (Arora *et al.*, 2006).
2. Technology exchange. As argued in the previous section, it is difficult to avoid infringing on competitors' technology in complex technology industries given that innovation is cumulative and the ownership of patent rights is widely distributed. In this case, the cross-licensing of patent portfolios reduces the threat of patent suits and ensures freedom to operate across different technology fields (Grindley *et al.*, 1997; Teece, 2000).

3. Market enhancement. Licensing can also help reduce technological uncertainty by establishing technology standards. In this case, 'patent pools' are usually created where an entire group of patents is licensed either by one of the patent holders or by a new entity created for this purpose (Shapiro, 2001). In order to discourage predatory pricing and ensure reasonable levels of competition, such patents are licensed under fair, reasonable, and non-discriminatory terms (FRAND).
4. Royalty generation. The collection of royalty fees is an important source of income for innovators. In the case of cross-licensing agreements, balancing royalty payments are calculated when the value and importance of the patent portfolios shared differs (Grindley *et al.*, 1997).

An extensive literature has looked into the decision to license and the choice between exclusive and non-exclusive licensing under various model assumptions (Arora *et al.*, 2001; Katz *et al.*, 1985, 1986). One of the main challenges in this setting lies in balancing the benefits from licensing a technology with the 'rent-dissipation effect' created by the fact that competition intensifies in product markets (Arora *et al.*, 2003b). Specifically, Arora *et al.* (2003b) suggest that licensing will be discouraged if (a) the potential licensor has a large market share, (b) the product market is differentiated, and (c) patent protection is weak. Rockett (1990) points to another strategic aspect in the decision to license whereby firms essentially choose their competitors through their licensing behavior.

Fosfuri (2006) confirms these suggestions by demonstrating a negative link between licensing propensity and licensor's market share in a study of technology licensing in the chemical industry. He also finds that the rate of technology licensing displays an inverted U-shaped relationship with the number of potential technology suppliers and is negatively related to the degree of technology-specific product differentiation (Fosfuri, 2006:1141). A study of patents granted by the European Patent Office (EPO) similarly finds that large firms make fewer patents available for licensing (16% compared to 37% by small firms defined in this study as those with fewer than 100 employees), while, from the patents offered, few are eventually licensed (Gambardella *et al.*, 2007).

Markets for technology

Patent licensing can be seen as the central component of 'markets for technology'. These are usually defined to include all transactions or contracts for the exchange of existing technology through licensing deals or through the establishment of technology alliances (Arora *et al.*, 2001; Arora *et al.*, 2010). Hence, joint ventures, technology acquisitions and human capital mobility are excluded from this definition. Interest in this topic arose following developments, such as advances in computer technologies and the grounding of new technologies in science, that enabled the gradual disembodiment of technology from physical goods and the (re)emergence of technology as a tradable commodity (Arora *et al.*, 2001:776; Arora *et al.*, 1994a).

Robbins (2009) estimates that transactions in markets for technology (royalties and licensing fees) were worth approximately $50 billion in the US, reporting a steady increase throughout the 1990s. Although this figure is significant, it does suggest that the majority of technologies are still confined within the boundaries of the firm-inventor (Arora *et al.*, 2001; Arora *et al.*, 2010; Robbins, 2009).

Besides the incentives not to license already discussed, additional factors limit the development of markets for technology. First, firms often lack the absorptive capacity to utilize and evaluate external technologies, reducing the demand for external technologies as a result (Arora *et al.*, 1994b; Cohen *et al.*, 1990). Second, transaction costs in these markets are high as firms need to account for the potential of opportunistic behavior in licensing negotiations and also spend time and resources in order to find a licensee (Arora, 1997). Third, these markets could suffer from a 'lemons problem', whereby the technologies made available for licensing are of lower quality compared with the ones exploited in-house (Zeckhauser, 1996). Fourth, the inherent uncertainty regarding both the validity and value of intellectual property rights is likely to introduce an asymmetric information problem in technology transactions (Gans *et al.*, 2008).

2.5 PATENT RIGHTS AND RBV

The preceding discussion suggests that patent rights are strategically relevant resources and, under certain circumstances, can help firms achieve competitive advantage. Their primary role lies in creating *ex post* limits to competition by excluding competitors from the use of a patented invention. Hence, patents can be seen as a case of formalized isolating mechanisms (Lippman *et al.*, 1982; Rumelt, 1984). However, it should be also obvious that the link between a patented invention and competitive advantage is far from straightforward. Following a simplistic view of patents as monopoly instruments, patents seem to fulfill Barney's (1991) criteria for achieving competitive advantage: they are valuable, rare, inimitable and non-substitutable resources. In reality, however, there are limitations in patents' ability to confer competitive advantage.

To begin with, there is substantial heterogeneity in the importance of patented technologies. Most studies measuring patent value report a highly skewed distribution of patent value with a long right hand tale (Bessen, 2009; Hall *et al.*, 2005; Pakes, 1986; Schankerman *et al.*, 1986). Yet, patents are rarely valuable in isolation. As explained before, patent holders need access to complementary assets in order to commercialize their inventions. In addition, in complex technology industries the value of patents lies in their aggregation (Merges *et al.*, 1990; Parchomovsky *et al.*, 2005). That is, patent value is highly dependent on the presence of other complementary patents that allows firms to negotiate licensing agreements. Similarly, enforcement requires substantial managerial and financial resources (Lanjouw *et al.*, 2004b; Lerner, 1995). Unless the assignee can enforce her rights, patents do not confer any considerable benefits.

Then, there is the issue of imperfect imitability and substitutability. Although patented inventions are protected from imitators by law, this does not always guarantee their effectiveness as isolating mechanisms. Competitors can develop substitute technologies and invent around patented technologies (Gallini, 1992; Shapiro, 2001). In this case, patent assignees can maintain their technological edge by patenting a range of different technical solutions that achieve similar functional results, a strategy commonly referred to as 'patent fencing' (Granstrand, 1999; Reitzig, 2004). Imitation is also encouraged when firms are unable to identify infringers and enforce their patent rights.

2.5.1 Managing Patent Portfolios

These examples suggest that patents exhibit increased interdependence and complementarity with other firm resources. As Pisano (2006:1128) argues, the effectiveness of appropriability strategies is endogenously influenced by the behaviors and strategies of firms. In a similar manner, Bessen (2008) points to efforts at 'patent refinement' undertaken by assignees, such as litigation, claim construction, re-issuance etc, and concludes that patent value is, to some extent, endogenous. Thus, competitive advantage derives not from patents *per se*, but rather from resource collections, including patents, that generate value appropriable to the firm.

Somaya (2012) builds on this idea and suggests that 'patent management capabilities' enable firms to increase the value captured from their patent rights. A limited number of studies point towards this direction. Somaya *et al.* (2007) find that in-house patent law expertise increases patenting output. They also show that this effect is magnified in the presence of patent expertise in top management teams

(Somaya *et al.*, 2007). In another study, Reitzig *et al.* (2009) demonstrate how intermediate levels of cross-functional involvement across intellectual property management activities increases the speed with which assignees have their patents granted.

Importantly, patent management capabilities need to be developed and maintained or risk atrophy. Mayer *et al.* (2012) find that the outsourcing of patent work, patent listing in particular, reduces firms' ability to develop their own patent management capabilities over time. These results are in line with earlier work suggesting that the outsourcing of patent prosecution activities reduces firms' ability to detect and oppose competitors' patent applications (Reitzig *et al.*, 2010).

Patent management then should be seen as a multidimensional or 'high-order' capability where different resource combinations are brought together to ensure the appropriation of rents resulting from patented inventions. This view puts emphasis on the links between patents and other organizational resources, including patent rights, that generate synergistic value. Although existing literature has explored some of these links, there are still important unanswered questions (Somaya, 2012). For example, we know little about the patent litigation strategies of the firms, the combination and interactions between different appropriability strategies, firms' incentives to acquire external patents, the impact of the structure and design of patent portfolios on performance etc (Arora *et al.*, 2010; Parchomovsky *et al.*, 2005; Somaya, 2003, 2012).

2.6 CONCLUSION

This overview of relevant literature suggests that there are important benefits in combining insights from RBV and theories of patent management. In particular, RBV's focus on resource interdependence and capabilities provides an ideal framework for understanding how and why firms with different resource endowments capture value from patenting. Nevertheless, the full potential of such an endeavor has yet to emerge, as there is a relative dearth of work focusing on the strategic aspects of patenting. Hence, identifying the firm-specific factors that moderate the patent-performance relationship is the key area this dissertation intends to contribute to.

Accordingly, I first consider the relevance of patent strategy by assessing its relative importance for appropriability. This is a critical undertaking in order to understand the extent to which patent strategy contributes to performance. If the contribution of patent strategy to appropriability is negligible, then the literature is right in not paying too much attention to it. If patent strategy does play a role though, these results would emphasize the need for additional empirical work uncovering the various facets of patent strategy.

Following that, I focus on the specific resource combinations that work synergistically with patent rights. This inquiry is concentrating on the sources of synergy as well as the processes through which firms acquire these resources in the first place. This dual focus is necessary to understand how firms design and implement patent strategies.

Importantly, this approach advocates a subtle but critical change in the way we understand appropriability. The economics and, to a certain extent, management literatures have primarily adopted 'contingency theory' arguments where the effectiveness of patenting is seen as an industry characteristic (Cohen, 2010; Cohen *et al.*, 2000; Levin *et al.*, 1987). Yet, the preceding discussion argues that the choice of appropriability strategies and their performance implications should not be studied solely with reference to their environmental fitness. Instead of asking whether patenting is a profitable strategy in industry A, it would be useful to also ask whether patenting is a profitable strategy for Firm B which has certain resources and capabilities.

Of course, just like any study within the RBV context, a challenge lies in operationalizing the notion of resources, synergy etc. As suggested before, this is a major source of criticism for RBV and limits its ability to develop empirically testable propositions. Here, I address these concerns by taking advantage of the richness and unique characteristics of patent data. These provide detailed information on the source, significance, applicability and antecedents of inventions that allows the researcher to isolate the phenomenon of interest. Hence, my results inform the study of patent strategy while, at the same time, providing examples of how to avoid potential biases introduced by poorly constructed resource-based measures.

The subsequent chapters build on the theories presented here and provide evidence on the increased importance of patent strategy for appropriability. In this way, they emphasize the importance of closer integration between the resource-based and patent management literatures.

CHAPTER 3

HOW IDIOSYNCRATIC IS PATENT VALUE? THE IMPORTANCE OF ASSIGNEE FIRM CHARACTERISTICS IN PATENT VALUATION[3]

3.1 INTRODUCTION

The literature on the economic value of patenting primarily distinguishes between the private value of patent rights to their holders and the social value of disclosure (Griliches, 1990; Schankerman *et al.*, 1986; Scotchmer *et al.*, 1990). This reflects the patents' widely accepted role as a solution to the market failure associated with the inappropriability of knowledge (Arrow, 1962): patents balance dynamic efficiency gains, through disclosure and increased incentives to innovate, with static efficiency losses resulting from granting monopolistic power to inventors.

However, the focus on the private versus social value of patents has left another question relatively unexplored within the field of private valuation: how important is the idiosyncratic value (i.e. value unique to a particular firm) component of patents compared to their common value (i.e. value common across firms) component? Here, I am borrowing the terminology of auction theory to differentiate between two (extreme) possibilities. On the one hand, the value of a patent could be characterized by a very large idiosyncratic value component, in which case the valuation of the

[3] The ideas in this chapter were developed together with professor Mari Sako. However, data collection, empirical analysis and write up were done by the candidate.

same patent would be independent across different assignees. In contrast, the same patent could be equally valuable to any potential assignee, suggesting a very high common value component[4]. Hence, I am not concerned with measuring patent value *per se*. Rather, the crux of this research is to understand if, and to what extent, patents are equally valuable to all firms. That is, how idiosyncratic is the value of patents?

A simple example would help explicate this question. Suppose a researcher decides to sell her patent by inviting two firms, A and B, to a second-price auction. Let's further assume that there is no technological uncertainty and that the two firms have no information about the value of the patent to the other firm. In this scenario, the optimal strategy for both firms is bidding their respective valuations, say b_a and b_b, of the patent (Kagel *et al.*, 1993). Should we expect b_a and b_b to be equal? If this were a pure common value auction the answer is yes given that we assumed no technological uncertainty. The actual value of the patent would be the same for both firms. However, in practice, we have reasons to believe that b_a and b_b would differ. For example, patents are more valuable to firms that have access to related complementary assets (Arora *et al.*, 2006; Teece, 1986). Or, some firms are better than others in protecting their intellectual property rights (Agarwal *et al.*, 2009; Lanjouw *et al.*, 2004b). Hence, it is reasonable to expect that patent value differs across potential assignees or licensees, with patents having both common and idiosyncratic value components.

[4] See Vickrey (1961) for an early analysis of private value auctions, Wilson (1969) for an analysis of the pure common value model and Klemperer (1999) for an overview of the literature.

Existing literature offers limited guidance on this topic. Much of the focus and emphasis has been put on differences in patent value across technology areas or industries (Arora *et al.*, 2003a; Cohen *et al.*, 2000; Levin *et al.*, 1987; Schankerman, 1998). Very few studies have focused on patents' idiosyncratic value component, i.e. the interaction between assignee firm characteristics and patent value. In particular, systematic differences in the value of patents between small and large firms have been noted (Bessen, 2008; Lanjouw *et al.*, 2004b). Moreover, the innovation strategy literature offers some evidence that patent value is driven by assignee firm characteristics (Agarwal *et al.*, 2009; Reitzig *et al.*, 2009; Teece, 1986). Yet, no study has focused on the question: how large is the idiosyncratic component of patent value, and what is the relative importance of idiosyncratic and common components in patent value?

Addressing this question is important given that bidding strategy (in a patent auction context) and technology licensing strategy (in a bi- or multi-lateral negotiations context) hinge critically upon the value structure of the patent (Katz *et al.*, 1985; Paarsch, 1992; Shapiro, 1985). Of course, patent auctions are far from commonplace. There have been only a few cases of public auctions of patent rights in the recent past[5]. However, technology licensing is much more widespread and is expected to gain prominence in the future (Arora *et al.*, 2003b; Arora *et al.*, 2010). Hence, exploring the value structure of patents is crucial for the design of innovation strategy. In addition, shedding light on this issue is important for understanding the

[5] See for example Ocean Tomo's patent auctions.

function and ensuring the optimal design of markets for technology. Although patent transfer/licensing does not account for the entirety of transactions in these markets, the volume and importance of patent-related transactions is increasing (Arora *et al.*, 2010; Grindley *et al.*, 1997; Serrano, 2010).

In order to address this question, I compiled a dataset of US patents granted to S&P 400MidCap companies from 1995 to 1999 and used an event study of the stock market's reaction to the grant of a patent to estimate their total value. I find that, in my sample of patents, mean total value is $7.765 million and median total value is approximately $0.152 million. Then, I estimated the variance components of a mixed model where patent characteristics are treated as fixed effects while assignee, technology area and grant year are treated as random effects. Surprisingly, I find that, after controlling for the quality of the patented invention, assignee firm effects explain a larger percentage of variance in patent value than technology area effects. This suggests that assignee firm characteristics – or the idiosyncratic value component – play a major role in the determination of patent value. Rather than focusing on inter-technology area differences, studies measuring patent value would benefit by exploring heterogeneity among assignee firms.

In addition, I identify some of these assignee characteristics. My analysis shows that patent value is correlated with firm size, access to complementary assets, R&D intensity and patent portfolio relatedness. Although the effect of firm size and R&D intensity has been noted before (Bessen, 2008; Lanjouw *et al.*, 2004b), this is one of the first studies to empirically demonstrate the dependence of patent value on the composition of the assignee firm's patent portfolio. Specifically, I find that the value of a patent increases when it is combined with other technologically related patents while this effect is stronger in complex-technology industries. Moreover, I confirm suggestions that patenting and complementary assets work synergistically in appropriating returns from innovation (Arora *et al.*, 2006; Teece, 1986).

My results then point towards a more holistic understanding of patent value: patent value largely depends on the assignee firm's collection of tangible and intangible resources. This has interesting implications for innovation strategy and public policy. For example, firms need to develop the necessary skills and capabilities in defining, protecting and using patents that will enable them to maximize their value. In addition, the large idiosyncratic component of patent value affects the demand for patents and, consequently, the function of markets for technology.

In the next section I review related literature. Subsequent sections sequentially present data, patent value estimation methodology, the results from regression analysis and variance components analysis and a concluding discussion.

3.2 MEASURING PATENT VALUE

Unlike some assets, patents are not readily traded in the marketplace and technology licensing is not a widespread activity (Arora *et al.*, 2010). As a result, economists have to rely on indirect measures in order to come up with estimates of their value. Schankerman and Pakes (1986) and Pakes (1986) pioneered the use of patent renewal data. Starting from the premise that patent owners keep their patents in force if and only if the expected returns to patent protection outweigh the costs of renewal, they calculate estimates of the mean (UK: 6,963 – France: 6,656 – Germany: 19,124 – all 1980 $) and median (UK: 1,861 – France: 847 – Germany: 1,580 – all 1980 $) of the patent value distribution. Their results confirm earlier suggestions that the value distribution of patents is highly skewed towards the low value side (e.g. Scherer, 1965).

However, these models do not fully capture the possible realized values of patents in the extreme right tail of the distribution (Lanjouw *et al.*, 1998). In addition, annual patent returns are assumed to decrease at a constant rate *δ,* which is not necesarilly the case in industries with rapidly evolving technologies. Hence, these studies provide minimum estimates of patent value.

An interesting extension of these models involves the combination of renewal data with patent transfer data. Using a dataset of patent transfers recorded by the USPTO, Serrano (2005) calculates the value of the median patent to be $27,895 while mean patent value is found to be $86,782 (2003 $). Nevertheless, these estimates are based on patents issued to 'small innovators', i.e. firms that were issued no more than 5 patents in a given year. Hence, a broader interpretation of these results rests on the assumption that there are no systematic differences in the value of patents granted to firms with small and large patenting output.

Other authors use firms' market value, usually Tobin's *Q*, to test the impact of patenting on stock market performance (Griliches, 1981; Pakes, 1985). For example, using Compustat data for the years 1968-1974, Griliches (1981) suggests that a successful patent is worth about $200,000. Hall *et al.* (2005) find that a highly-cited patent portfolio commands a significant market-value premium. And Bessen (2009) calculates average patent rents ranging from $205,000 to $445,000 (1992 $) depending on different model specifications. Nevertheless, Bessen (2009:1605) points out that the potential of omitted variable bias requires careful interpretation of such results, as these models provide upper bound estimations of mean patent rents.

Finally, survey data have been used to measure the economic value of patents. One of the earliest attempts towards this direction was by Sanders *et al.* (1958) who conducted a mail survey of US patent assignees in 1957. They found that the mean value of patents in current use and with net gain was $577,000. The figure is lower but still significant, approximately $112,000 (or $473,000 in 1988 $), when considering all patents in their sample (Griliches, 1990). More recently, the PatVal-EU survey, conducted in 2003-2004, asked inventors and managers in the EU to provide their best estimate of the value of their patents. The results suggest that the average patent is worth more than €10 million and the value of the median patent is €650,000 (Gambardella *et al.*, 2008).

3.2.1 Total Patent Value and Patent Premium

It is hard to overlook the differences in estimates of patent value offered by various researchers. In fact, when comparing some studies, the results differ by several orders of magnitude. To a certain extent, these inconsistencies reflect differences in the estimation techniques and data used. More importantly, however, these results can also be explained by differences in analytical focus: while some of the studies cited measure the 'asset value' of the patent right, others calculate 'patent premia'.

The patent premium is defined as the proportional increment to the value of innovations realized by patenting them (Arora *et al.*, 2003a:1). Given that innovators choose from a variety of strategies to protect their inventions – e.g. secrecy, lead time or complementary assets – the patent premium reflects the additional value captured by innovators as a result of patenting. In particular, Arora *et al.* (2003a) report that, conditional on patenting, US firms earn between 75% to 125% more from the decision to patent their inventions. The renewal studies similarly focus on calculating patent premia. Since the decision to renew does not affect the innovator's ability to use the patented invention, the results from this literature capture the value of continued patent protection, without including the value of the invention (Harhoff *et al.*, 2003).

Serrano (2005) or Gambardella *et al.* (2008), however, measure what Harhoff *et al.* (2003) define as the asset value of the patent right. This can also be described as total patent value since it includes both patent premium and the value of the invention (Gambardella *et al.*, 2008). The distinction between the two value constructs is better understood when considering a case of inter-firm technology transfer. When a firm sells a patent right, then the recipient firm can block all other competitors, including the selling firm, from using the invention. Thus, the selling firm forgoes both the patent right and the right to use the invention. On the contrary, when a firm licenses its patented technology to a competitor, then it loses its monopoly over the invention, but it can still use the technology for its own production. It should be obvious then that the patent premium is equivalent to the value of licensing the patent right to all market participants while total patent value is equivalent to the value of selling a patent right to a competitor (Harhoff *et al.*, 2003).

In practice, it is difficult to disentangle total patent value and patent premium. Jensen *et al.* (2011) were successful in separating the two by surveying patent applicants (not just patentees) and asking them to provide estimates of past and future revenues from using or licensing the invention. Their results suggest that, *ceteris paribus*, patented inventions are 38% to 47% more valuable than inventions without a patent.

3.2.2 Sources of Variation in Patent Value

Patent value[6] depends on the quality of the underlying invention and on the effectiveness of patents as mechanisms of appropriability. Hence, the observed variability in patent values can be attributed to a number of parameters. Below I examine these sources of variation more systematically.

<u>*Technology area*</u>

Most studies measuring patent value emphasize the differences in their use and value across technology areas. For example, a number of important contributions have

[6] Unless otherwise stated, the term 'patent value' refers to total patent value, which includes the value of the patented invention and the patent premium.

established that patents are not equally effective as mechanisms of appropriability across technology areas (Cohen *et al.*, 2000; Levin *et al.*, 1987). In addition, patents serve different purposes. When innovation is cumulative in nature, patents act as 'bargaining chips' rather than exclusion rights (Hall *et al.*, 2001b). In other cases, patents are used as defensive mechanisms (Arora, 1997). There is also considerable variability in the cost of protecting intellectual property, as demonstrated by the differences in litigation rates across technology fields[7] (Lanjouw *et al.*, 2001b).

There is strong empirical evidence documenting these differences. Lanjouw (1998), Schankerman (1998) and Bessen (2008) find significant differences in estimates of patent value across technology areas. For example, Bessen (2008) reports that mean patent rents amount to $497,200 in chemicals while the same figure is much lower in other fields (computers and communications: $45,247 – drugs and medical: $120,419 – electrical and electronic: $68,459 – mechanical: $86,033). Arora *et al.* (2003a) similarly find substantial differences in their estimates of industry patent premia[8].

Assignee firm characteristics

Assignee firm characteristics have received less attention in the literature. However, as indicated before, there are reasons to believe that a given patent is not equally valuable to different firms. First, some firms are better than other in protecting

[7] Lanjouw and Schankerman (2001) suggest that these differences may be associated with variation in the value of patent protection.

[8] Arora et al. (2003) calculate industry, as opposed to technology area, patent premia because they are using data from the Carnegie survey. Although there is no clear, one-to-one matching between technology area and industry, the basis of the argument is very similar.

their intellectual property rights. Second, the value of a patent is a function of a firm's patent portfolio and complementary mechanisms of appropriability.

It is important to remember that patent rights do not immediately confer monopoly power over an invention. Rather, if a patent is being infringed upon, it gives the patent assignee firm the right to sue the infringer for damages. However, patent enforcement is costly in the US[9], making it especially difficult for small firms to protect their intellectual property (Lanjouw *et al.*, 2004b:45). In fact, small firms face much higher litigation costs as compared to larger firms (Lerner, 1995). Because of this disadvantage, patents are expected to be less valuable to small firms. These claims are consistent with Bessen's (2008) finding that small companies have on average less valuable patents.

In addition, some firms enhance the value of their patents by building a reputation for enforcement (Agarwal *et al.*, 2009; Lanjouw *et al.*, 2001b). For example, Agarwal *et al.* (2009) demonstrate that a reputation for toughness reduces the likelihood of costly IP-related disputes.

Besides the issue of enforcement, the value of a patent varies across firms due to differences in the composition of their patent portfolio. This is in line with the view that the value of patents lies not in their individual worth, but in their aggregation into a collection of related patents (Parchomovsky *et al.*, 2005:5). In particular, a large patent portfolio improves the bargaining position of firms and enables them to design

[9] The American Intellectual Property Law Association estimated in 2007 that the average cost of a patent dispute is between $3 and $5 million.

and manufacture without fear of infringement (Grindley *et al.*, 1997). Moreover, the value of a patent increases when it creates a patent 'thicket' along with other existing company patents (Reitzig, 2004).

Finally, access to complementary assets enhances the value of patent protection (Arora *et al.*, 2006; Teece, 1986). This is because an innovator with specialized complementary assets is able to profit more from a market characterized by lack of close substitutes – due to patent protection – than an innovator lacking such assets (Arora *et al.*, 2006:297).

Invention quality

Of course, invention quality plays an important role in determining the value of a patent. Given that the quality (which defines the value) of the underlying invention varies considerably across patents, the skewed nature of the patent value distribution is not surprising (Griliches, 1990; Scherer, 1965). Examples of invention quality indicators put forward in the literature are novelty, originality, generality and difficulty of inventing around (Gallini, 1992; Reitzig, 2003; Trajtenberg *et al.*, 1997).

Yet, finding good proxies for invention quality is a difficult task. Trajtenberg *et al.* (1997) provide a number of measures based on patent citations. Other patent characteristics such as forward citations, backward citations, number of claims and patent scope are found to correlate with patent or innovation value (Lerner, 1994; Tong *et al.*, 1994; Trajtenberg, 1990). Bessen (2008:933) confirmed the usefulness of such measures, forward citations in particular, but emphasized that these are more informative about the value of the underlying technology than they are about the value of the patent per se.

Regulatory environment

Finally, the regulatory environment matters for patent value. Indeed, if there is no credible threat of punishment for patent infringers, then there is no real value in patenting. Unfortunately, there are few opportunities to test this assumption. In the US, the creation of the Court of Appeals for the Federal Circuit (CAFC) in 1982, which has been widely perceived as resulting in the strengthening of patent rights, provides a good testing ground. However, the hypothesis that the creation of the CAFC made patents more valuable has received little empirical support (Kortum *et al.*, 1998).

Overall, the preceding discussion suggests that the value of a patent has an idiosyncratic component, depending on assignee firm characteristics, and a common component, depending on technology area characteristics, invention quality and the regulatory environment. In this chapter, I am extending the inquiry into the relationship between assignee firm characteristics and patent value in an attempt to further explore the idiosyncratic component of patent value.

In addition, I want to evaluate the relative importance of the idiosyncratic and common value component. Of course, it is challenging, if not impossible, to formally do such a comparison. For example, it is very difficult to model the effect of the regulatory environment (Jaffe, 2000). Hence, I narrow down my research question to compare the relative effect of firm and technology area characteristics in patent valuation after controlling for the quality of the patented invention. This will enable me to assess the degree to which patent value varies across assignee firms and across technology areas. Given that the literature has primarily focused on technology area heterogeneity in patent value, this analysis allows for a more accurate description of these differences after 'removing' the effect of assignee firm characteristics. It also allows for a direct comparison of the relative importance of firm and technology area characteristics in patent valuation.

3.3 AN EVENT STUDY APPROACH TO MEASURING PATENT VALUE

In this chapter, I use an event study of the stock market's reaction to the grant of a patent to estimate patent value. Despite their widespread use to assess the financial impact of corporate announcements, event studies are less common in the patenting literature[10]. There are two main reasons for this. First, in most countries (including the US after November, 2000) patent application information are made available by patent offices. Second, even when patent applications are confidential, firms can issue press releases about pending patent applications or 'notices of allowance'[11] (NOAs) (Lerner, 1994). This creates problems with event studies as events are assumed to be unanticipated by the market.

In order to address the first concern, I focused on the pre-2000 period when the USPTO kept patent applications and NOAs confidential. This sampling strategy

[10] See for example Austin's (1993, 2000) studies on patent valuation in the biotechnology sector employing the event study methodology.

[11] A notice of allowance (NOA) indicates that the patent is near approval. The USPTO issues NOAs a few months prior to the award of a patent.

ensures that the market did not previously have any information on patent grants unless there was a voluntary disclosure. Then, I assessed the extent to which firms issue announcements related to their patent applications based on Lansford's (2006) study of voluntary patent disclosures. In particular, Lansford (2006) collected a sample of all patent-related announcement from US-listed firms between January, 1990 and November, 2000. He found that there were 1,977 unique patent announcements from companies listed in the US[12], 37% of which were related to patent applications and NOAs. During the same period, there was a total of 1,283,393 patents awarded by the USPTO. From these, approximately 23.2% (or 297,747) were granted to US-listed companies[13]. This suggests that pre-grant information leakage is a concern for just 0.0025% of the total population of patents awarded to US-listed companies.

Hence, information about patent grants becomes available through the USPTO's announcements that are public, detailed and well-advertised. Austin (1993) confirms these results by making reference to anecdotal evidence suggesting that the actual timing of patent grants is a surprise. Then, under certain sampling criteria, the event study methodology can produce accurate estimates of patent value. Nevertheless, Lansford (2006) notes that firms tend to announce only economically significant patents. This might result in slightly underestimating mean patent value.

[12] Lansford (2006) constructed his dataset using keyword searches of Dow Jones News Service articles.

[13] This calculation is based on Bessen's (2008) data indicating that from all patents issued in 1991, 23.2% were granted to US-listed companies.

A final note before describing data collection is related to the value construct measured with event studies. When a firm is awarded a patent, there are in fact two ‘distinct’ announcements: a) the company came up with an invention and b) the company has patented this invention. Hence, event studies produce estimates of total patent value and not just patent premium. Indeed, Gambardella *et al.* (2008:70) state that total patent value is equivalent to the market value of a firm whose only asset is the patent. This is precisely what an event study is measuring.

3.3.1 Data & Methodology

My dataset consists of patents granted to S&P 400MidCap companies from 1995 to 1999. I include in my sample the 400 constituent companies of the index at the start of 1995 but do not collect data on companies added to the index in later periods. When companies were taken over or their stock ceased trading during this 5-year period, I stopped collecting additional patent data. In addition, I excluded companies with less than 5 patents granted during the 1995-1999 period.

This sampling strategy has a number of advantages. Firstly, given that my primary focus is on exploring the firm-specific component of patent value, this approach ensures enough variation at the firm level. Secondly, S&P indices are specifically constructed to reflect a sector balance that is representative of the economy as a whole. Thirdly, the selection of medium-sized companies allows me to avoid two potential biases. On the one hand, small firms are more likely to voluntarily disclose information on patent applications prior to the grant day[14]. Yet, very large companies might suffer from a ‘small pebbles in a big pool problem’ in the context of this study: the grant of a single patent might be considered as economically immaterial to the future cash flows of very large corporations (Benson *et al.*, 2009:337; Dimson *et al.*, 1986).

<u>*Dataset construction*</u>

Given the difficulties of matching company names with patent data, I used a combination of dictionary-based identification and manual matching (Thoma *et al.*, 2010). I began with the match file (last updated in 2010) provided by the NBER (Hall *et al.*, 2001a) and then manually checked for alternative spellings and subsidiaries that were not already identified. Using Standard and Poor’s Capital IQ database, I checked for existing subsidiaries as well as changes in names, acquisitions and divestures that took place during this period. I was thus able to track all patents awarded to the firms either directly or though their subsidiaries. This procedure generated a list of 11,903 patents granted to 137 firms from the original sample of 400 companies during the 1995-1999 period.

Subsequently, I matched the patent list with stock market data from CRSP and financial data from Compustat. Finally, I excluded 1,602 patents from my analysis after checking for confounding events (e.g. earnings announcements, mergers and acquisitions, lawsuits etc.) using the LexisNexis database. So, my sample consists of

[14] Lansford (2006) finds that firms using strategic patent announcements have very low median market capitalization, $113 million, while mean market capitalization is approximately $1 billion. In contrast, S&P MidCap400 membership requires a market capitalization between $1 and $4.4 billion.

10,301 patents granted to 137 firms[15] in 6,461 separate event days (some firms received multiple patents on the same day). The distribution of the number of patents per firm is skewed to the right: firms in my sample received an average of 75 patents but the median firm received 36 patents.

Dependent variable: Total patent value

The total value of a patent (or multiple patents in the case of multiple patents granted to the same firm on the same day) is estimated based on the difference between the assignee's actual return over the event window minus the assignee's expected return as follows:

$$AR_{it} = R_{it} - \left(\widehat{\alpha_i} + \widehat{\beta_i} R_{mt}\right)$$

Here, AR_{it} denotes the daily, firm-specific abnormal returns, R_{it} the daily, firm-specific actual returns, R_{mt} the corresponding daily returns of the CRSP value-weighted index and $\widehat{\alpha_i}$,$\widehat{\beta_i}$are estimates obtained from the following market model:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}\ , where\ E(\varepsilon_{it} = 0)\ and\ var(\varepsilon_{it}) = \sigma_\varepsilon^2$$

Following standard practice, I use a 2-day (0,+1) event window and a 260-day (-262, -3) estimation window (MacKinlay, 1997; McWilliams *et al.*, 1997).

It is important to note at this stage that the grant of multiple patents to the same firm on the same day imposes some additional challenges to the interpretation and testing of the abnormal returns. In fact, Austin (1993:254) chose to focus only on

[15] In terms of industry representation, 85% of the patents in my sample were granted to firms with primary SIC codes in manufacturing (20-39). This is hardly surprising given that the USPTO only recently started granting more patents in other fields (e.g. business method patents).

‘solitary’ patents, those issued in weeks when no other patent in the sample was issued. However, such an approach could bias my results, as the most active patentees would be excluded from my sample. I come back to this issue in the next section.

Patent value indicators

I include a number of patent, assignee firm and technology area characteristics in my analysis to check if they are correlated with my estimates of patent value.

Patent characteristics. The NBER database provides information on the number of claims, number of forward citations (corrected for truncation – see Hall *et al.* (2001a)) and number of backward citations. I also calculated measures of generality and originality as well as measures of forward and backward distance in technology space[16,17] (see Trajtenberg *et al.*, 1997).

Firm characteristics. I include information on sales, R&D spending and patenting experience, defined as the number of patents granted to the firm 5 years prior to the grant date of the focal patent. In addition, I calculate measures of patent stocks based on firms’ existing patent portfolio at the time of the grant. In particular, I construct a measure of patent portfolio quality as recorded at the time of the patent grant:

$$CWPT_t = \sum_{i=1}^{N} C_i(1-\delta)^{t-T}/100$$

[16] The number of claims, patent classes and forward/backward citations were added in the case of multiple grants. Measures of generality, originality and distance in technology space were averaged.

[17] All the measures using patent class information in this chapter are calculated based on three-digit IPC classification codes. The main advantage of the IPC classification scheme is its nested structure (Lerner, 1994).

where $CWPT_t$ stands for citation-weighted patent portfolio in year t up to the grant, C_i denotes the number of forward citations (corrected for truncation) received by existing patents i=1,…,N granted in year T and δ is the annual depreciation rate set equal to 0.15[18]. The intuition behind this formula is that citation-weighted measures are much more informative than simple patent counts (Hall *et al.*, 2005). Besides this measure of quality, I added a measure of technological relatedness between the granted patent and the assignee's patent portfolio. In particular, I calculated the percentage of patents in the assignee firm's portfolio that are already granted in the same technology area as the focal patent.

Finally, I constructed a continuous variable reflecting the likelihood of access to complementary assets required to commercialize the patented invention. Given that the USPTO does not individually assign each patent to SIC codes, I relied on Silverman's concordance[19] to map the patents in my sample to different industries. In more detail, Silverman's concordance provides probability-weighted matches between IPC classes and SIC codes and has been shown to outperform other concordances (McGahan *et al.*, 2001). Based on this, I calculated the technology area-adjusted probability of using an invention in any given IPC class as an input to the assignee firm's primary SIC (three-digit) code as follows:

$$ap_{tI} = {}^{p_{tI}}\!/_{(p_{1A}^2 + p_{2B}^2 + \cdots + p_{nN}^2)}$$

[18] A depreciation rate equal to 0.15 is the standard convention in the literature – see Hall *et al.* (2005) or Bessen (2009).

[19] Downloaded from http://www.rotman.utoronto.ca/~silverman/ipcsic/documentation_ipc-sic_concordance.htm

where ap_{tI} stands for technology area-adjusted probability of using an invention in technology area $t = 1, 2, \ldots, n$ as input in industry $I = A, B, \ldots, N$ and p_{tI} is the unadjusted probability of using an invention in any technology area as input in any industry given by Silverman's concordance. Essentially, this formula accounts for the fact that some technologies have wider applicability across industries. By dividing with a simple measure of dispersion of the probability of use across SIC codes (the term $p_{1A}^2 + p_{2B}^2 + \cdots + p_{nN}^2$ takes values between 0 and 1), the raw probability is adjusted upwards when use of the focal technology is not restricted to a small number of SIC codes.

Technology area characteristics. In order to isolate the effect of technology area characteristics I had to address the possibility of multiple patents granted to the same firm, on the same day but in different technology areas. In my sample, I found 1,595 such observations. For these cases, I identified the 'dominant' technology area as the one with the highest frequency of appearance in the granted patents[20].

3.4 RESULTS

Table 1 reports summary statistics from the event study. The table presents results for single-patent grants, multiple-patent grants and the full sample. Not surprisingly, there is a stronger reaction in the stock market when a firm receives multiple patents. In particular, mean abnormal returns are 0.27% in the case of multiple grants and 0.17% for the full sample. This difference is significant at the 10% level (one-tailed

[20] When this criterion could not be applied, e.g. when a firm was awarded two patents with different IPC classes on the same day, I randomly picked an IPC class as the dominant one using a random number generator. I repeated the analysis with the outcomes of 10 random number generation processes but my results were not affected.

test). Median values are much lower, at 0.01% for the full sample. Hence, as expected, the distribution of cumulative abnormal returns is skewed to the right.

Table 3.1 Event study results
Summary statistics of abnormal returns and associated economic impact calculated from the event study. Economic impact is calculated by multiplying the cumulative abnormal returns by the firm's market capitalization 2 trading days before the grant of the patent(s). The economic impact is calculated in 1999 dollars.

Group	Variable	Mean	Median	St. Dev.	Min.	Max.	N
Single-patent grants	$CAR_{(0,+1)}$	0.12%	0.00%	0.036	-27.07%	27.93%	4,331
	Economic Impact ($M)	6.4	0.216	506	-13,600	10,600	4,331
Multiple-patent grants	$CAR_{(0,+1)}$	0.27%	0.05%	0.040	-25.29%	30.41%	2,130
	Economic Impact ($M)	24.4	0.653	703	-13,200	6,570	2,130
Full sample	$CAR_{(0,+1)}$	0.17%	0.01%	0.038	-27.07%	30.41%	6,461
	Economic Impact ($M)	12.4	0.109	579	-13,600	10,060	6,461

Cumulative abnormal returns are positive and significant. In particular, the 'standard test'[21] rejects the null hypothesis of zero abnormal returns at the 1% level (t-statistic = 3.73). The standardized residual test (Patell, 1976) also rejects the null hypothesis at the 1% level (z-statistic = 4.09). However, both tests assume that abnormal returns are uncorrelated and that event-induced variance is insignificant. In the context of this study, this might not be an appropriate assumption as event windows overlap across stocks ('event-date clustering'). The 'standardized cross-sectional test', suggested by Boehmer *et al.* (1991), allows for event-induced variance changes by combining Patell's test with ordinary cross-sectional approaches[22]. Again,

[21] The test is equal to the sum of abnormal returns divided by the square root of the sum of all securities' estimation period residual variances.

[22] This is calculated as $t = \overline{SAR}\sqrt{n}/s$, where $s^2 = (1/n - 1)\sum_{i=1}^{n}(SAR_i - \overline{SAR})^2$ and SAR stands for standardized abnormal returns.

abnormal returns are found to be significant (z-statistic = 2.77). Finally, I used Brown and Warner's (1980) 'crude dependence adjustment'. This involves the formation of a portfolio of firms experiencing a patent grant in a given day, thus accounting for cross-sectionally correlated abnormal returns. Cumulative abnormal returns remain positive and significant at the 5% level (t-statistic = 2.34).

The economic impact of patent grants is quite sizeable. The mean dollar value captured by patent assignee firms is \$12.4 million, while median value is \$0.109 million (\$ 1999). Yet, the economic impact of patent grants is not directly equivalent to measures of total patent value because of the issue with multiple-patent grants. In these cases, it is impossible to disentangle the effect of each individual patent. This does not affect the estimation of mean patent value. However, I assumed that patents granted on the same day to the same firm are equally valuable in order to come up with an estimate of median patent value. Hence, I find that, in this sample of patents, mean total value is \$7.765 million and median total value is approximately \$0.152 million.

These estimates are much higher than those of other studies measuring the value of US patents[23]. As explained before, this is not surprising given that my measure of patent value captures the total value of the patent as opposed to just the patent premium. In addition, the value of patents awarded to listed companies is, on average, higher than the value of patents assigned to individual inventors (Bessen, 2008).

[23] See Bessen (2008) and Bessen (2009) for a good comparison of different studies measuring patent value.

It is interesting to compare my results with those of other studies measuring the total value of European patents, although one should be cautious given the differences in patent law across jurisdictions. Harhoff *et al.* (2003) report an average (total) patent value of $1.84 million and median value of $0.24 million ($ 1999)[24]. In another study, Gambardella *et al.* (2008) find that the average patent is worth $12.58 million while median value is $0.75 million ($ 1999). In both cases, the relatively high estimates can be explained by the oversampling of the more valuable patents. Harhoff *et al.* (2003) focused only on patents renewed to full term while the PatVal-EU survey, used by Gambardella *et al.* (2008), oversampled patents that were opposed and with at least one forward citation. Finally, Serrano's (2005) estimates of total value of US patents are significantly lower than the ones presented here. However, his sampling was confined to traded patents initially awarded to firms that were issued less than 5 patents per year. Hence, a large share of high-value patents are excluded from his sample given that these are not readily traded and are owned by firms with large patenting output.

In any case, it is important to emphasize the limitations of my own estimates. In particular, all the companies in my sample are listed and medium-sized in terms of market capitalization. In addition, I excluded from my sample firms with less than 5 patents granted during the 1995-1999 period.

[24] Harhoff *et al.* (2003) report their results in DM. I transformed these figures into 1999 $ using yearly average exchange rates and assuming that patent values are normally distributed around interval midpoints. I applied the same methodology to Gambardella *et al.*'s (2008) results.

3.4.1 Event Study Results and Patent Value Indicators

Estimates of total patent value are correlated with a number of assignee and patent characteristics. Table 2 reports the results of regression analysis.

Table 3.2 Regression analysis

OLS regression analysis using standardized cumulative abnormal returns $CAR_{(0,1)}$ as dependent variable. Estimates of fixed effects are suppressed. Huber-White robust standard errors are used in all models and p-values are reported in parentheses.

	(i)	(ii)	(iii)
Constant	-0.0013 (0.556)	-0.0049 (0.529)	0.0476^{+} (0.068)
No of patents granted	-0.0005* (0.023)	-0.0005* (0.015)	-0.0008** (0.010)
Patent characteristics			
Claims	0.0020** (0.003)	0.0019** (0.007)	0.0019** (0.010)
Forward citations	0.0001** (0.007)	0.0001** (0.002)	0.0001** (0.003)
Backward citations	-0.0002 (0.639)	-0.0002 (0.747)	-0.0001 (0.991)
Generality	0.0002 (0.895)	-0.0007 (0.749)	-0.0010 (0.644)
Originality	-0.0036 (0.172)	-0.0028 (0.285)	-0.0024 (0.386)
Tech distance (backward)	-0.0014 (0.563)	-0.0003 (0.897)	-0.0006 (0.814)
Tech distance (forward)	0.0012 (0.189)	0.0022* (0.027)	0.0031** (0.008)
Assignee characteristics			
R&D intensity		0.0021* (0.045)	0.0213* (0.022)
Sales (log)		0.0005** (0.010)	0.0042** (0.007)
Complementary assets		0.0003^{+} (0.089)	0.0005 (0.156)
Citation-weighted patent portfolio		0.0001 (0.586)	0.0001 (0.236)
Patent portfolio tech. relatedness		0.0032* (0.017)	0.0051** (0.007)
Patenting experience		0.0012 (0.707)	0.0008 (0.887)
Fixed effects	No	No	Yes
Technology area characteristics			
Fixed effects	No	Yes	Yes
Year fixed effects	Yes	Yes	Yes
No of observations	6,461	6,461	6,461
R^2	0.0294	0.1288	0.2077
F-value	13.12**	7.12**	11.33**

$^{+}$ significant at the 10% level, * significant at the 5% level, ** significant at the 1% level

The first model includes a number of patent characteristics along with fixed year effects and a variable equal to the number of patents granted to the company in the event day. These variables reflect the quality of the underlying invention. In particular, the number of claims measures the breadth of the invention while citation-based measures capture the technological importance and centrality of patented inventions. I find positive and significant correlations between patent value and the number of claims and citations received. Similar results have been obtained by Harhoff *et al.* (2003), Gambardella *et al.* (2008) and Bessen (2008). From the remaining variables, only forward technological distance has a positive and significant coefficient in two of the models. This suggests that more valuable patents are cited in diverse technological fields.

Another thing to note is the negative sign in the coefficient of the number of patents granted. Although there is a stronger reaction in the stock exchange in the case of multiple grants, this effect disappears when controlling for the quality of the patented inventions. In fact, the value of the patents decreases, *ceteris paribus*, when multiple patents are granted on the same day. One possible explanation for this result is that patents granted on the same day tend to protect similar or related inventions.

In the second and third model assignee and technology area characteristics are introduced. I find that R&D intensity increases with total patent value. Bessen (2008:941) finds a similar effect, suggesting that more valuable patents are correlated with more valuable technology. Moreover, sales are positively correlated with patent value. This is consistent with the view that larger firms are better able to protect their intellectual property rights (Lanjouw *et al.*, 2004b; Lerner, 1995). Yet, I find qualified support for the expected increase in patent value in the presence of complementary assets. The coefficient for complementary assets is positive and significant at the 10% level only in the second model. This is likely to be attributed to the lack of a very accurate procedure of assessing whether the assignee has access to complementary assets or not.

The results from the regression analysis also support a 'portfolio theory of patents' (Parchomovsky *et al.*, 2005). That is, the value of a patent should not be seen in isolation from the assignee's existing patent portfolio. In particular, I find that technical proximity with other patents in a firm's portfolio increases with patent value[25]. This effect could reflect the benefits of creating patent 'thickets' or 'fences' through patenting in closely related technological fields (Reitzig, 2004). Alternatively, related patent portfolios lower enforcement costs as assignee firms do not need to monitor diverse technological fields.

Finally, I performed a Hausman test to check if we can achieve more efficient estimates by employing a random-effects assumption for the firm effects. However, the test rejects the null hypothesis (*p*-value=0.00) that the random effects assumption provides consistent estimates. I also conducted joint significance tests for firm and technology area dummies. I was able to reject the null hypothesis of no explanatory

[25] A competing explanation for this finding could be that it reflects a generalized halo effect. However, it is not possible to separate the effect of the two explanations.

power at the 1% level for both effects. Hence, there are time-invariant, unobservable firm and technology area characteristics correlated with the total value of patents.

3.5 EXPLORING THE IMPORTANCE OF ASSIGNEE AND TECHNOLOGY AREA EFFECTS IN PATENT VALUATION

The empirical results presented in the previous section suggest that the value of a patent is not just a function of invention quality. Indeed, I find that patent value depends on a number of observable and other unobservable assignee firm characteristics. Hence, patent value includes an idiosyncratic component. Equally important is the finding that patent value depends on technology area characteristics. Preceding analysis, however, does not provide any evidence on the relative importance of these effects. How much of the variance in patent value is attributed to assignee firm and technology area effects?

3.5.1 A Variance Components Model

Here, I am not concerned with the estimation of individual coefficients but rather with comparing the degree to which patent value varies across assignee firms and technology areas after controlling for invention quality. In essence, the variability of these effects reflects their contribution to the variance of the dependent variable. For example, a relatively large inter-firm dispersion in the value of patents would highlight the importance of firm characteristics. On the contrary, larger intra-technology area variability would suggest that patent value is primarily driven by the characteristics of different technology areas. As explained by Rumelt (1991:173), it is only by estimating the variance of effects that relative importance can be assessed.

My analytical approach is guided by the studies of Schmalensee (1985), Rumelt (1991) and McGahan *et al.* (1997) who have addressed a similar question related to firm profitability[26]. Hence, I rely on the theory of variance components estimation for linear models (Searle, 1971; Searle *et al.*, 2008). In particular, I employ the following mixed model:

$$tpv = X\beta + Zu + \varepsilon\, , where\ u \sim (0, G)\ and\ \varepsilon \sim (0, R)$$

Here, I assume that total patent value, tpv, is adequately described by a linear model with a 8 x 1 vector of fixed effects (β) and a 4 x 1 vector of random effects (u). The vector β includes the population mean and the patent characteristics also included in the regression analysis presented in Table 2. These variables control for the quality of the patented invention. The elements of the vector u of random effects include assignee firm, technology area (3-digit IPC), grant year and assignee firm-grant year interaction effects. I add the grant year and assignee firm-grant year interaction terms to account for year-to-year variations in overall patent value and year-to-year variation in firm-specific contribution to patent value. For example, the first term captures the effect of changes in the strength of protection that patents provide (e.g. through regulatory changes) while the latter term captures the effect of changes in the composition of a firm's patent portfolio, size, reputation for enforcement etc.

[26] These studies focused on assessing the relative importance of industry, corporate and business unit effects on firm performance.

X and Z are respectively n x 7 and n x 4 incidence matrices and ε is the n x 1 column vector of residuals assumed to be distributed independently of the random effects. Hence, for this model we have:

$$E(tpv) = X\beta \text{ } and \text{ } var(tpv) = ZGZ^T + R$$

In order to compare the relative importance of assignee and technology area effects, I need to calculate the variance components of the covariance matrices G and R. In effect, the comparison of the different variance components allows us to identify the percentage of variance in patent value attributable to each specific effect. In the estimation of these, I use the restricted maximum likelihood method (REML) which is based on maximizing the portion of the likelihood that is invariant to the fixed effects.

It is important to note here that the random effects assumption does not explain why the effects differ across firms or technology areas. This approach suggests that the differences among effects are 'natural', i.e. not affected by the research design, and are independent of other effects, i.e. the different random effects are uncorrelated (Rumelt, 1991). The first assumption is not necessarily realistic given that firms in the sample were chosen on the basis of technology area representiveness and ability to employ an event study to measure patent value. Nevertheless, a purely random sample of firms would not be easily compatible with this research design as there could be very low variation at the firm level (i.e. firms with very low number of patents) or abnormal returns would fail to capture patent valuation (see methodology section).

The second assumption, that of independence among the random effects, could be violated if firms that are good in patenting also choose to patent in technology areas where patent protection is stronger. In order to account for this possibility I include a covariance term between firm and technology area in the model.

3.5.2 Results

Table 3 presents the results of the variance components estimation. I find that the majority of the explained variance in patent value is attributed to firm effects. In particular, 6.02% of the total variance is due to stable firm effects while 3.35% is due to transient firm effects. Technology area and grant year effects account for 5.63% and 3.22% of the variance respectively. Finally, 81.78% of the variance is unexplained by firm, technology area and grant year effects.

Table 3.3 Variance components estimates
The results are presented as a percentage of the total variance in patent values σ^2_{tpv}. Fixed effect coefficients are suppressed.

Components	% of total variance	% of total variance
Technology area	5.63	5.52
Assignee	6.02	6.01
Grant year	3.22	3.21
Assignee-grant year	3.35	3.35
Covariance (technology area/assignee)	-	0.12
Error	81.78	81.79
Total	100	100

These results do not change when accounting for the possibility that firms that are good in patenting also choose to patent in technology areas where patent protection is stronger. The covariance term between assignee firm and technology area is almost zero, suggesting that the original model is correctly specified.

These results suggest that, after controlling for invention quality, the value of patents differs more between firms than it does between technology areas. Hence, the significance of assignee firm characteristics outweighs that of technology area characteristics in patent valuation. Although the existence of firm effects was expected, it is their increased importance as compared to technology area effects that is surprising. In fact, the presence of strong firm effects reinforces the notion that patent value is highly dependent on the assignee's organizational context. The assignee's patent portfolio quality, reputation for enforcement, size etc. seem to matter a great deal for patent value.

Of course, I am not arguing that technology area characteristics are unimportant. Indeed, technology area effects account for a sizeable percentage of the explained variance. Thus, differences in the use of patents or in their effectiveness as mechanisms of appropriability across different technology areas play a role in the determination of patent value. However, technological classification should not be seen as the primary variable of interest. Assignee firm characteristics matter more.

These findings could help explain some reported inconsistencies in the literature with regards to differences in patent value across technological areas (Jensen *et al.*, 2011). For example, in contrast to most studies measuring patent value, Schankerman (1998) reports that the value of patents is lower in pharmaceuticals as compared to other technology areas. In addition, Jensen *et al.* (2011) find no differences in patent premiums across technological fields. Yet, if patent value is strongly influenced by assignee firm characteristics, these inconsistencies could be attributed to the underlying heterogeneity of individual assignee firms. By just focusing on inter-technology area variation, the effect of inter-assignee variation cannot be controlled for.

Finally, it is important to recognize that the model presented does not explain roughly 81% of the variance in patent value. This is not surprising, given that most models in the literature using patent value as a dependent variable are able to explain only a limited percentage of the variance. Nevertheless, we cannot exclude the possibility that patent value is driven by additional parameters not included in the model presented here.

3.5.3 Robustness Checks

A central assumption in event studies is that the event in question is unanticipated (Campbell *et al.*, 1997; MacKinlay, 1997). If the market anticipates the event, then abnormal returns actually measure the deviation from the market's prior expectation. In the context of this study this is not a major concern as the firms in my sample are not very 'active' patentees. The median firm in my sample received patents in 34 event days from 1995-1999. Thus, I have no reasons to believe that my measures of patent value are biased.

Despite that, I tested for the existence of such expectations by including a measure of patenting frequency in the regression models. In particular, I counted the number of days when the firm received patent(s) in the year before the grant of each patent and divided that with the number of weeks. This measure essentially reflects how often firms received patents the year prior to the grant day. If expectations exist, then this variable should be negative and significant[27]. Yet, the coefficient of this variable is not significant and positive in all models (p-value = 0.95 in the full model). In addition, all results hold after the inclusion of this variable and after excluding the two most 'active' patentees in my sample. Hence, prior expectations do not affect my estimations.

A second concern is related to pharmaceutical patents. Due to regulatory requirements set by the FDA, inventors who want to commercialize their inventions need to go through a multi-stage testing process. The average duration between patent filling and the completion of 'phase I' testing is 2.5 years and the results of these tests are usually made available by listed firms (Girotra *et al.*, 2007; Sharma *et al.*, 2004). However, the average patent grant lag in this technology area is 3.1 years (Popp *et al.*, 2003). Consequently, for some of these patents, the market has information about the pending patent application prior to the grant date. This suggests that patent value could be underestimated using an event study. In my sample I have 183 such observations[28]. My results hold when excluding these from the regression analysis. I also find very small changes in my estimates of the variance components, with firm and technology area effects being slightly less and more important respectively: stable

[27] If expectations exist, then firms with high patenting frequency should have abnormal returns distributed around zero. This is because abnormal returns would reflect the difference between expected and observed patenting behavior. On the contrary, the abnormal returns of firms with low patenting frequency – and as a result no expectations – would be distributed around the true value of the patent.

[28] In the following IPC classes: A61K, A61M, A61N, A61P

firm effects explain 5.9%, transient firm effects explain 3.2%, technology area effects explain 5.8% and year effects explain 3.3% of the total variance.

Complex vs. discrete technologies

Given that the literature highlights important differences in the use of patent rights across complex- and discrete-technology industries, an interesting extension of my analysis is to check the robustness of these results across technology areas (Merges *et al.*, 1990; Reitzig, 2004). In particular, patents develop important interdependencies in complex-technology industries, like semiconductors or electronics, because of the cumulative nature of innovation. As suggested before, patents are often labeled 'bargaining chips' in these areas as infringement of competitors' technologies is the norm and firms regularly engage in the cross-licensing of their patent portfolios (Grindley *et al.*, 1997). In contrast, patent rights in discrete-technology industries, with the pharmaceutical industry being the typical example here, do not develop such dependencies.

These differences should have an impact on the idiosyncratic component of patent value. Specifically, patent value in complex-technology industries will increase more (as compared to patent value in discrete-technology industries) in the presence of related or overlapping patent rights as the assignee firm will be able to 'block' certain parts of the technology space and, as a result, better negotiate licensing agreements, capture royalty fees etc[29]. To test for this proposition, I classified the different technology areas as either complex or discrete using von Graevenitz *et al.*'s (2011)

[29] This proposition is also developed in chapter 4.

classification. I then interacted this term with patent portfolio technological relatedness – see Table 3. Results in model (ii) are not supportive as the interaction term is positive but not significant. However, results are consistent with predictions in model (iii) where I focus only on semiconductors and pharmaceuticals, the archetypical examples of complex- and discrete-technology industries (Merges *et al.*, 1990; Reitzig, 2004). Hence, patent portfolio technological relatedness is beneficial for patents, but these benefits are higher for complex-technology industries. The lack of significance for the interaction term in model (ii) is likely to be attributed to the lack of a very accurate procedure of identifying complex- and discrete-technology industries.

Table 3.4 Robustness checks

OLS regression analysis using standardized cumulative abnormal returns $CAR_{(0,1)}$ as dependent variable. Estimates of fixed effects and non-relevant regressors are suppressed. Huber-White robust standard errors are used in all models and p-values are reported in parentheses. Model (i) is the full model as in Table 3.2, model (ii) is using von Graevenitz *et al.*'s (2011) categorization to define complex and discrete technologies for the whole sample and model (ii) just focuses on electronics & semiconductors (SIC 36) and drugs & chemicals (SIC 28).

	(i)	(ii)	(iii)
Constant	0.0476^{+} (0.068)	-0.0249 (0.323)	-0.0593 (0.222)
Patent portfolio tech. relatedness	0.0051** (0.007)	0.0073^{+} (0.079)	0.0132* (0.025)
Complex technology		-0.0016 (0.123)	
Semiconductors			-0.0325^{+} (0.092)
Interaction term		0.0058 (0.237)	0.0154^{+} (0.059)
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
No of observations	6,461	6,461	2,719
R^2	0.2077	0.1294	0.1423
F-value	11.33**	7.08**	10.44**

$^{+}$ significant at the 10% level, * significant at the 5% level, ** significant at the 1% level

3.6 DISCUSSION

The empirical findings presented in this chapter clearly demonstrate that invention quality is not the sole determinant of patent value. I confirm earlier suggestions that patent value varies across technology areas but primarily emphasize the relevance of assignee firm characteristics in patent valuation. In particular, I demonstrate that assignee effects are more important than technology area effects. Although the studies measuring patent value have traditionally focused on inter-technology area differences, the results here suggest that assignee firm characteristics should be seen as the primary value determinant. Thus, the value of patents has a large idiosyncratic component.

I was able to identify some of these assignee characteristics. The regression analysis shows that patent value is positively correlated with firm size, R&D intensity, access to complementary assets and patent portfolio relatedness. The effect of firm size and R&D intensity has been noted before (Bessen, 2008; Lanjouw *et al.*, 2004b). However, this is one of the first studies to empirically demonstrate the dependence of patent value on the composition of the assignee firm's patent portfolio. I find that the value of a patent increases when it is combined with other technologically-related patents.

This dependence has been conceptually articulated in the portfolio theory of patent value (Parchomovsky *et al.*, 2005), suggesting that the value of patents lies in their aggregation. Indeed, my results provide strong support for this view. Yet, these findings point towards a more holistic understanding of patent value: the value of a patent largely depends on the assignee firms' collection of tangible and intangible resources, which include, but are not limited to, other patents in their portfolio.

The emphasis on assignee characteristics is also in line with Bessen's (2008) assertion that patent value is endogenous. He explains that patentees can exert varying degrees of effort in the design, prosecution and enforcement of their patents (Bessen, 2008:934). The increased importance of firm effects precisely suggests that assignee firms influence the value of their patents by means unrelated to the underlying technology.

Besides that, the results of the event study are also of interest as they provide estimates of total patent value for US patents. In particular, I find that mean total value is $7.765 million and median total value is approximately $0.152 million. Of course, the patents in my sample are hardly representative of the entire population of patents. Patent assignees in my sample are all listed companies and medium-sized in terms of market capitalization. Since private inventors and small firms tend to hold less valuable patents (Bessen, 2008, 2009; Lanjouw *et al.*, 2004b), these results are likely to overestimate the mean and median of the entire population.

3.6.1 Implications for Innovation Strategy

These findings have important implication for the design of innovation strategy. Organizations are increasingly reliant on intangible assets, including intellectual property, in order to create and sustain competitive advantages (Grindley *et al.*, 1997;

Shapiro, 2003). In addition, the scope of patentable subject matter has widened, as the USTPO has been granting software and business method patents for almost two decades now (Hall, 2003; Samuelson, 2009). In view of these developments, firms need to develop the skills and capabilities that will enable them to maximize the value of their patent portfolio.

My results suggest that patenting should not be seen in isolation from innovation and, more generally, organizational strategy. The value of patents lies in their combined use with other intellectual property rights and organizational resources. Firms need to uncover these synergistic configurations and develop a more systematic approach to patenting. In terms of concrete recommendations, I show that patent value is enhanced when it is part of a technologically related portfolio and, additionally, when patenting is combined with access to complementary assets.

3.6.2 Implications for Public Policy

A corollary of this analysis is that the same patent is not equally valuable to different firms. Then, it is reasonable to expect that gains from trade would materialize in the presence of well-functioning markets for technology, as the diffusion and efficient use of technology would be promoted (Arora *et al.*, 2001; Arora *et al.*, 2010).

Of course, supply and demand economics of markets for technology are complicated since they involve the simultaneous presence of participants in both technology and product markets (Arora *et al.*, 2003b). Hence, incentives to trade in technology markets are affected by strategic considerations related to product markets. In addition, transaction costs in technology markets – e.g. search costs, fear of opportunism and technological or regulatory uncertainty – impose imperfections that reduce gains from technological trade (Gans *et al.*, 2008).

Nevertheless, my results could point towards another limitation in the development and 'thickness' of markets for technology. This is related to the demand side of technology markets which has received less attention in the literature (Arora *et al.*, 2010). In particular, the large idiosyncratic component of patent value creates asymmetries in patent valuation which, in turn, may reduce incentives to trade. This is because, on average, a patent is more valuable to the assignee firm than to other firms. For example, the patent assignee normally enjoys access to downstream assets or related intellectual property rights and has increased capacity to understand, assimilate and commercialize the patented invention (Cohen *et al.*, 1990; Teece, 1986).

In other words, I am suggesting that the large idiosyncratic component of patent value could actually reduce the likelihood of profitable trades in markets for technology. Instead, transactions motivated by access to external technologies take place in the market for corporate control as the value of a patented technology increases when acquired together with other surrounding organizational assets[30]. Consistent with this view, Bena *et al.* (2011) find that innovative firms are more

[30] I discuss technology acquisitions in more detail in Chapter 4.

likely to engage in acquisition activities and Desyllas *et al.* (2010) report that in the 1990s alone, the value of high technology acquisitions surpassed $1.93 trillion.

3.7 CONCLUSION

This chapter essentially argues for a reconceptualization of patent value. In particular, I argue that patent value involves a relatively large idiosyncratic component which results in asymmetric valuations by different assignee firms. Hence, I suggest that patent value should not be seen in isolation from the assignee firm and its organizational resources. Nevertheless, it is important to recognize that this chapter has yielded primarily descriptive insights and does not provide as an 'in-depth' analysis of the causal mechanisms that result in firm and technology area heterogeneity in patent value. What the study does without a doubt, however, is to highlight the idiosyncratic nature of patenting and the associated complexity of measuring and understanding patent value. Additional studies on this topic would help further explore the normative implications of these findings and design a patent system that supports innovation and knowledge diffusion across the economy.

CHAPTER 4

INIMITABLE SYNERGIES IN TECHNOLOGY ACQUISITIONS: THE ROLE OF OVERLAPPING PATENT RIGHTS

4.1 INTRODUCTION

Generating synergies through novel combinations of organizational resources is a key objective in strategic management. To this end, corporate acquisitions provide an important avenue for reconfiguring a firm's resource portfolio (Capron *et al.*, 1998; Karim *et al.*, 2000). However, it is a well-known fact that acquisitions, be related or not, often fail to create value for the acquirer (Moeller *et al.*, 2005; Singh *et al.*, 1987). Barney (1988) offers an explanation for this empirical observation by suggesting that acquirers only capture part of the value created if the synergy is bidder-specific. That is, the acquirer must be able to generate inimitable synergies with the target firm.

Despite the intuitive appeal of this proposition, its empirical verification is limited by the difficulty of operationalizing inimitable synergies (Harrison *et al.*, 1991; Uhlenbruck *et al.*, 2006). Like other tenets of resource-based theorizing (Hoopes *et al.*, 2003; Priem *et al.*, 2001), the inimitable synergy hypothesis is vulnerable to the tautology critique: positive acquirers' returns are attributed to the presence of inimitable synergies which are in turn observed through positive acquirers' returns. In addition, empirical tests of the inimitable synergy hypothesis have yielded somewhat inconsistent results. Different measures of similarity (or complementary differences) have been found to be positively correlated with acquirers' performance, negatively correlated with acquirers' performance or unrelated to acquirers' performance (Harrison *et al.*, 1991; Kim *et al.*, 2009; Lubatkin, 1987; Singh *et al.*, 1987).

In this chapter, I argue that a theory of value creation is essential in order to understand value capture in acquisitions. That is, exploring inimitable synergies requires a greater focus on the micro-mechanisms of surplus value generation. Such emphasis not only allows for inimitable synergies to be more accurately identified but also sheds light on acquirers' strategies for selecting targets. In fact, very few studies have simultaneously explored the resource acquisition strategies of acquirers and the emergence (or not) of synergies (Capron *et al.*, 2007). These issues are intertwined though, as acquirers attempt to access specific target resources that allow for synergies to emerge.

To this end, I identified a suitable empirical context in technology acquisitions that also involve the transfer of patent rights from the target to the acquirer. This study then examines two interrelated questions: (1) Why do acquirers choose targets with patents? (2) How, and under what circumstances, does the merging of acquirer and target's patent portfolios generate inimitable synergies?

I address these questions by taking advantage of the richness and unique characteristics of patent data. The basis of my analysis is that overlapping patent portfolios, measured through common citations to other patents, generate inimitable synergies in industries using complex technologies but have no effect in industries using discrete technologies. This is because innovation in complex technology industries is cumulative and merging related patent portfolios allows the acquiring firm to profit by controlling and (partly) blocking certain parts of the technology space (Merges *et al.*, 1990; Reitzig, 2004; Shapiro, 2001). In contrast, overlapping patent portfolios in discrete technology industries do not allow for such opportunities to emerge as patent rights do not develop interdependencies, they work more or less alone (Cohen *et al.*, 2000; Merges *et al.*, 1990). My results confirm this premise and the importance of Barney's (1988) framework in explaining value capture in acquisitions.

The differences in patent use across technologies also help understand the target selection strategies of technology acquirers. Although much emphasis has been put on the decision to acquire (Hitt *et al.*, 1991; Zhao, 2009), we know less about the characteristics of the firms targeted. Here, I find that acquirers are more likely to buy targets with patents when they operate across multiple technology areas but only in complex technology industries. Given that patents develop interdependencies in these industries, acquirers are keen to exploit potential future synergies. The nature of resource interdependence then directs target selection as acquirers scan the environment for resources that are likely to generate synergies with existing organizational resources. I also find that, in both settings, acquirers facing an increased threat of patent litigation and low patent productivity are more likely to buy targets with patents. These results provide more clarity to the strategies of technology acquirers and complement studies exploring the relationship between acquirer characteristics and target selection (Mitchell *et al.*, 2003; Schildt *et al.*, 2006).

Overall, this study contributes to the study of acquisitions by emphasizing the need to observe synergy potential at a much finer level of analysis and to better understand what resource combinations generate surplus value. A more superficial focus on resource similarities or differences, evident in much of the earlier empirical work, will not necessarily translate into higher acquisition performance. As Kim *et al.* (2009) point out, just because two firms are the same on some dimension does not mean that their strategies, or resources, necessarily fit together in some value-creating manner. Instead, researchers should identify the underlying mechanisms of value creation by carefully observing the nature and characteristics of resource interdependence.

By exploring the link between resource characteristics and target selection, this study also reinforces the notion that existing resources shape the trajectory of firms' growth and expansion (Mahoney *et al.*, 1992; Penrose, 1959). However, a lack of attention to the micro-mechanisms of resource interdependence inevitably leads to ambiguous results – e.g. see discussion about corporate diversification and its performance implications (Berger *et al.*, 1995; Campa *et al.*, 2002; Lien *et al.*, 2009; Montgomery, 1994). Hence, strategic decisions like industry entry or target and alliance partner selection should be studied with reference to detailed accounts of resource characteristics and the likely effects of resource redeployment on value creation. Such focus is essential in order to transform resource-based theories, arguably the dominant lenses through which strategic decisions are currently studied, into an empirically relevant and fully operationalizable theory.

4.2 THEORY AND HYPOTHESES

Economists have traditionally seen corporate acquisitions as motivated by economies of scale and scope and the transfer of management practices (Jensen *et al.*, 1983; Shleifer *et al.*, 1988). Strategy scholars emphasize the benefits of resource redeployment following an acquisition (Capron, 1999; Capron *et al.*, 1998). According to this view, value is created through the combination of resources that were previously deployed separately and are subject to market failure (Capron *et al.*, 1998). Indeed, acquisition activity is a key mechanism by which firms change and reconfigure their resource portfolio (Karim *et al.*, 2000).

The resource redeployment perspective of acquisitions largely rests on the idea that resource value is endogenous, that is resource value is a function of other resources in a firm's portfolio. A number of mechanisms have been proposed in support of this view. For example, firms increase resource productivity through the development of idiosyncratic capabilities (Makadok, 2001). Alternatively, resources can exhibit complementarity allowing for value-enhancing redeployment (Kim *et al.*, 2009; Milgrom *et al.*, 1995). In this context, complementarity is present when a combination of resources leads to the creation of surplus value over and above the sum of the amounts of value the resources could create independently (Adegbesan, 2009:463). Resource orchestration and co-specialization are similar concepts to that of complementarity and have been used to describe interdependencies among resources (Adner *et al.*, 2003; Sirmon *et al.*, 2009; Teece, 1986).

4.2.1 Value Capture in Acquisitions

Although it is often hard to disentangle the different sources of surplus value creation, e.g. resource divesture versus resource redeployment (Capron, 1999), empirical evidence is broadly supportive of the generation of synergistic gains from acquisitions (Moeller *et al.*, 2005; Mulherin *et al.*, 2000). Here, I use synergy to describe any value-enhancing opportunity resulting from resource redeployment. This includes notions of complementarity, co-specialization, economies of scale etc. Nevertheless, these synergies are not equally distributed between the merged entities. A number of studies demonstrate that bidding firms often fail to capture any value from the acquisition (Fuller *et al.*, 2002; Moeller *et al.*, 2005). Synergistic gains are, to a large extent, captured by the shareholders of the target firm.

Barney (1988) suggests that this observation can be explained by the competitive nature of markets for corporate control. Corporate takeovers are similar to auctions, with bidding firms competing on the basis of their respective valuations. If the target is equally valuable to bidding firms, the competitive bidding process will result in zero returns for the acquiring firm. Acquirers then profit by taking advantage of imperfections in the markets for corporate control. Barney (1988:73-74) identifies three possibilities: (1) when private and uniquely valuable cash flows exist between a bidder and target, (2) when inimitable and uniquely valuable cash flows exist between a bidder and a target, and (3) when unexpected synergistic cash flows exist between a bidder and target.

It is interesting to note that Barney (1988) was careful to avoid focusing on the sources of surplus value in his original formulation of the problem. His framework uses the 'net present value of synergistic cash flows' to identify the surplus value resulting from acquisitions but remains essentially agnostic about the underlying mechanism generating the synergy. Given his focus on generating a theory of value distribution, this is an appropriate assumption. However, empirical tests of the inimitable synergy hypothesis are problematic unless informed by a theory of surplus value creation. Two issues stand out. First, there is the operationalization of inimitable synergies. Essentially, it is difficult to avoid the tautology trap of identifying inimitable synergies through acquirers' returns and vice versa. A theory of value creation should *a priori* identify the conditions under which resources generate surplus value (or not) when brought together. This point is part of a broader discussion centering on the explanatory power of resource-based theorizing. Its critics suggest that the resource-based view of the firm often defines what it attempts to explain, thus rendering the empirical falsification of its propositions almost impossible (Hoopes *et al.*, 2003; Priem *et al.*, 2001).

Second, it is difficult to disentangle the effect of the different possibilities identified by Barney (1988) without a theory of value creation. Leaving aside the case of unexpected synergies, a positive correlation between acquirer's performance and acquisition characteristics could be attributed either to private information or to inimitable synergies. In addition, synergies could emerge from various kinds of resource combinations. Yet, pursuing these different strategies is not a random decision on behalf of the acquiring firm but rather depends on both observable and unobservable firm characteristics (Capron *et al.*, 2007). A theory of value creation then should also explore target selection and the drivers for acquiring specific resources that generate synergies. Failing to account for this selection process could bias results and confound interpretation (Capron *et al.*, 2007; Hamilton *et al.*, 2003; Shaver, 1998).

These concerns are evident in studies exploring inimitable synergies. Harrison *et al.* (1991) found that differences in capital, administrative, interest and R&D intensity between target and acquirer are positively correlated with return on assets. However, it is not clear how these differences generate synergies and whether these differences give rise to private or inimitable synergies. Barney's (1988) starting point for formulating the unique synergy hypothesis is the lack of support for the 'relatedness hypothesis' (Lubatkin, 1987; Singh *et al.*, 1987), predicting that acquirers will profit more from related acquisitions as opposed to unrelated ones. A lack of relatedness does not necessarily lead to inimitable synergies just like the presence of relatedness doesn't. In fact, when controlling for related versus unrelated acquisitions, some of these results do not hold.

In another study focusing on differences, Kim *et al.* (2009) looked into the distance between target and acquirer's product and market presence in the US commercial banking industry. These measures are much more fine-grained and capture resource interdependence to a greater extent. Nevertheless, results are mixed as only differences in product presence positively contribute to acquirers' returns. The coefficient for market presence differences is negative and significant, indicating that similarity is beneficial. Hence, a theory of inimitable synergies based on complementary differences is not fully supported.

Capron and Pistre (2002) took advantage of post-acquisition survey data to identify inimitable synergies. They hypothesize that synergies are unlikely to be inimitable when they originate from the transfer of the target's resources. In contrast, inimitable synergies should be present when resources are transferred from the acquirer to the target. Results are supportive but not entirely consistent. Abnormal returns are positively correlated with the transfer of marketing resources from target to acquirer and negatively correlated with the transfer of marketing resources from acquirer to target. Moreover, resource transfer is a necessary but not strictly sufficient condition for inimitable synergies to emerge.

Overall, these and other studies have greatly contributed to the elucidation of Barney's (1988) hypothesis. However, the inconsistencies found in the literature reinforce the notion that additional work is required. I argue that more attention should be paid to the micro-mechanisms for generating inimitable synergies. This requires a theory of value creation as well as focusing on acquirer's motives for selecting targets. Target firms differ in the composition of their resource portfolio, with different resource bundles allowing for different opportunities to achieve inimitable synergies. Hence, addressing value capture and creation simultaneously provides more clarity to the motives of acquirers and to the strategies employed to profit from acquisitions. Acquisition activity in high tech industries provides an ideal setting to develop such a framework. Below, I explain the theory and develop hypotheses.

4.2.2 Technology Acquisitions – Operationalizing Inimitable Synergies

Technology acquisitions provide technological input to the acquiring firm enabling it to avoid the uncertain process of internal technology development and to leverage the target's knowledge base and capabilities (Ahuja *et al.*, 2001; Puranam *et al.*, 2007). Much of the emphasis in the literature is on technology acquisitions' impact on post-acquisition innovative performance (Ahuja *et al.*, 2001; Desyllas *et al.*, 2010; Hitt *et al.*, 1991). Yet, the resource redeployment perspective of acquisitions points towards a number of avenues for generating synergistic value. For example, the rent-generating potential of technology resources is subject to access to specialized complementary assets such as manufacturing or marketing capabilities (Arora *et al.*, 2006; Teece, 1986). Or, the productivity of internal R&D is found to increase when external knowledge is acquired (Cassiman *et al.*, 2006). For this study though, I focus on the transfer of patent rights and merging of acquirer and target's patent portfolios. This is because patent data convey information about both the strategic intent of acquirers and the extent to which inimitable synergies can be achieved.

In more detail, patents are important means of competition in high tech industries. They protect innovators by granting them monopoly rights over distinct parts of the technology space. The extent of this protection is defined by the claims listed on the patent document and citations to other patents. The role of citations is crucial in the patent system as they delimit the scope of patent protection *vis-à-vis* other patented technologies: the claims of the citing patent are suppressed by those of the cited patent (Hall *et al.*, 2005; Trajtenberg, 1990). This legal function of citations allows us to observe technological overlap in a very precise manner as citations reveal the antecedents of patented inventions. Whereas measures of technological distance across patent classes capture broad technological associations (Jaffe, 1986; Paruchuri *et al.*, 2006), citation data reveal unique links between technologies.

Uniqueness results directly from the statutory requirements for patentability as multiple patents cannot be granted for the same invention. This suggests that any citation links between patents are unique in the sense that no other patent assignee can replicate it. Hence, citation links between target and acquirer qualify as inimitable according to Barney's (1988) terminology. This feature of patent data is central to my framework as I am able to distinguish between the different possibilities for generating unique synergies identified by Barney (1988).

Of course, inimitability does not necessarily lead to surplus value. It is not *a priori* clear why overlapping patent portfolios, as measured by citation patterns, generate additional value when brought together. In fact, this is not a straightforward matter as the characteristics of the underlying technology need to be considered.

Complex vs. discrete technologies

A well-established distinction in the patenting literature is between complex and discrete technologies. The key difference between the two is whether a new, commercializable product or process is comprised of numerous separately patentable elements (complex) versus relatively few (discrete) (Cohen *et al.*, 2000:19; Merges *et al.*, 1990). Typical examples of complex technologies are electronics and semiconductors while examples of discrete technologies include chemicals and drugs (Cohen *et al.*, 2000; Reitzig, 2004).

This distinction is important because it mediates the potential of patent portfolios with overlapping rights to generate synergies. In complex product industries, companies do not have control over all of the patented technologies included in their products. Firms regularly use competitors' technologies either through cross-licensing agreements or through the threat of litigation[31] (Bessen *et al.*, 2005a; Grindley *et al.*, 1997). As explained by Merges *et al.* (1990:881), such technologies define a complex system with many components and existing inventions get incorporated into subsequent inventions. Not surprisingly, patents are often labeled as bargaining chips (Hall *et al.*, 2001b).

The combination of patent portfolios then will change the competitive and bargaining dynamics in complex product industries. When the acquirer and target's patents overlap, the combined firm will be able to control and (partly) block certain

[31] See for example the recent wave of patent suits in the smartphone industry where competing firms (in particular Apple and Samsung) are found to violate each other's patent rights.

parts of the technology space (Reitzig, 2004; Shapiro, 2001). This results in increased ability to negotiate, compete and extract licensing fees. The underlying mechanism can be paralleled to 'rebalancing' the patent thicket. A patent thicket is defined as a dense web of overlapping intellectual property rights that includes multiple blocking patents in areas where innovation is cumulative (Shapiro, 2001:120). In equilibrium, the terms for cross-licensing agreements and the resulting balancing royalty payments reflect the relative importance and coverage of each firm's patents (Cockburn *et al.*, 2010; Grindley *et al.*, 1997; Siebert *et al.*, 2010). However, when the equilibrium is disrupted by the merger of two overlapping but previously separate patent portfolios, the consolidated firm will command a premium. This is because its bargaining power relative to other competitors will be enhanced.

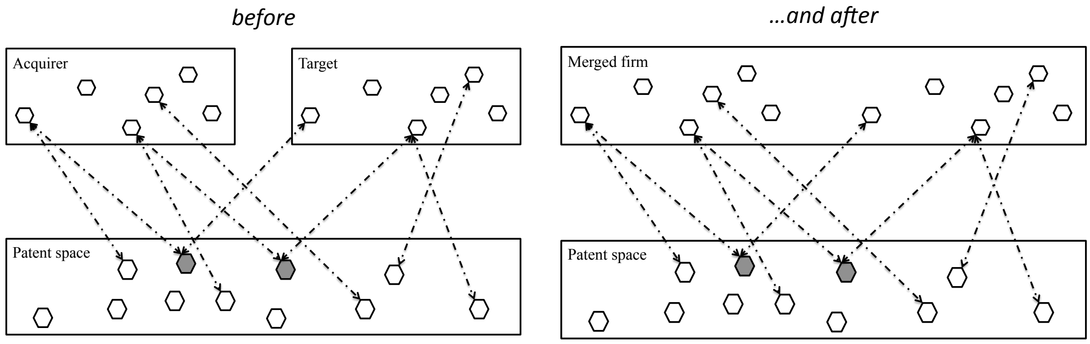


Figure 4.1 Patent portfolio dependence in complex technology industries

Figure 4.1 makes this point more clear. The hexagons represent the patents in acquirer and target's portfolios while the arrows represent technological dependence (i.e. the fact that a patent is building on an existing patent in the technology space).

The important thing to note here is that technological dependence is bilateral in complex technology settings (as demonstrated by the dual arrows) due to innovation cumulativeness. Hence, unlike in discrete technology industries, the assignees of both the citing and cited patent are dependent on each other's technologies. Before the acquisition (left side of Figure 4.1), the relative strength of the acquirer's patent portfolio and its dependence on other patented technologies define the magnitude of balancing payments or freedom to operate in the patent space. However, following the acquisition and the incorporation of the target's overlapping patents (right side of Figure 4.1), the acquirer has increased negotiating power vis-à-vis its competitors. The degree of overlap between the acquirer and target's patent portfolio essentially represents the fact that both acquirer and target are dependent on the same patents (the shaded patents in the graph). The merged entity then enjoys an advantage over the owners of such patents, as competitors in the technology space become more dependent on its (now combined) patent portfolio. This allows the merged entity to better negotiating licensing agreements or freedom to operate.

In contrast, patents in discrete technologies work more like exclusion rights. Most products incorporate only a few patented technologies normally held by the same firm (Cohen *et al.*, 2000; Reitzig, 2004). Indeed, discrete inventions do not typically incorporate a large number of interrelated components – they stand more or less alone (Merges *et al.*, 1990:881). Overlapping patent rights then shouldn't provide any opportunities for synergies to emerge. Given this background, we expect patent portfolio overlap to differentially affect acquirer's returns in complex and discrete technology industries:

Hypothesis 1a: Acquirer's returns will be higher when the acquirer and target's patent portfolios overlap in industries using complex technologies.

Hypothesis 1b: Acquirer's returns will be unaffected when the acquirer and target's patent portfolios overlap in industries using discrete technologies.

4.2.3 Selection of Target with Patents

Given that acquisitions are motivated by the generation of synergies, acquirers select targets with resources that are likely to generate surplus value when employed together with other resources in their portfolio. Hence, target selection is largely driven by the patterns of resource interdependence. This view is in line with evidence on the effect of information environments and existing capabilities on acquisition strategy (Mitchell *et al.*, 2003; Schildt *et al.*, 2006). Acquirers select targets based on the characteristics of existing resources and on their ability to actually appreciate and internalize potential synergies. Then, the selection of targets with patents in technology acquisitions, as opposed to targets without patents, is driven by the degree to which the target's patents are able to generate synergies with acquirer's resources. The higher the ability to generate such synergies, the higher the likelihood of acquiring a target with patents.

Here, I identify other factors that could influence the propensity of acquirers to buy targets with patents. Three stand out: complementary assets, patent portfolio diversity and the threat of patent litigation.

Complementary assets

Technology development is an inherently uncertain and risky process. Even when investment in R&D is high, there is no guarantee of a high-quality patenting output (Hall *et al.*, 2005; Miller *et al.*, 2004). In essence, the firm-level patent productivity function includes an important stochastic component (Lanjouw *et al.*, 2004a).

Low patent productivity indicates failure to generate patents of increased value and technological importance. In this case, firms find it difficult to recoup their investment in R&D. However, the productivity or 'rent generating capacity' of other resources is also limited, especially in industries where patents are important means of competition. Specifically, firms develop complementary assets that enable them to commercialize their inventions (Teece, 1986). Examples include manufacturing or marketing capabilities. These work in concert with patents by enabling inventors to capture additional value from a market characterized by a lack of close substitutes (Arora *et al.*, 2006; Teece, 1986).

Yet, in the absence of high quality or marketable patents, complementary assets will be underutilized. These resources are the result of path dependent processes of co-specialization within the firm boundaries so there are no liquid markets for these to trade (Arora *et al.*, 2006; Teece, 1992). Hence, when acquirers face a diminishing patenting return on their R&D investment, they will address this deficit by focusing on targets with patented technologies. This will allow acquirers to increase their stock of patentable technologies and, as a result, the productivity of existing complementary assets. Rothaermel (2001) reached similar conclusions, albeit in the context of strategic alliances, by demonstrating that incumbent firms with complementary resources achieved superior performance by pursuing strategic alliances with new entrants owing superior technologies. I therefore hypothesize that:

> *Hypothesis 2: Acquirers are more likely to buy targets with patents when the quality of their patenting output – or patent productivity – is low.*

Patent portfolio diversity

As explained in previous sections, patent value is, to a certain extent, dependent on other related patents and their value changes as technology landscapes evolve (Bessen, 2008, 2009; Parchomovsky *et al.*, 2005). For example, a patent today could be seen as relatively peripheral to the development of a certain production process. However, this could change in the future if an important subsequent invention builds (at least partly) on this patent. In this case, the value of the patent will increase and will enable the assignee firm to reap additional benefits. Alternatively, a patent could become part of a thicket or pool with other company patents in the future, again resulting in increased negotiating power and ability to extract licensing fees on the part of the assignee firm.

The propensity of acquirers to buy targets with patents then will increase with the probability, or scope of opportunity, of the acquired patents to generate additional value for the acquiring firm. However, a patent's scope of opportunity is not independent of the acquirer's characteristics. The technological diversity of the acquirer's patent portfolio is likely to increase its value and, consequently, the probability of acquiring a target with patents.

The underlying mechanism here is an increase in the patent's scope of opportunity. More diverse patent portfolios increase the scope for generating synergies (broadly defined) in the future with any given patent because they allow for interdependencies to develop with a wider range of technologies. In contrast, highly concentrated patent portfolios are less likely to exhibit such synergy potential as there are less technology areas to allow for them to develop. In essence, an acquiring firm with a diverse patent portfolio is more likely to value patents highly as it accounts for future interdependencies between patented technologies. Hence, the net present value of a given patent (accounting for the potential of future synergies with existing patents in the acquirer's portfolio) will be higher for assignees with diverse patent portfolios.

Of course, this relationship is mediated by the characteristics of the underlying technology. As explained before, the synergy potential described here is primarily a characteristic of industries using complex technologies. Patents develop interdependencies in these settings resulting from the cumulativeness of innovation. In discrete technology industries, such synergies are unlikely to be expected and included in pricing. Hence, I expect the reasoning described above to play a role only in industries using complex technologies.

This logic is evident in the aggressive patenting strategies of firms in complex technology industries, often labeled as patent races (Hall *et al.*, 2001b; Lerner, 1997). Hall *et al.* (2001b:104) demonstrate that the patenting behavior of semiconductor firms is not driven by a desire to win strong legal rights to a standalone technological prize but primarily aims at reducing concerns about being held up by external patent owners and at negotiating access to external technologies on more favorable terms. Ziedonis (2004) similarly points to the forward-looking, strategic motives for patenting by demonstrating that aggressive patenting is increased when *ex ante* contracting costs are expected to be high. Hence:

> *Hypothesis 3: Acquirers are less likely to buy targets with patents when their patent portfolio is concentrated across few technology areas. However, this relationship holds only in industries using complex technologies.*

<u>*Patent litigation threat*</u>

In theory, the patent system grants exclusion rights to patent holders over clearly defined parts of the technology space. In practice, however, patent protection has imperfections and infringement, be that deliberate or not, is not uncommon (Bessen *et al.*, 2006; Choi, 1998). For example, Bessen *et al.* (2005b) calculate a litigation hazard of 1.18% of lawsuits per patent and Lanjouw *et al.* (2004b) report a rate of

1.04% lawsuits per patent (both figures based on public firms). Overall, the number of litigation suits has increased substantially after the mid-1980s while the threat of litigation is higher for small firms (Bessen *et al.*, 2005b; Gallini, 2002).

Of course, the observed cases of patent litigation are uncharacteristic of the entire population of patent disputes. This is formally expressed in litigation models where patent disputes are endogenized by allowing for costly monitoring and imitative behavior (Bessen *et al.*, 2006; Crampes *et al.*, 2002). In a series of papers, Bessen and Meurer develop a model that identifies four possible outcomes – acquiesce, settlement, litigation and deterrence – based on the probability of winning an infringement suit (Bessen *et al.*, 2005b; Bessen *et al.*, 2006; Meurer, 1989). Litigation occurs when deterrence is not strong enough or when the costs of settlement exceed those of litigation. Patent suits then represents a failure of both parties to reach agreement.

Nevertheless, patent litigation is costly and entails significant uncertainty. The American Intellectual Property Law Association estimated in 2007 that the average cost of a patent dispute, including the cost of discovery, is between \$3 and \$5 million. These costs are substantial and put limits on the patenting behavior of firms. For example, Lerner (1995) found that firms with high litigation costs avoid technology areas where rivals hold patents. Indirect litigation costs, resulting from business disruption or preliminary injunctions, can be even higher. Using an event study, Bessen *et al.* (2007b:4) found that firms lose about half a percentage point of their stock market value upon being sued for patent infringement, corresponding to a mean cost of \$28.7 million (\$1992). Plaintiffs also report significantly negative returns in some specifications (Bessen *et al.*, 2007b). In the presence of multiple infringing technologies, a patent suit risks the disruption of a cooperative equilibrium leading to a series of lengthy and costly suits (Bessen *et al.*, 2005a; Gallini, 2002). Similar conclusions can be reached from theoretical models of litigation: the expected payoffs of either the plaintiff or the defendant are suboptimal in the litigation region. The plaintiff increases her profits by moving to the deterrence (i.e. deterring the competitor from infringing) region while the defendant increases her profits by moving to the settlement (i.e. agreeing on a licensing agreement) region (Bessen *et al.*, 2006; Meurer, 1989).

Given this background it follows that when the threat of litigation is high, firms will try to move away from the litigation region. This can be achieved by increasing the size of their patent portfolio. Firms with large patent portfolios access competitors' technologies more easily and better negotiate cross-licensing agreements (Grindley *et al.*, 1997; Hall *et al.*, 2001b). In addition, a large patent portfolio deters competitors from suing as the alleged infringer is more likely to retaliate with a countersuit (Bessen *et al.*, 2005a, 2005b). The strategy of amassing patents in order to avoid being threatened by litigation is commonly referred to as 'defensive patenting' and has been shown to reduce firm litigation risk in a number of industries (Gallini, 2002; Lanjouw *et al.*, 2001b). Since a larger patent portfolio reduces litigation risk, I expect that acquiring firms are more likely to buy target with patents when the threat of litigation they face is high. Specifically:

Hypothesis 4: Acquirers are more likely to buy targets with patents when the threat of patent litigation for the acquirer is high.

4.3 DATA AND METHODOLOGY

4.3.1 Data

The sample of acquisitions I use to test my hypothesis comes from Securities Data Company's (SDC) M&A database. I select deals with announcement dates between 1990 and 2002 and where both the target and acquirer are US firms. In addition, the following conditions must be satisfied:

1. The acquirer is a public company and has data in CRSP, Compustat and the NBER patent database (at least one patent granted 10 years prior to the deal).
2. The acquirer bought more than 50% of target's shares and the target is either a public or private firm (but not a subsidiary). This is to ensure that the ownership of patent rights was transferred along with other corporate resources.
3. The deal was completed and the deal value is equal to or greater than $1 million.
4. The acquirer's primary SIC code is either in electronics (SIC 36: Electronic and other electrical equipment and components, except computer) or chemicals and drugs (SIC 28: Chemicals and allied products). These two industries are the textbook examples of complex and discrete technology

industries so I focused on these ‘clear-cut’ cases (Arora *et al.*, 2003a; Cohen *et al.*, 2000).

The final sample consists of 420 unique acquirers making 1,052 successful deals. I then matched my list of acquisitions with stock market data from CSRP, financial data from Compustat and patent data from NBER’s database (Hall *et al.*, 2001a).

Following a number of studies (Bessen *et al.*, 2005b; Lanjouw *et al.*, 2001b), I used Derwent’s Litalert database as the primary source of patent litigation data. It is important to note that Litalert has been found to suffer from underreporting (Lanjouw *et al.*, 2001b, 2004b). However, this is not a major concern for this study as underreporting is more pronounced prior to the mid-1980s (Hall *et al.*, 2007). In addition, underreporting does not introduce selection bias to the data (Bessen *et al.*, 2005b; Lanjouw *et al.*, 2004b).

4.3.2 Dependent Variables

Acquirer’s returns

Acquirer’s returns were calculated using standard event study methodology (Brown *et al.*, 1985; Khotari *et al.*, 2007). I calculated cumulative abnormal returns (CAR) over a five-day window surrounding the announcement date [-2,2] using the CRSP value-weighted index as market benchmark. Expected returns were calculated based on firm-specific parameters obtained over a 259-trading day estimation window [-270,-11].

Short-horizon event studies are preferred for measuring acquisition performance given that they minimize the impact of other confounding events and are more robust to different model specifications (MacKinlay, 1997; McWilliams *et al.*, 1997). In addition, several studies have demonstrated that CAR are strongly correlated with other long-term acquisition performance measures (Healy *et al.*, 1992; Kaplan *et al.*, 1992).

Target with patents

For the selection model (Hypotheses 2-4) I use a binary variable equal to one when the target firm had at least one patent granted 10 years prior to the announcement date, zero otherwise.

4.3.3 Independent Variables

Common citation rate

I use common citation rate to test Hypothesis 1a and 1b. This is calculated as in Mowery *et al.* (1998:513), i.e. the ratio of citations in acquirer's patents to patents cited in target's patents divided by the number of total citations in acquirer's patents (and then added to that the equivalent ratio for the target firm). The ratio is calculated for patents granted up to 10 years prior to the announcement date. The only difference in my calculation is that I weigh this ratio with citations received by patents with common cites as follows:

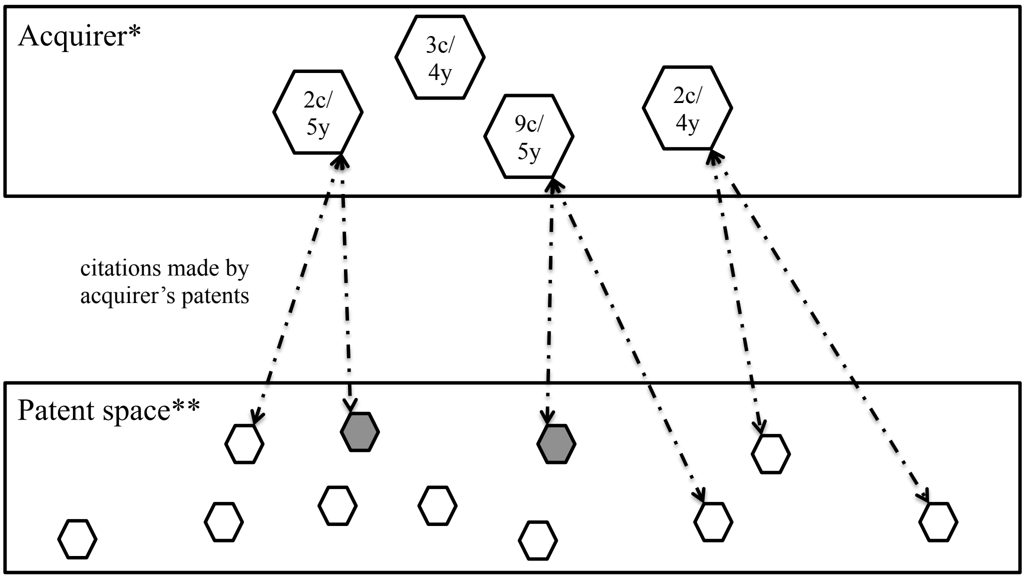
$$common\ cit.rate = \frac{\sum_{pa=1}^{N} citr_{pa}(1-\delta)^{y-T}\ /citm_{pa}}{\sum_{pa=1}^{N} citr_{pa}(1-\delta)^{y-T}} + \frac{\sum_{pt=1}^{N} citr_{pt}(1-\delta)^{y-T}\ /citm_{pt}}{\sum_{pt=1}^{N} citr_{pt}(1-\delta)^{y-T}}$$

where $citr_{pa}$ is the number of citations received by patent p in acquirer a's portfolio, $citr_{pt}$ is the number of citations received by patent p in target t's portfolio, $citm_{pa}$ is the number of citations made (to other patents) by patent p in acquirer a's portfolio, $citm_{pt}$ is the number of citations made (to other patents) by patent p in target t's portfolio, y is the year the acquisition took place, T is the year patent p was granted and δ is a depreciation rate set equal to 15% following convention in much of the literature (Hall *et al.*, 2005; Pakes, 1985). I only include patents that cite patents also cited by the target (acquirer) in the numerator of the acquirer's (target's) ratio. Measures of citations received are corrected for truncation as in Hall *et al.* (2001a).

Mowery *et al.* (1998:513) explain that common citation rate measures the degree to which two firms draw from the same external technology pool. This is an appropriate measure in the context of my study as I am interested in changes in the bargaining power of the merged entity *vis-à-vis* other competitors. Common citation rate essentially captures the 'exposure' of other competitors to the patent portfolio of the merged entity. The higher the ratio, the more competitors have to rely on the merged entity's technologies. This results in increased bargaining power on behalf of the merged firm. However, by using discounted citation-weighted patent counts as opposed to simple patent counts, I am able to account for the relative importance of the common citation pool for the merged entity (Hall *et al.*, 2005; Trajtenberg, 1990).

Figure 1 provides a simple example of calculating the common citation rate for the acquiring firm. In this case, the citation-weighted common citation rate is 0.32%

while the unweighted common citation rate is 0.22%. The citation-weighted rate is higher because it accounts for the fact that the acquirer's most important patent, as demonstrated by the high number of citations received, cites a patent also cited by the target's patents. In addition, this rate is slightly lower compared to the one not accounting for patent age (0.34%), because the patents with common cites are older than the average age of other patents in the portfolio. Clearly, the citation-weighted measure captures additional information related to the technological relationship between the target and acquirer and is thus preferable.



$$common\ cit.rate(Acq) = \frac{(2\times0.85^5/2) + (9\times0.85^5/2)}{(2\times0.85^5) + (3\times0.85^4) + (9\times0.85^5) + (2\times0.85^4)}$$

* Hexagons symbolize acquirer's patents as well as the number of citations received by each patent and the number of years granted prior to the acquisition

** Hexagons symbolize different patents in the patent space while shaded hexagons are patents also cited by patents held by the target firm

Figure 4.2 Example calculation of common citation rate for the acquiring firm

Patent productivity

Patent productivity of the acquiring firm is measured as the natural logarithm of citation-weighted count of patents granted per R&D expenses during a 10-year period prior to the acquisition:

$$patent\ productivity_a = \sum_{pa=1}^{N} citr_{pa} \Big/ \sum_{t=-10}^{0} R\&D_{at}$$

where $citr_{pa}$ is the number of citations received by patent p in acquirer a's portfolio and $R\&D_a$ is annual R&D expenses incurred by the acquiring firm *a* in year *t* prior to the acquisition. Again, the rationale for not using simple patent counts is to account for the quality and importance of patenting output.

Patent technological concentration

To measure the acquirer's patent technological concentration I use a simple Herfindahl index of the distribution of the acquirer's patents across US patent classes:

$$patent\ technological\ concentration = p_a \sum_{j=1}^{J} \left(\frac{p_{aj}}{p_a}\right)^2 - 1 \Big/ p_a - 1$$

where p_a is the number of patents in the acquiring firm's portfolio and p_{aj} is the number of patents in US patent class *j*. This formula is a variation of the standard Herfindahl index used in the literature but adjusted, as suggested by Hall (2002), for producing non-biased estimates when the number of observations is small. See also Ziedonis (2004) and Garcia-Vega (2006) for examples of other studies using this non-biased estimator.

Patent litigation threat

Litigation threat is measured as the number of firms that were either plaintiff or defendant in a case involving patents held by the acquirer and initiated during a 10-year period prior to the deal. This measure is well-placed to reflect litigation threat as the lag between filing a patent suit and reaching a resolution can be considerable, in excess of 5 years in several cases (Hall *et al.*, 2003; Kesan *et al.*, 2006). During this time, the two parties are involved in ongoing negotiations, adjusting their positions according to changes in their patent portfolio. In addition, past litigation is indicative of a firm's inability to negotiate a settlement or deter a competitor from suing. Hence, past litigation cases capture some unobservable characteristics that increase the litigation hazard faced by the firm.

Although Litalert provides detailed data on litigation, I chose not to count individual cases. This is because litigants usually target each other's patents in a number of lawsuits while trying to maximize their negotiating power (Bessen *et al.*, 2005a, 2007b). Hence, counts of discrete litigants more accurately reflect litigation threat.

4.3.4 Control Variables

Acquirer's returns

There is a considerable literature, primarily in finance, relating acquirer's returns with other acquirer, target and deal characteristics. I therefore include a number of control variables in my analysis.

Acquirer characteristics. Financial leverage, calculated here as total liabilities divided by market capitalization, has been shown to have a positive effect on abnormal returns (Maloney *et al.*, 1993). Cash available, here as the percentage of cash out of total assets, proxies agency costs and is found to be negatively correlated with acquirers' returns (Harford, 1999). Tobin's Q, here as market capitalization divided by book value of assets, has been shown to be both positively and negatively correlated with abnormal returns (Moeller *et al.*, 2004; Servaes, 1991). I also include a measure of acquisition experience, i.e. a count of acquisitions undertaken by the acquirer in a 5-year period prior to the announcement date. This controls for acquirer's learning in managing the acquisition process and for information revealed about the acquirer's acquisition program and internal growth opportunities (Fuller *et al.*, 2002; Hayward, 2002; Laamanen *et al.*, 2008). Finally, I include information on operating cash flow divided by assets (Moeller *et al.*, 2004; Moeller *et al.*, 2005), R&D intensity, firm size (natural logarithm of sales), industry (a dummy variable equal to one if the acquirer's primary SIC code is in electronics, zero otherwise) and patent portfolio (discounted citation-weighted count of patents[32] and technological concentration of patents across US patent classes for patents granted up to 10 years prior to the announcement date).

Deal characteristics. There is robust evidence that the method of payment affects abnormal returns in corporate takeovers. For example, Fuller *et al.* (2002) and Chang (1998) have shown that equity-financed deals yield lower abnormal returns for the

[32] This is calculated as the denominator of the first fraction in the formula for common citation rate.

acquirer. Here, I include two dummy variables equal to one for deals financed solely either with cash or equity. In addition, I calculate a measure of operational proximity based on SIC codes. This measure is equal to 4 when the target and acquirer are in the same 4-digit SIC code, equal to 3 when target and acquirer are in the same 3-digit SIC code etc. Although some studies use this continuous measure of distance across SIC codes, such an approach has been criticized for assuming that industries equally distant within the SIC hierarchy are equally dissimilar (Lien *et al.*, 2009). Hence, I include instead a set of four dummy variables representing each case. I also include a measure of relative size, here as deal value divided by the acquirer's market capitalization. This has been shown to affect abnormal returns, although the direction of the relationship is not clear (Asquith *et al.*, 1983; Fuller *et al.*, 2002; Moeller *et al.*, 2004). Finally, a variable equal to one if the acquisition was a tender offer is included (Jarrell *et al.*, 1989).

Target characteristics. I include a dummy variable equal to one if the target firm is public. Several studies have shown a negative correlation between target public status and acquirer's returns. However, the proposition that markets for private firms are less competitive has not received support (Chang, 1998). To better control for the level of competition in takeover markets I calculate a liquidity index for the target, adapted from Schlingemann *et al.* (2002), as the number of deals that took place in a particular year and three-digit SIC code. Finally, I calculate measures of patent portfolio quality and concentration (same as acquirer characteristics).

Selection of target with patents

For testing hypotheses 2-4 I include the following control variables: cash available, R&D intensity, firm size, acquirer experience and industry, all defined as above. In addition, I include a measure of profitability, EBITDA divided by sales, and a count of the number of patents acquired through acquisitions by the acquiring firm during the past 5 years prior to the announcement date.

Tables 1 and 2 present descriptive statistics and correlations of the variables included in the selection and outcome equation respectively.

Table 4.1 Summary statistics and pairwise correlations of variables used in selection equation (N=1052).

Variable	Mean	St.Dv.	1	2	3	4	5	6	7	8	9	10	11
Deal with patents	0.38	0.49	1										
Litigation threat	0.75	2.34	0.40*	1									
Patent productivity	3.50	1.53	0.03	0.09*	1								
Tech. concentration	0.26	0.29	-0.10*	-0.17*	-0.32*	1							
Cash available	0.66	0.47	-0.05	-0.12*	0.08*	0.06	1						
Acq. R&D intensity	0.22	0.20	-0.06	-0.11*	-0.15*	0.19*	0.08*	1					
Acq. sales (log)	0.15	0.19	-0.01	-0.06	-0.27*	0.07*	0.06*	0.40*	1				
Electronics	6.14	2.31	0.17*	0.41*	0.03	-0.39*	-0.05	-0.38*	-0.28*	1			
Profitability	0.07	0.32	0.11*	0.16*	0.05	-0.18*	0.13*	-0.34*	-0.44*	0.60*	1		
Acq. experience	2.43	3.78	0.05	0.37*	0.06	-0.20*	0.05	-0.15*	0.05	0.38*	0.15*	1	
Acq. patents past deals	0.31	0.50	0.10*	0.40*	0.09*	-0.16*	-0.12*	-0.06*	-0.03	0.38*	0.13*	0.32*	1

* $p \leq 0.05$

Table 4.2 Summary statistics and pairwise correlations of variables used in outcome equation (N=304).

Variable	Mean	St.Dv.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
CAR (%)	0.00	0.10	1																					
Com. cit. rate	0.02	0.12	0	1																				
Electronics	0.64	0.48	0.02	-0.01	1																			
Cash available	0.22	0.19	-0.13*	-0.06	0.1	1																		
Acq. R&D intensity	0.17	0.17	-0.06	0	0.07	0.41*	1																	
Litigation threat	1.82	3.19	-0.04	0.15*	-0.20*	-0.20*	-0.13*	1																
Acq. pat. prod.	6.72	2.56	0.03	0.05	0.09	-0.15*	-0.26*	0.17*	1															
Acq. tech. conce.	0.23	0.25	0.00	0	-0.08	0.23*	0.08	-0.36*	-0.28*	1														
Leverage	0.33	0.48	0.02	0.02	-0.01	-0.39*	-0.29*	-0.08	0.11	-0.11*	1													
Acq. sales (log)	6.55	2.25	-0.05	0.04	-0.1	-0.35*	-0.30*	0.63*	0.05	-0.54*	0.09	1												
Op. cash flow/assets	0.07	0.15	-0.03	0.03	0.06	-0.09	-0.37*	0.27*	0.01	-0.18*	-0.06	0.56*	1											
Acq. experience	2.45	3.66	-0.05	0.19*	0.02	-0.12*	0	0.56*	0.07	-0.29*	-0.07	0.41*	0.17*	1										
Tobin Q	2.73	2.80	-0.11	-0.02	-0.09	0.26*	0.17*	0.08	0.00	0.1	-0.38*	-0.02	0.12*	0.11	1									
Tar. citw. port.	4.49	1.81	-0.17*	0.14*	-0.1	0.07	0.15*	0.33*	0.03	-0.25*	-0.11	0.33*	0.17*	0.17*	0.06	1								
Tar. tech. conce.	0.57	0.31	0.1	-0.08	0	0	-0.05	-0.15*	-0.05	0.24*	-0.11	-0.15*	0.03	-0.06	0.11	-0.53*	1							
Public	0.51	0.50	-0.21*	0.11	-0.30*	-0.05	-0.03	0.26*	-0.12*	-0.1	0.04	0.30*	0.07	0.11*	-0.05	0.32*	-0.24*	1						
Cash only	0.29	0.45	0.08	-0.05	-0.08	-0.17*	-0.20*	0.12*	0.07	-0.15*	0.21*	0.18*	0.15*	0.03	-0.1	-0.14*	0.03	0.02	1					
Equity only	0.41	0.49	-0.13*	0	0.02	0.19*	0.16*	0.01	-0.13*	0.08	-0.20*	-0.1	-0.13*	0.02	0.18*	0.12*	-0.02	0.12*	-0.53*	1				
Tender	0.14	0.35	0	0.1	-0.25*	-0.18*	-0.11	0.23*	0.00	-0.14*	0.12*	0.29*	0.18*	0.07	-0.08	0.07	-0.07	0.39*	0.42*	-0.30*	1			
Relative size	0.17	0.22	-0.13*	0.20*	-0.12*	-0.1	-0.01	-0.16*	-0.03	0.17*	0.40*	-0.25*	-0.21*	-0.11	-0.23*	0.06	-0.17*	0.23*	-0.12*	0.04	0.01	1		
Liquidity index (log)	4.11	1.23	-0.01	0.02	0.16*	0.26*	0.24*	0.12*	0.14*	-0.01	-0.32*	0.11*	0.20*	0.17*	0.24*	0.12*	0.04	-0.01	-0.05	0.18*	-0.01	-0.20*	-0.04	1

* $p \leq 0.05$

4.4 ANALYSIS AND RESULTS

Table 3 presents the results from the event study. Acquirers' returns are overall positive and significant while the median is negative. Yet, returns loose significance when we allow for event-induced variance (Boehmer *et al.*, 1991). Consistent with the literature, I find acquirers' returns are positive for private targets but negative for public targets. In fact, the higher percentage of public targets in chemicals explains the relatively lower abnormal returns as compared to those in electronics. Interestingly, mean dollar returns are negative, indicating that larger acquirers perform worse than smaller ones (Moeller *et al.*, 2004).

Table 4.3. Abnormal returns are estimated using the market model with CRSP value weighted index as market benchmark. Dollar returns (in millions) are calculated by multiplying the cumulative abnormal returns by the acquirer's market capitalization 11 trading days prior to the announcement date. *t*-statistic calculated as in Brown *et al.* (1985).

	Observations	Average (median) $CAR_{[-2,2]}$	Average (median) dollar returns	*t*-statistic (one-tailed)
Panel A: Acquisitions in Electronics				
Public targets	107	-1.75% (-1.94%)	-572.29 (-5.70)	-3.03**
Private targets	585	0.81% (0.24%)	-79.56 (0.30)	3.12**
Total	692	0.41% (-0.06%)	-155.75 (-0.06)	1.75*
Panel B: Acquisitions in Chemicals				
Public targets	105	-1.80% (-1.01%)	-514.69 (-19.04)	-4.08**
Private targets	255	1.14% (0.22%)	-50.52 (0.41)	3.43**
Total	360	0.28% (-0.11%)	-185.91 (-0.65)	1.06
Panel C: All acquisitions				
Public targets	212	-1.78% (-1.14%)	-543.76 (-12.55)	-4.87**
Private targets	840	0.91% (0.23%)	-70.74 (0.35)	4.40**
Total	1052	0.37% (-0.10%)	-166.07 (-0.21)	2.05*

$^{+}$ $p \leq 0.10$ * $p \leq 0.05$ ** $p \leq 0.01$

For presentational convenience, I begin by exploring the second set of hypotheses discussing acquirers' propensity to buy targets with patents – see Table 4. I find support for Hypotheses 2 and 4. In particular, the marginal effects (at variables' mean) are positive and significant (5%) for litigation threat and negative and significant (10%) for patent productivity in all models. Hence, as suggested by Hypothesis 2, acquiring firms with strong internally-generated patenting output are less inclined to buy targets with patents. In addition, litigation threat has a strong positive effect on the probability of acquiring a target with patents (Hypothesis 4). Marginal effects are quite sizeable, with a single-unit increase in the number of litigants resulting in almost 50% higher probability of acquiring a target with patents.

Table 4.4 Probit estimates using a binary variable (=1 if target firm has patents, 0 otherwise) as dependent variable. Estimates of year dummies are suppressed and *p*-values are reported in parentheses. Marginal effects are calculated with the other variables at their mean value. Robust standard errors clustered by acquirer are used in all models.

	Model 1		Model 2		Model 3	
	Coefficients	Marginal effects	Coefficients	Marginal effects	Coefficients	Marginal effects
Litigation threat	1.267** (0.000)	0.482** (0.000)	1.310** (0.000)	0.502** (0.000)	1.302** (0.000)	0.500** (0.000)
Patent productivity	-0.070* (0.034)	-0.027* (0.032)	-0.061^{+} (0.081)	-0.023^{+} (0.078)	-0.066^{+} (0.057)	-0.025^{+} (0.055)
Tech. concentration	-0.155 (0.398)	-0.058 (0.400)	-0.258 (0.167)	-0.099 (0.167)	0.265 (0.450)	0.102 (0.451)
Electronics	-0.040 (0.705)	-0.015 (0.704)	-0.080 (0.455)	-0.030 (0.453)	0.121 (0.438)	0.046 (0.439)
Electronics x Tech. concentration					-0.709^{+} (0.069)	-0.273^{+} (0.069)
Cash available			-0.137 (0.596)	-0.052 (0.594)	-0.186 (0.476)	-0.071 (0.474)
R&D intensity			0.300 (0.316)	0.115 (0.312)	0.283 (0.353)	0.109 (0.350)
Sales (log)			-0.041 (0.245)	-0.015 (0.238)	-0.036 (0.296)	-0.014 (0.290)
Profitability			0.309 (0.113)	0.119 (0.110)	0.304 (0.119)	0.117 (0.116)
Acq. experience			-0.027 (0.222)	-0.010 (0.223)	-0.029 (0.213)	-0.011 (0.214)
Past deals patents			-0.004** (0.007)	-0.001** (0.003)	-0.004** (0.009)	-0.001** (0.004)
Constant	-0.202 (0.321)		0.164 (0.623)		-0.021 (0.950)	
Year dummies	Yes		Yes		Yes	
Chi^2	35.77**		35.74**		40.05**	
Log likelihood	-529.9		-523.8		-521.6	
N	1052		1052		1052	

$^{+}$ $p \leq 0.10$ * $p \leq 0.05$ ** $p \leq 0.01$

Of course, the significance of marginal effects, albeit informative, is not a definitive test of the hypothesized relationship given that they vary with the value of all model variables. In fact, marginal effects at variables' mean do not necessarily capture the 'average' effect of each variable, especially when mean observations vary across variables (Hoetker, 2007; Train, 1986). I thus followed Hoetker (2007) and Wiersema *et al.* (2009) and calculated the value and statistical significance of the marginal effects at each observation – see Figure 2[33]. For patent productivity, panel (a), z-statistic values range from -0.11 to -2.0 and the majority of them lie close to the -1.96 threshold. Similarly, z-statistic values for the marginal effects of litigation threat, panel (b), range from 0.17 to 7.7 and most of them lie above the 1.96 threshold[34]. This supplementary analysis further supports the robustness of the hypothesized relationships.

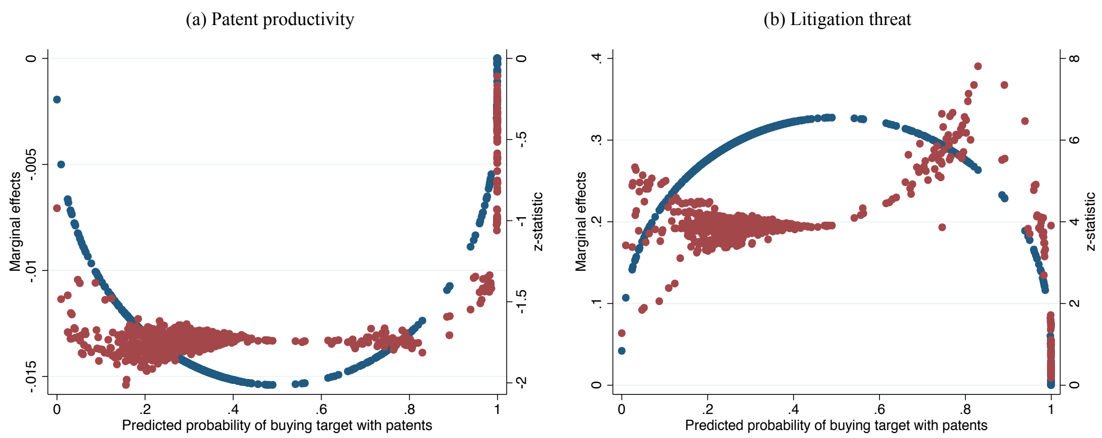


Figure 4.3 Marginal effects of litigation threat and patent productivity on the probability of buying target with patents

[33] The solid symbols indicate values of the marginal effect (recorded on the left axis) while the diamond shaped symbols indicate z-statistic values (recorded on the right axis) following Wiersema *et al.* (2009:684).

[34] As Wiersema *et al.* (2009:684) explain, the lack of significance at extreme probability values is to be expected. It reflects that the slope of the probit cumulative distribution function approaches zero at extreme ends of the distribution.

For Hypothesis 3, I am interested in evaluating the coefficient of the interaction term between technological concentration and complex industry (=*1* if in electronics). However, it is important to avoid modeling interactions in probit models as typically done in an OLS framework (Hoetker, 2007; Wiersema *et al.*, 2009). Although I include an interaction term in model 3, this is not necessarily informative neither of the sign, nor of the significance of the hypothesized effect. Instead, a number of approaches have been put forward to test interaction effects in nonlinear models.

First, I split the sample in two along industry membership (Hoetker, 2007:338). I find that the marginal effects of technological concentration are negative and significant in electronics (p=0.032) but not in chemicals (p=0.306). I also performed Allison's (1999) test[35] and was able to reject the null hypothesis that the coefficient of technological concentration is the same across the two industries (p=0.037). Second, I calculated the 'true' marginal effects of the interaction term for each observation (Wiersema *et al.*, 2009:686, eq.5) along with their z-statistic. As can be seen from Figure 3, panel (a), z-statistic values range from -0.16 to -2.46 and the majority of them are close to or below the -1.96 threshold.

Third, I followed Zelner (2009) and calculated the difference in predicted probabilities of buying a target with patents associated with a complex (versus discrete) technology industry. Panel (b) in Figure 3 maps the difference in predicted probabilities along with the 95 percent confidence intervals surrounding the predicted

[35] This was performed with Stata's 'complogit' command. This test essentially allows us to compare probit coefficients while adjusting for unequal residual variance.

probabilities. These were produced using King *et al.*'s (2000) simulation-based approach[36]. The figure indicates that as technological concentration increases, the likelihood of buying target with patents decreases in complex technology industries. However, this effect is statistically significant for values of technology concentration higher than (approximately) 0.5, as only in this region the bars do not cross zero. Taken together, these results provide support for Hypothesis 3, suggesting that acquirers are less likely to buy a target with patents in complex technology industries when their patent portfolio is concentrated across few technology areas.

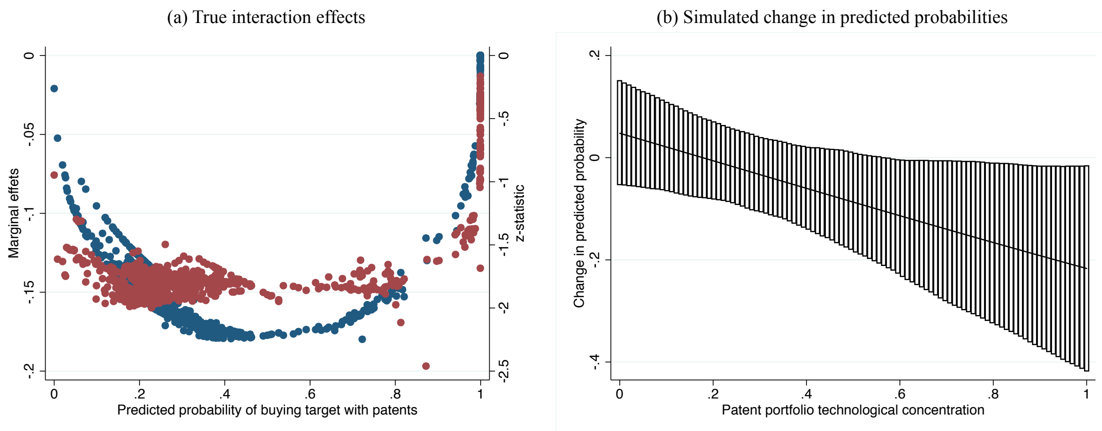


Figure 4.4 Interaction effect of complex technology on the relationship between technological concentration and probability of buying target with patents

I now turn to the analysis of acquisition performance. Table 5 presents the results of regression analysis. Model 1 doesn't account for the differential impact of common citation rate across the two industries. As a result, common citation rate doesn't seem to affect acquisition performance. However, when I account for differences in

[36] The graph was created using Stata's 'intgph' command – see Zelner (2009).

technology characteristics I find strong support for my predictions. In particular, common citation rate is positive and significant in industries using complex technologies (Model 2) but negative and not significant in industries using discrete technologies (Model 3). The full model includes all observations and interacts common citation rate with a dummy variable equal to one when the acquirer's primary SIC code is in electronics. Again, I find that common citation rate increases CAR but only in electronics.

Other variables are also significant. As expected, acquirer's returns are reduced when the target firm is public. In addition, Tobin's Q is negatively correlated with abnormal returns. This result is consistent with the overvaluation hypothesis, i.e. high Q firms provide a negative signal about their true value to the market when announcing an acquisition (Dong *et al.*, 2006). The effect of relative size is also negative and significant. I explained before that there is no consensus in the literature about the direction of the effect. However, it is reasonable to expect a negative sign in high-tech industries. This is because a number of studies have demonstrated that integrating large knowledge bases entails significant organizational disruption and is likely to negatively affect future inventive performance (Ahuja *et al.*, 2001; Cloodt *et al.*, 2006).

Table 4.5 Regression analysis using cumulative abnormal returns $CAR_{[-2,2]}$ as dependent variable. Estimates of year dummies are suppressed and *p*-values are reported in parentheses. Robust standard errors clustered by acquirer are used in all models.

	(1) No interaction	(2) Electronics	(3) Chemicals	(4) Full model
Common citation rate	0.0295 (0.425)	0.0538+ (0.055)	-0.0888 (0.192)	-0.0555 (0.200)
Common citation rate x Electronics				0.112* (0.019)
Acquirer Characteristics				
Electronics	-0.00778 (0.568)			-0.0109 (0.433)
Cash av.	-0.0527 (0.313)	-0.126 (0.114)	0.0185 (0.796)	-0.0512 (0.329)
R&D int.	0.0124 (0.712)	0.0490 (0.259)	0.000716 (0.990)	0.0128 (0.701)
Litigation threat	0.000582 (0.766)	0.000999 (0.827)	0.00183 (0.496)	0.000780 (0.693)
Citation-weighted portfolio (log)	-0.00295 (0.463)	0.000817 (0.903)	-0.00791 (0.238)	-0.00324 (0.422)
Tech. concentration	-0.000943 (0.978)	-0.0346 (0.487)	0.0258 (0.597)	-0.00253 (0.940)
Leverage	-0.00751 (0.488)	-0.0183 (0.243)	0.0451 (0.131)	-0.00816 (0.451)
Sales (log)	0.000114 (0.982)	-0.00363 (0.661)	0.00252 (0.769)	0.000275 (0.958)
Op. cash flows/Assets	-0.0231 (0.564)	-0.0237 (0.745)	0.00619 (0.921)	-0.0227 (0.573)
No past acquisitions	-0.000666 (0.658)	-0.00343 (0.294)	0.00259+ (0.085)	-0.000101 (0.950)
Tobin's Q	-0.00447* (0.037)	-0.00425 (0.283)	-0.00236 (0.546)	-0.00459* (0.033)
Target characteristics				
Citation-weighted portfolio (log)	-0.00310 (0.472)	-0.00115 (0.858)	-0.00294 (0.595)	-0.00304 (0.482)
Tech concentration	-0.00254 (0.893)	0.0269 (0.391)	-0.0556+ (0.062)	-0.00281 (0.882)
Public	-0.0351* (0.031)	-0.0141 (0.579)	-0.0616* (0.017)	-0.0359* (0.028)
Liquidity index	0.000697 (0.911)	-0.000138 (0.986)	-0.00448 (0.757)	0.00113 (0.857)
Deal characteristics				
All cash	0.000895 (0.962)	0.00917 (0.725)	-0.0146 (0.557)	0.00139 (0.941)
All equity	-0.0152 (0.274)	-0.0234 (0.280)	0.0133 (0.641)	-0.0143 (0.302)
Tender	0.00246 (0.880)	-0.00696 (0.824)	0.0285 (0.149)	0.000557 (0.973)
Relative size	-0.0619* (0.037)	-0.0498 (0.256)	-0.0831 (0.143)	-0.0568+ (0.060)
Constant	0.117* (0.018)	0.0226 (0.727)	0.151+ (0.067)	0.116* (0.019)
SIC proximity dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
R^2	0.14	0.17	0.39	0.14
N	302	192	110	302

$^{+}$ $p \leq 0.10$ * $p \leq 0.05$ ** $p \leq .01$

Not surprisingly, I don't find any significant effects of SIC proximity on acquirers' returns. None of the dummies enters significantly in the equation. This measure captures broad operational synergies that are unlikely to be unique between the target and bidding firms.

4.4.1 Robustness Checks

Table 6 lists different models of acquirer's returns. In Model 1 I used unweighted common citation rate, as originally in Mowery *et al.* (1998), while in Model 2 I measure weighted common citation rate but only for patents granted up to 5 years prior to the announcement date. My results do not change. Results are also robust to different abnormal return specifications. In model 3, abnormal returns are calculated over a 7-day [-3,3] window while in model 4 S&P 500 is used as market benchmark.

It is possible of course that common citation rate captures other synergies between the acquirer and the target's innovative capabilities as opposed to inimitable synergies resulting from common citations. In this case, my model fails to accurately capture inimitable synergies as hypothesized. To account for this possibility I included in my model two measures of technological distance across patent space between the acquirer and target. Jaffe's (1986:6) measure, Model 5, uses the uncentered correlation of two vectors including the number of patents in each US patent class for the acquirer and target respectively. Another measure, proposed by Paruchuri *et al.* (2006:553), measures the Euclidian distance of target and acquirer's patents across US patent classes. Results remain essentially unchanged.

Table 4.6 Robustness checks. In Model 1, common citation rate is not weighted by citations received. In Model 2, patents granted up to 5 years prior to the announcement date are used for the calculation of common citation rate. In model 3 abnormal returns are calculated over a 7-day [-3,3] event window while in model 4 S&P index is used as market benchmark. Model 5 and 6 control for Jaffe's (1986) technological proximity and patent Euclidian distance (Paruchuri *et al.*, 2006) respectively. Model 7 is the IV regression for the subsample of electronics.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Common citation rate	-0.048 (0.229)	-0.054 (0.197)	-0.081 (0.125)	-0.054 (0.221)	-0.083+ (0.090)	-0.068 (0.128)	0.495+ (0.091)
Common citation rate x Electronics	0.111* (0.023)	0.097* (0.043)	0.113* (0.046)	0.114* (0.019)	0.129** (0.010)	0.108* (0.025)	
Jaffe's tech. proximity					0.027 (0.168)		
Euclidian distance						-0.062 (0.132)	
R^2	0.15	0.14	0.18	0.15	0.15	0.15	0.17
N	302	288	302	302	302	302	192

$^{+}$ $p \leq 0.10$ * $p \leq 0.05$ ** $p \leq .01$

Another possibility I explored is the endogeneity of patent portfolio overlap. In particular, patent portfolio overlap could be correlated with unobservable factors affecting acquirer's performance, thus rendering my estimates biased. Even in this case, the differential impact of patent portfolio overlap across discrete- and complex-technology industries supports my hypothesis unless the patterns of correlation between the unobserved variables and patent portfolio overlap differ across the two settings. In any case, I identified two suitable instruments: a) the geographical distance between the headquarters of the merged entities and b) the total supply of patents in the target's industry (defined by 4-digit SIC code). The geographical distance between the two firms is likely to be negatively correlated with patent portfolio overlap as Jaffe *et al.* (1993) have demonstrated that citations are more likely to come from the same state. Yet, geographical proximity should not affect acquisition performance. Similarly, the total supply of patents in the target's industry should be negatively correlated with patent portfolio overlap but have no effect on acquisition performance (similar instruments albeit in different settings have been used in Somaya *et al.* (2007) and Dushnitsky *et al.* (2005)).

The correlations between patent portfolio overlap and the instruments are negative as expected and the F-test of excluded instruments suggests that we can reject the null hypothesis of no explanatory power. The results of the IV estimation can be seen in Table 6, model 7 and provide further support to my predictions. The coefficient for patent portfolio overlap remains positive and significant for electronics as suggested by Hypothesis 1a.

Finally, I used alternative measures for Hypotheses 2, 3 and 4. Patent productivity was proxied using simple (as opposed to citation-weighted) patent counts. Patent portfolio technological concentration was calculated without accounting for small-sample bias (Hall, 2002). Litigation threat was proxied using the number of litigants 5 years prior to the acquisition announcement and also the number of litigation cases 5 and 10 years prior to the acquisition announcement. All results hold.

4.5 DISCUSSION

This chapter contributes to the M&A literature by exploring the conditions under which acquisitions generate value for the acquiring firm. This is a central question for strategy research as acquisitions are some of the most important decisions in corporate history and can inadvertently affect firm survival and profitability (Jensen, 1986; Moeller *et al.*, 2005). Interestingly, the popularity of corporate takeovers does not seem to decline even though it is a well-known fact that acquirers, on average, fail to capture any value. However, the variance of acquirers' returns is high, suggesting that some acquisitions do generate important benefits for the acquiring firm (Capron *et al.*, 2002; Moeller *et al.*, 2004).

I set out to empirically test Barney's (1988) inimitable synergy hypothesis. According to this, acquirers capture part of the synergistic value created when the resulting synergy cannot be replicated by other bidding firms. Barney's hypothesis is a corollary of his work on strategic factor markets and profit opportunities under conditions of (near-perfect) competition in resource markets (Barney, 1986; Makadok *et al.*, 2001). However, as with many other facets of resource-based theorizing, the empirical verification of this hypothesis has been problematic (Hoopes *et al.*, 2003; Priem *et al.*, 2001). Basically, it is challenging to *a priori* theorize about the likelihood of generating inimitable synergies.

In this chapter, I suggest that some of these limitations can be overcome by simultaneously focusing on value capture and value creation. That is, understanding and exploring inimitable synergies requires a greater focus on the micro-mechanisms of value creation and the strategies acquirers use to achieve these synergies. Using a sample of technology acquisitions, I find that that overlapping patent portfolios generate inimitable synergies in industries using complex technologies but have no effect in industries using discrete technologies. This claim is backed by an extensive and well-established literature on differences in patent value and use across industries and technologies (Cohen *et al.*, 2000; Levin *et al.*, 1987; Merges *et al.*, 1990). My results strongly support Barney's hypothesis and the notion that acquirers should primarily focus on identifying inimitable synergies with the target.

In addition, I explore the propensity of technology acquirers to buy targets with patents. Previous studies focused on the determinants of technology acquisitions, finding that technology acquirers have low R&D intensity and patent quality (Blonigen *et al.*, 2000; Hitt *et al.*, 1991; Zhao, 2009). However, we know less about the specific nature and selection of technology resources. Here, I find that acquirers with low patent productivity, low concentration of patents in complex technologies and high threat of litigation are more likely to buy targets with patents. These findings provide more clarity to the strategies of technology acquirers and emphasize their diverse motives.

4.5.1 Implications for Resource-Based Theories of Acquisitions

My results suggest that a theory of value creation, or synergy, is an important precondition for understanding value capture in acquisitions. Consequently, the resources of merged entities should be compared at a much finer level of analysis, as opposed to simply looking at common SIC codes. This requires an in-depth understanding of the nature and characteristics of resource interdependence. Although theories of similarity, relatedness or complementary differences make intuitive sense, their predictions are unlikely to be true for every kind of acquisition. In some cases, complementary differences contribute to acquisition performance while in others neither similarity nor complementarity seem to matter (Harrison *et al.*, 1991; Kim *et al.*, 2009).

The reason is that each type of resource has a unique 'production function' with different parameters coming into play. Hence, a general theory of acquisition performance based on simple resource comparisons is unlikely to emerge. As Silverman (1999) observes, more fine-grained measures of resources are required to improve the predictive power of the resource-based view of the firm. In the case of combining patent rights, I find that citation patterns and the nature of the underlying technology are important determinants of value capture. Had I not accounted for these specific characteristics, this would have been another study disproving the relatedness hypothesis but offering no explanation for the observed heterogeneity in acquisition performance.

An improved understanding of resource interdependence also provides more clarity to the target selection strategies of acquirers. In fact, this question pertains to strategy's core interest in understanding patterns of firm growth resulting from preferential access to resources (Penrose, 1959; Wernerfelt, 1984). Although the idea that existing resources guide corporate expansion is theoretically well-founded (Mahoney *et al.*, 1992; Peteraf *et al.*, 2003), few studies have operationalized this in the context of acquisitions (exceptions are Mitchell *et al.*, 2003; Schildt *et al.*, 2006). This chapter provides evidence on how resource interdependence guides acquisition strategy and complements existing theories on the role of product and technology overlap in target selection (Mitchell *et al.*, 2003; Schildt *et al.*, 2006).

4.5.2 Implications for Technology Strategy

This chapter also contributes to the technology strategy literature by pointing to the importance of M&As as avenues for accessing patented technologies. From the deals in my sample, roughly 38% involve the transfer of patent rights. This corresponds to more than 12,000 patents changing ownership in two industries (SIC36 and SIC28) over a 12-year period[37]. In comparison, the total number of traded patent (i.e. patent assignments) for corporate inventors in the US over a 21,5-year period is 139,432[38] (Serrano, 2010). This suggests that technology acquisitions are an important, albeit underexplored, component of markets for technology (Arora *et al.*, 2001; Arora *et al.*, 2010). Recognizing that acquiring patents via corporate M&As as an alternative channel for technology exchange other than patent trades and technology licensing, would help better understand the function of markets for technology and their apparent lack of development (Arora *et al.*, 2010).

In addition, these findings reinforce the notion that patent value is driven by the characteristics of the assignee firm. Although an extensive literature tackling the problem of measuring patent value has developed (Bessen, 2008; Hall *et al.*, 2005; Jensen *et al.*, 2011; Pakes, 1986), little attention is paid to individual assignee firm characteristics beyond size. Most of the emphasis lies in heterogeneity in patent value across industries. Yet, I demonstrate here that the composition of the patent portfolio and the links between patented technologies can generate important value for the

[37] This figure underestimates the total amount of patents due to the sampling criteria of this study and missing values.
[38] These figures are not comparable but they suggest that the number of patents transferred through technology acquisitions is not negligible as compared to that of patent reassignments.

assignee firm. These results echo assertions that patent value is endogenous and that the value of patented technologies lies in their aggregation (Bessen, 2008; Parchomovsky *et al.*, 2005). Management theorists have long acknowledged the importance of access to complementary assets as a mediating factor for capturing value from patented technologies (Arora *et al.*, 2006; Teece, 1986), but it is important to extend this logic to the composition and design of patent portfolios.

Finally, the link between target selection and litigation threat highlights how changes in firm boundaries can be used to manage patent litigation. Patent enforcement involves important tradeoffs and the decision to settle is driven by both firm and technology characteristics (Somaya, 2003). Here, I show that firms dynamically manage this process by acquiring additional patents in the face of increased litigation threat. This enables them to improve their bargaining power and negotiate with more favorable terms.

In fact, this is the first study to demonstrate that technology acquisitions can be a strategic response to the threat of patent litigation. The majority of patent litigation models focus on firm characteristics that increase litigation hazard, treating firm scope as largely exogenous. In contrast, I explicitly hypothesize and provide evidence that changes in firm scope are central means with which firms manage observable or latent patent disputes. Google's takeover of Motorola Mobility (August 2011) is a case in point. With patent wars in the smartphone industry raging and after failing to successfully win the bid for Nortel's patent portfolio, Google spent $12.5 billion largely for access to Motorola's 17,000-strong patent portfolio. As Larry Page, Google's CEO, put it: "*Our acquisition of Motorola will increase competition by strengthening Google's patent portfolio, which will enable us to better protect Android from anticompetitive threats from Microsoft, Apple and other companies*"[39][40].

4.5.3 Limitations

Of course, this study is not without limitations. First, as a result of my sampling frame and methodology, I focused only on acquirers' returns. Unfortunately, it is extremely difficult to come up with acquisition performance measures in the case of private targets. It would be interesting nevertheless to explore overall acquisition performance and measure the total surplus value generated from the transfer of patent rights. This would allow us to better evaluate what combinations of patent rights are profitable and also to explore the distribution of synergistic gains between the target and acquirer.

Second, like any study focusing on specific industries, I cannot be certain about the generalizability of my results. I chose the chemicals and electronics industries because the specific characteristics of patent rights in these two industries enabled me to isolate the effect of interest. I am confident though that the general prescriptions and insights of the study hold true at least in industries where patents are important means of competition. Naturally, additional work in different settings would help

[39] Source: New York Times, August 15, 2011, Google to buy Motorola Mobility for $12.5 billion

[40] Of course, it is too early to tell what the impact of Google's acquisition of Motorola Mobility will be in terms of patent litigation in the smartphone industry. However, the rationale offered by both Google executives and industry analysts is very much in line with the reasoning behind Hypothesis 4.

extend our understanding of resource redeployment and the associated costs and benefits.

Third, this study is less informative about the actual process of resource transfer and redeployment. I assume that this process is automatic and cost-free. This is a reasonable assumption when considering the merge of patent portfolios, given that patent rights primarily function as a deterrent for competitors. Yet, this is not necessarily true for other types of resources like tacit knowledge, star scientists or marketing experience. Other studies have demonstrated that there are significant costs and challenges involved in these cases that can influence acquisition performance (Capron, 1999; Capron *et al.*, 1998; Paruchuri *et al.*, 2006).

4.6 CONCLUSION

This study contributes towards elucidating one of the central questions in strategic management, that of value creation and capture in corporate acquisitions. In doing so, it suggests ways of operationalizing concepts of synergy and interdependence and argues in favor of more rigorous testing of RBV predictions. In addition, it contributes to the study of technology acquisitions by identifying the drivers of acquirers' selection strategies. It is important to further extend this line of inquiry in order to better understand how resource redeployment motivates corporate strategy and contributes to acquisition performance.

CHAPTER 5

PROFITING FROM NON-TECHNOLOGICAL INNOVATION: BUSINESS METHOD PATENTS AS MECHANISMS OF APPROPRIABILITY

5.1 INTRODUCTION

The problem of appropriating returns from innovation has been of particular interest to innovation and strategy scholars. Indeed, a number of studies have attempted to uncover the determinants of appropriability and understand the role of patenting in the innovation process (Arora *et al.*, 2003a; Cohen *et al.*, 2000; Levin *et al.*, 1987). A key finding from these studies is that there is increased heterogeneity in the effectiveness of the appropriability mechanisms employed across technological areas and industries. As explained by Teece (1986), the nature of the underlying technology and the efficacy of legal mechanisms of protection play a central role in the distribution of profits from innovation.

However, it is immediately obvious that the majority of these studies are concerned with appropriability in the technological domain. Although such focus was warranted at a time when manufacturing was the key driver of productivity and growth, this is no longer the case. Modern economies are increasingly dominated by services and advances in management practices are seen as key contributors to long-term firm success (Benner *et al.*, 2003; Birkinshaw *et al.*, 2008; Gallouj *et al.*, 1997).

Yet, there are few attempts to study the link between innovation and performance outside the traditional industrial setting (Cainelli *et al.*, 2004; Chesbrough, 2011; Roberts *et al.*, 2003). In short, we know very little about the mechanisms of appropriability in the non-technological domain.

Here, I use the term non-technological to describe innovation that involves novelty in areas other than technology. Non-technological innovation then includes management innovation – defined by Birkinshaw *et al.* (2008:825) as the invention and implementation of a management practice, process, structure, or technique that is new to the state of the art and is intended to further organizational goals – and business model innovation – defined by Teece (2010:173) as the logic behind how the enterprise creates and delivers value to customers and then converts payments received to profits. Although non-technological innovations are ubiquitous across sectors, including manufacturing and services, management scholars have only recently started to acknowledge their performance implications (Chesbrough, 2010; Desyllas *et al.*, 2012; Teece, 2010).

This dearth of knowledge becomes quite problematic at a time when major changes in the regulatory environment in the US are taking place. A ruling by the US Court of Appeals for the Federal Circuit (CAFC) in 1998 emphasized that business methods are patentable subject matter. Although it is hard to precisely define the subject matter of business method patents, these are used to protect elements of business model innovations and management innovations[41] (Desyllas *et al.*, 2012; Hall, 2009a; USPTO, 1999). For example, some of the subclasses of class 705 'Business method patents' are targeting specific industries (e.g. the definition of subclass 705/4 is "Insurance (computer implemented system or method for writing insurance policy, processing insurance claim, etc.)"). Other subclasses describe management innovations not tied to a specific industry (e.g. the definition of subclass 705/7.12 is "Resource planning, allocation or scheduling for a business operation").

Hence, non-technological innovators are now able to rely on formal intellectual property protection mechanisms, as opposed to other strategies, such as secrecy or lead time advantages. This opens up a host of new ways for firms to capture value from novel business models by patenting specific methods that underpin a business model and combining various strategies of appropriability (Desyllas *et al.*, 2012; Zott *et al.*, 2011). However, few studies have explicitly considered the effectiveness of business method patents or provided estimates of their value. In fact, this is not a straightforward matter as several authors have raised questions about their use and quality (Barton, 2000; Dreyfuss, 2000).

In an attempt to address this gap in the literature, I used an event study to measure the stock market's reaction resulting from the grant of a business method patent. I relied on a sample of patents issued by the US Patent and Trademark Office (USPTO) following CAFC's 1998 decision regarding business method patent eligibility. The

[41] In the case of business method patents, business model innovations protected are primarily applicable to service industries.

results provide strong support for the hypothesized positive relationship between patent protection and assignee firm's market value. In particular, I find that mean total patent value is $65.50 million and median total patent value is approximately $2.37 million.

In addition, I find that business method patents are less valuable when the underlying invention is a management innovation (as compared to business model innovation). This result can be explained by the increased difficulty of identifying infringers and engaging in licensing agreements for the case of management innovations. Finally, I find that different assignees are not equally able to profit from business method patents. In particular, business method patents are more valuable when the assignee firm has experience in patenting and, additionally, when the assignee firm has access to complementary assets.

These results have important implications for the design of firm innovation strategy and also for public policy and intellectual property regulation. Regimes of appropriability in the non-technological domain appear to strengthen as business method patents are found to significantly increase the market value of innovators. Hence, non-technological innovators need to develop the necessary skills and capabilities to manage patent portfolios in order to increase their share of value captured. Moreover, business model innovators need to combine patenting with investments in complementary assets as these are found to work synergistically with business method patents. Finally, experience in patenting increases the value of business method patents, suggesting that experienced patentees are better able to manage the patenting process and deal with the regulatory uncertainty surrounding business method patents.

The remainder of this chapter is organized as follows. The next section briefly reviews appropriability in the non-technological domain along with the recent changes in the regulatory environment in the US that enabled the patenting of business methods. In the third section a set of hypotheses is developed while in the fourth section the methodology employed is presented. Subsequently, I present the results of the analysis, discuss their implications and draw several conclusions.

5.2 NON-TECHNOLOGICAL INNOVATION AND APPROPRIABILITY

The increasing importance of non-technological innovation in modern economies has inevitably drawn attention to issues related to appropriability. Put simply, the appropriability problem refers to innovators' inability to fully capture the value created from their inventions (Arrow, 1962; Teece, 1986). However, despite the large number of studies focusing on the effectiveness of the various mechanisms of appropriability (Arora *et al.*, 2003a; Cohen *et al.*, 2000; Levin *et al.*, 1987), there remains less emphasis on exploring the link between innovation and appropriability in the non-technological domain. A frequently cited reason for this dearth of empirical work is the lack of available innovation output measures (Sirilli *et al.*, 1998). Nevertheless, the thesis put forward is that non-technological innovations are characterized by weak regimes of appropriability due to their intangible nature and the lack of formal intellectual property protection mechanisms (Amara *et al.*, 2008; Gallouj *et al.*, 1997; Teece, 1980).

Indeed, until recently, patent offices worldwide were rarely granting patents for innovations that did not involve technological novelty. Given that such innovations have little or no technical component, patent offices were reluctant to provide competitive protection to firms for introducing novel business methods. Although there is usually no explicit requirement for a method to be tied to a machine or physical transformation, in practice most jurisdictions do not consider pure business methods as patentable subject matter (Hall *et al.*, 2009; Wagner, 2008). In addition, reliance on other methods of intellectual property protection is equally challenging (Amara *et al.*, 2008; de Vries, 2006). For example, in the case of business models, secrecy or complexity of design are not always appropriate defensive strategies as clients, competitors and suppliers actively participate in the ecosystem promoted by the business model (Zott *et al.*, 2010).

5.2.1 Business Method Patents

The weak regime of appropriability in the non-technological domain was challenged in the late 1990s, however, by a change of policy at the USPTO. This change has been largely attributed to a ruling by the CAFC reviewing the State Street vs. Signature case in 1998[42]. The CAFC's decision argued that Signature's patent, a pure mathematical algorithm application, was eligible, and also emphasized that

[42] State Street Bank & Trust Co. v. Signature Financial Group, 149 F.3d 1368 (Fed. Cir. Jul. 23, 1998).

business methods in general are patentable subject matter[43] (Lerner, 2002). This decision had major implications for innovators as it triggered an awareness of the 'business method claim' as a viable form of patent protection[44] (USPTO, 1999). In fact, the USPTO was indicating its approval of business method patents throughout the 1990s, with the introduction of Class 705 (data processing: financial, business practice, management or cost/price determination) and with a gradual shift from a hostile to a significantly more favorable view on software-related inventions, which are often combined with business method innovations (Bessen *et al.*, 2007a; USPTO, 1999).

Not surprisingly, the number of applications for business method patents to the USPTO has increased dramatically since 1998 and many firms operating in the non-technological domain are developing patent portfolios as part of their innovation strategy (Messinger *et al.*, 2006). Of course, this surge in applications does not necessarily mean that non-technological innovators suddenly became more productive given that many organizations patented business methods already in use (Scott *et al.*, 2007). It does demonstrate, however, that firms are increasingly considering patents

[43] The court specifically suggested that "…as an alternative ground for invalidating the '056 patent under § 101, the court relied on the judicially-created, so-called "business method" exception to statutory subject matter. We take this opportunity to lay this ill-conceived exception to rest. Since its inception, the "business method" exception has merely represented the application of some general, but no longer applicable legal principle, perhaps arising out of the "requirement for invention" — which was eliminated by § 103. Since the 1952 Patent Act, business methods have been, and should have been, subject to the same legal requirements for patentability as applied to any other process or method. The business method exception has never been invoked by this court, or the CCPA, to deem an invention unpatentable. Application of this particular exception has always been preceded by a ruling based on some clearer concept of Title 35 or, more commonly, application of the abstract idea exception based on finding a mathematical algorithm. Illustrative is the CCPA's analysis in *In re Howard,* 55 C.C.P.A. 1121, 394 F.2d 869, 157 USPQ 615 (CCPA 1968), wherein the court affirmed the Board of Appeals' rejection of the claims for lack of novelty and found it unnecessary to reach the Board's section 101 ground that a method of doing business is "inherently unpatentable." *Id.* at 872, 55 C.C.P.A. 1121, 394 F.2d 869, 157 USPQ at 617.

[44] See also the discussion about the eligibility of Amazon's one-click patent (e.g. Lesavich, 2001).

as a method of protecting their non-technological inventions from imitation. This is evident in the large increase in the number of business method patents granted by the USPTO in the last years – see Figure 1[45].

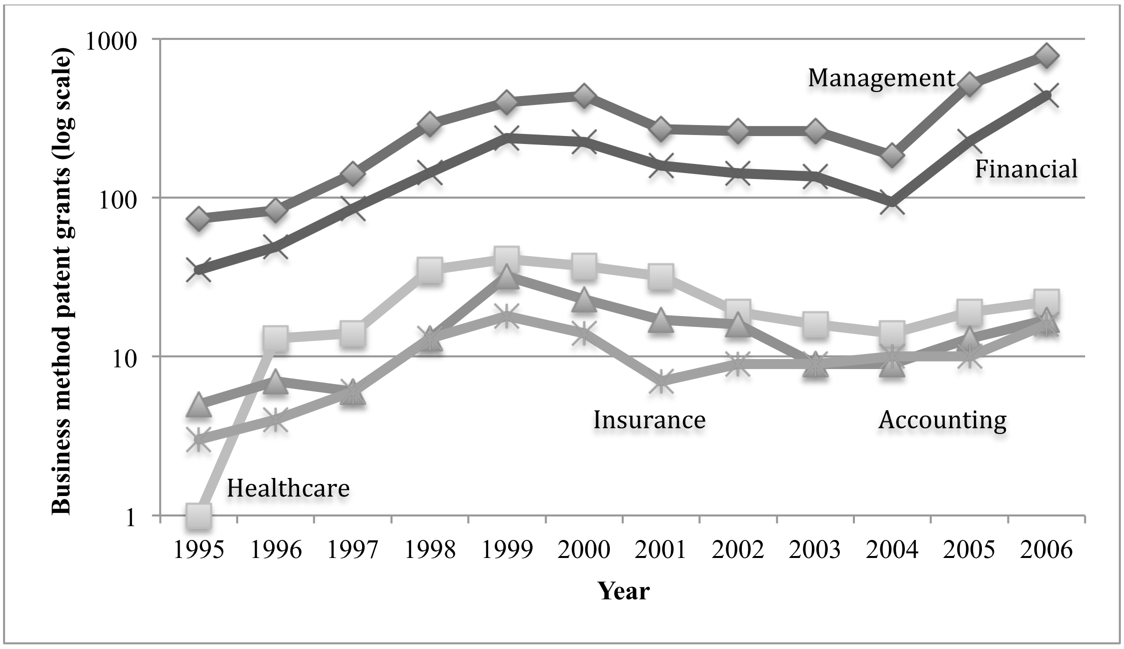


Figure 5.1 Business method patents granted by the USPTO, 1995-2006

It is important to emphasize though that since 1998 the regulatory environment in the US has been in a state of constant flux which generates increased uncertainty over the validity of business method patents. In 2004 and 2005 the USPTO examiners started requiring recitation of 'technology' in pending claims from business method patent applicants (Messinger *et al.*, 2006). In other words, business methods or mathematical algorithms without any implementing structure were not considered patentable because they lacked any 'technological association'. Yet, this attempt to confine the expansion of patentable subject matter was restrained by the USPTO's

[45] See methodology section for chart definitions.

Board of Patent Appeals and Interferences (BPAI). When reviewing the Lundgren patent application in 2005, the BPAI concluded that there is no judicially recognized separate 'technological arts' test to determine patent eligibility. Hence, the USPTO released new guidelines suggesting that a claim is within a statutory class when it produces a 'useful, concrete and tangible result' (i.e. something that produces a 'real world result' but is not limited to a machine or apparatus).

However, in 2008 the scope of the State Street ruling was again limited by a subsequent decision of the CAFC. In the case *In re Bilski*[46] a majority of the court suggested that a business method would be patent eligible if (1) it is tied to a machine or apparatus, or (2) it transforms a particular article into a different state of things (Hall, 2009b; Samuelson, 2009). Following that, the USPTO released a memo clarifying its guidelines in light of the Bilski decision. In particular, the USPTO communicated that the test for a method claim is the 'machine-or-transformation', suggesting that 'reciting a specific machine or a particular transformation of a specific article in an insignificant step, such as data gathering or outputting, is not sufficient to pass the test'. The last episode of this saga took place in 2010 when the Supreme Court rejected the Federal Circuit's holding that the 'machine-or-transformation' test

[46] In re Bilski, 545 F.3d 943, 88 U.S.P.Q.2d 1385 (Fed. Cir. 2008).

is the only test for patentability of a method claim. Hence, the Supreme Court supported a broader interpretation of subject matter eligibility[47].

The regulatory uncertainty surrounding business method patents is also reflected in the divided opinions of legal scholars regarding their usefulness and quality. For example, Dreyfuss (2000) not only suggests that the majority of business method patents suffer from low quality[48] but also questions the wisdom of recognizing exclusivity in competitive processes. Barton (2000) claims that business method patents contribute to the disproportionate increase in the systemic costs of IP protection in the US. Yet, others, including some CAFC judges, characterize the 'machine-or-transformation' test as appropriate for the age of iron and steel (Samuelson, 2009). According to this view, a restrictive view of patentable subject matter would undermine incentives to innovate in modern, service-oriented economies.

More importantly for innovation and strategy research, it is still unclear how valuable these patents are for the individual firm. In fact, no study has considered what parameters influence their effectiveness as mechanisms of appropriability. With

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[47] http://www.supremecourt.gov/opinions/09pdf/08-964.pdf. Part of the opinion reads "…It is important to emphasize that the Court today is not commenting on the patentability of any particular invention, let alone holding that any of the above-mentioned technologies from the Information Age should or should not receive patent protection. This Age puts the possibility of innovation in the hands of more people and raises new difficulties for the patent law. With ever more people trying to innovate and thus seeking patent protections for their inventions, the patent law faces a great challenge in striking the balance between protecting inventors and not granting monopolies over procedures that others would discover by independent, creative application of general principles. Nothing in this opinion should be read to take a position on where that balance ought to be struck.

[48] In this context, quality refers to the relative fulfillment of the statutory requirements of a patentable invention, i.e. inventions must be novel, non-obvious and useful.

innovators choosing from a variety of IP protection methods, answering this question becomes essential for the design of firm innovation strategy.

5.3 HYPOTHESES

In general, patents can be quite valuable for organizations. By definition, a patent is a document issued by an authorized governmental agency, granting the right to exclude anyone else from the production or use of a specific new device, apparatus or process for a stated number of years (Griliches, 1990:1662). Consequently, the assignee enjoys a temporary monopoly for the commercial use of an invention. Given that the ability to avoid competition has been consistently linked with superior performance (Nelson, 1986; Roberts, 1999; Schumpeter, 1934), one would expect that the grant of a patent to a firm will, *ceteris paribus*, increase its value. Ceccagnoli (2009) provides strong evidence that patent protection increases returns captured from R&D and, therefore, performance. This effect is not only attributed to a firm's ability to avoid competition for a specific technology, but also to its ability to preempt potential competitors by patenting substitutes of existing technologies (Ceccagnoli, 2009).

Of course, patents do not always ensure the monopolistic use of the invention by the assignee. In a number of industries patents are used as strategic tools for negotiating cross-licensing agreements and for obtaining first-mover advantages (Desyllas *et al.*, 2012; Hall *et al.*, 2001b). For example, Grindley and Teece (1997) have demonstrated that a high-quality patent portfolio can increase a firm's cross-licensing bargaining ability and reduce royalty payments. Finally, patents act synergistically with other forms of intellectual property protection, allowing assignee firms to deter market entry or increase the cost of conducting R&D in related areas for competitors (Arora, 1997; Cohen *et al.*, 2000). I therefore hypothesize that:

> *Hypothesis 1. The grant of a business method patent to a firm increases its value.*

5.3.1 Management Innovations

Patents do not work equally well across technological fields. A number of studies have established that the effectiveness of patents as mechanisms of appropriability differs across industries and technology areas (Cohen *et al.*, 2000; Levin *et al.*, 1987). The reported heterogeneity in patent value across industries and technological fields is consistent with such claims (Bessen, 2009; Schankerman, 1998).

These differences can be attributed to the nature of the underlying technology (e.g. complex versus discrete), the ease of licensing and enforcement, the dynamics of competition etc. In particular, patents are more valuable when enforcement is easy (Lanjouw *et al.*, 2004b; Lerner, 1995). For example, it is much easier to identify infringers when the patented invention is a new product (e.g. a new drug that is out in the public domain) as compared to a novel process (e.g. a manufacturing method that is not easily identifiable in the final product). In addition, patenting is expected to be more advantageous when technology transfer is easy. As mentioned before, in some cases patents act as 'bargaining chips' rather than exclusion rights. Hence, firms can use patents in order to extract licensing fees or negotiate cross-licensing agreements when technology transfer is feasible.

However, business method patents are not homogeneous with regards to these characteristics as they protect both management and business model innovations. In fact, management innovations are not easily transferable and infringement is not easily identifiable as compared to business model innovations. This is because management processes are embedded in the organizational context/culture and change thus entails significant organizational disruption (Birkinshaw *et al.*, 2008; Teece, 1980). Teece (1980:465) explicitly argues that the diffusion of an administrative (i.e. management) innovation is expected to be slower and more haphazard than the diffusion of other innovations with a similar cost reducing potential. In addition, management innovations are relatively difficult to observe and define as organizational membership is required and they allow a higher level of subjective interpretation on the part of the user (Alange *et al.*, 1998; Birkinshaw *et al.*, 2008:829). Hence, it will be harder for patent assignees to identify infringers and use litigation in the case of management innovations. I therefore hypothesize that patents protecting management innovations are, *ceteris paribus*, less valuable than patents protecting business model innovations.

> *Hypothesis 2. The positive impact on the innovative firm's value resulting from the grant of a business method patent will be lower when the patentable subject matter is a management innovation.*

5.3.2 Patenting Experience

Although the patenting literature has traditionally focused on heterogeneity in patent value and use across technological fields, there are also important differences in the ability of individual firms to use patents as mechanisms of appropriability. For example, firms reduce knowledge spill-overs and increase the credibility of threat of litigious action by developing a reputation for enforcement (Agarwal *et al.*, 2009). Or, assignee firms capture additional value from their IP rights through the creation of patent thickets and fences (Reitzig, 2004).

In the case of business method patents, assignees are faced with increased regulatory uncertainty and a lack of clear guidelines in the definition of patentable subject matter. Lanjouw and Schankerman (2001b) suggest that this combination increases the probability of litigation, a fact which is evident in the disproportionate number of lawsuits targeting the validity of business method patents (Baumann, 2001; Lerner, 2007). Hence, assignees will benefit more from business method patents by developing the skills to strategically define their IP rights (e.g. construct claims, process applications etc) and manage (or avoid) patent litigation. Such skills though are closely related with assignees' experience in patenting.

To begin with, firms engaged in patenting are more likely to understand patent litigation and have in-house expertise in IP management (Lerner, 1995; Pashigian, 1982). Experienced patentees can rely on internal corporate patent counsel, an option far more economical than reliance on outside counsel (Bellis *et al.*, 1992; Lerner, 1995). In addition, patenting experience and the accompanying large patent portfolio act as a deterrent for potential plaintiffs when considering litigation (Lanjouw *et al.*, 2001b, 2004b). Consequently, experienced patentees will be better able to protect their IP rights, a fact which increases their value.

Besides the issue of enforcement, patenting experience is beneficial for the management of the application process. For example, experienced firms are more likely to have developed interdependencies between R&D and other organizational functions, which are in turn associated with positive application outcomes such as higher or faster patent grant rates (Reitzig *et al.*, 2009). These skills are especially important when regulatory uncertainty is high, like in the case of business method patents. Finally, experienced patentees are more likely to have the skills and capabilities required to negotiate technology transfer agreements. These help assignees access external knowledge and generate value through the cross-licensing of patents (Grindley *et al.*, 1997). Thus:

> *Hypothesis 3. The innovative firm's patenting experience increases the positive impact on its value resulting from the grant of a business method patent.*

5.3.3 Complementary Assets

Innovators also need access to complementary assets, such as marketing, manufacturing skills or after-sales support, in order to increase their share of profits captured from innovation. Teece (1986) specifically argues that these assets are usually specialized (or co-specialized), i.e. complementary assets are components of a system of production or parts of a value chain characterized by unilateral (or bilateral) dependence with the innovation. Thus, innovators that hold vertically-related assets are better positioned to appropriate value created from innovation (Jacobides *et al.*, 2006).

This hypothesis has received strong empirical support in manufacturing industries. For example, Rothaermel (2001) demonstrated how established pharmaceutical firms can take advantage of their complementary assets in the face of radical technological change while Tripsas (1997) explained how incumbents managed to sustain a high level of commercial performance despite their technological disadvantage in the typesetter industry. In a more recent study, Ceccagnoli (2009:82) reports that greater appropriability, measured by the ownership of specialized complementary assets, has a large, positive and significant impact on a firm's economic performance.

Focusing explicitly on patenting, Arora and Ceccagnoli (2006) found that the presence of specialized complementary assets enhances the value of patent protection. This is because an innovator with specialized complementary assets is able to profit more from a market characterized by lack of close substitutes – due to patent protection – than an innovator lacking such assets (Arora *et al.*, 2006:297). Hence, patenting and complementary assets act synergistically in appropriating returns from innovation. The business model literature also emphasizes the importance of complementary assets by pointing to the mutually reinforcing nature of the relationship between patents and complementary assets in capturing value from novel business models (Desyllas *et al.*, 2012; Teece, 2010). Thus:

> *Hypothesis 4. The innovative firm's access to specialized complementary assets increases the positive impact on its value resulting from the grant of a business method patent.*

5.4 DATA AND METHODOLOGY

5.4.1 Data

The data on the patents examined were drawn from the NBER's patent database (Hall *et al.*, 2001a). I included in the dataset patents in the class 705 – 'Data processing: financial, business practice, management, or cost/price determination' – that were granted between 23 October 1998 (the date of CAFC's 1998 decision on business method patent eligibility) and 31 December 2003. I excluded patents granted after the end of 2003 because I would not be able to control for the quality of the underlying invention using forward citations. As explained in Hall *et al.* (2001a), it is not possible to get an accurate estimation of forward citations corrected for truncation when the time period to observe actual citations is relatively short (i.e. less than 3 years). In addition, I excluded patents filed after 1999. This is because, following the American Inventors Protection Act of 1999, patent application data are published by the USPTO. This pre-grant information disclosure could be problematic in the context of this study as I'm using an event study to measure the impact of a business method patent grant on the value of the assignee firm.

After applying these criteria, there were 2,881 patents identified in the NBER database. From these, 467 were assigned to individual inventors and were thus deleted from the dataset. From the remaining patents, analysis was restricted to those assigned to corporations that were listed in a US stock exchange (NYSE, NASDAQ and AMEX) for at least a year prior to the grant date as it is impossible to derive value appropriation measures for privately-held companies using an event study. Then, I used a combination of dictionary-based identification and manual matching in order to identify patent assignees (Thoma *et al.*, 2010). I begun with the match file (last updated in 2010) provided by the NBER and then manually checked for alternative spellings and that were not already identified. This procedure generated a list of 345 patents granted to 124 firms.

Subsequently, I matched the patent list with stock market data from CRSP and financial data from Compustat. A further 128 patents were dropped because other corporate announcements (such as mergers and acquisitions, the launch of a new product etc) coincided with the grant date or because the assignee was awarded additional patents in different classes. In these cases, it is impossible to accurately calculate the value increment resulting from the grant of the patent, as its impact cannot be isolated from that of other confounding events. Thus, the usable dataset is comprised of 237 patents granted to 95 firms in 224 separate event days[49].

[49] There were a few cases where multiple business method patents were granted on the same day to the same firm.

In terms of industry representation, 44% of the assignee firms in the sample have a primary two-digit SIC code in subdivision 73 (business services), 18% in subdivision 35 (industrial and commercial machinery and computer equipment), 8% in subdivision 60 (depository institutions) and 4% in subdivision 62 (security and commodity brokers, dealers, exchanges and services). No other industry exhibits a significant concentration of business method assignees included in the sample.

5.4.2 Methodology

I used an event study of the stock market's reaction to the grant of a patent to estimate the change in firm value resulting from the grant of a business method patent. This technique, introduced by Fama et al. (1969), has become the standard method of measuring security price reaction to some announcement or event (Binder, 1998; Park, 2004). Given rationality in the marketplace, the economic impact of an event can be accurately measured using asset prices observed over a relatively short time period (Campbell *et al.*, 1997). I used daily data on the stock market performance of innovating firms over a 262-day period (these are trading not calendar days) prior to the event day (i.e. the grant of the business method patent) to estimate a standard market model:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}\ , where\ E(\varepsilon_{it} = 0)\ and\ var(\varepsilon_{it}) = \sigma_\varepsilon^2$$

In this model R_{it} denotes the daily returns for firm i on day t, R_{mt} denotes daily market returns, and ε_{it} is a mean zero disturbance term. I used the CRSP value-weighted index as a market benchmark. Then, based on the estimates from this model, I calculated the abnormal returns AR_{it} for each firm *i* over the event window:

$$AR_{it} = R_{it} - \left(\hat{\alpha}_i + \hat{\beta}_i R_{mt}\right)$$

Following standard practice, I used a two-day event window, i.e. $t = [0, +1]$ with $t = 0$ representing the event day. A two-day window is suitable for capturing price effects that occur after the stock market closes on the announcement day while reducing the possibility of extraneous noise affecting the results (Campbell *et al.*, 1997; Hayes *et al.*, 2000).

Nevertheless, event studies heavily rely on the assumption that stock markets did not anticipate the event in question (McWilliams *et al.*, 1997). In fact, McWilliams and Siegel (1997:634) explain that when an event is anticipated or information is leaked, event study methodology becomes problematic. Given that the USPTO did not publicize patent application data prior to the grant date for the patents examined, this is not a concern unless there is voluntary disclosure. However, Lansford (2006) found that the extent of voluntary patent disclosure is extremely limited in the US. In addition, business method patents are notoriously difficult to get, with less than 20% of the total Class 705 applications eventually granted (Scott *et al.*, 2007). Hence, even when information about pending patent applications is available, the considerable uncertainty surrounding business method patent grants suggests that measuring stock reaction on the grant date is not problematic.

It is also important to clarify what is measured with the event study. When a firm is awarded a patent, there are in fact two 'distinct' announcements: a) the company came up with an invention and b) the company has patented this invention. Hence, event studies produce estimates of total patent value and not just of the patent premium[50] (Arora *et al.*, 2003a; Gambardella *et al.*, 2008; Harhoff *et al.*, 2003). That is, abnormal returns capture both the value of the invention to the firm and the value of patent protection.

The first hypothesis was tested using the following statistic (Khotari *et al.*, 2007; Serra, 2002):

$$t = \overline{AR}_t / S(\overline{AR}_t), \text{ where } \sigma^2(\overline{AR}_t) = (1/N^2)\sum_{i=1}^{N} \sigma^2(AR_{it})$$

The standard deviation of the average abnormal return for each security was estimated from the residual variance from the market model for each firm i (Campbell *et al.*, 1997). In addition, following Patell (1976) and Dodd and Warner (1983), I divided each firm's daily abnormal returns by its standard deviation (obtained from the market model over the estimation period) to calculate standardized abnormal returns, SAR_i. The statistic used to test their significance is (McWilliams *et al.*, 1997; Serra, 2002):

$$z = (1/N)\sum_{i=1}^{N} SAR_{it} / S(\overline{SAR}_t), \text{ where } S(\overline{SAR}_t) = 1/\sqrt{N}$$

Finally, to allow for event-induced variance, I used the 'standardized cross-sectional test', suggested by Boehmer *et al.* (1991):

[50] The patent premium is defined as the proportional increment to the value of innovations realized by patenting them while total patent value includes both patent premium and the value of the invention.

$$t = \overline{SAR}\sqrt{n}/s \text{ where } s^2 = (1/n-1)\sum_{i=1}^{n}(SAR_i - \overline{SAR})^2$$

5.4.3 Independent Variables

The remaining hypotheses were tested by cross-sectionally regressing cumulative abnormal returns, CAR_{01}. For Hypothesis 2 and 4, I generated a concordance to describe the subject matter of each patent and assign it to a SIC code – see table 1. Specifically for hypothesis 2, I went through all the subclasses of patent class 705 and identified the subclasses that describe innovations in specific industries. These were grouped into five categories: financial, insurance, healthcare, accounting and legal[51]. In this process I used USPTO's (1999) detailed description of class 705 and Hall's (2009a) similar categorization of financial patents. Then, I generated a dummy variable equal to one for patents in the remaining subclasses. These were designated as management innovations given that the subject matter is not tied to any specific industry but describes administrative or management functions within the firm (see Appendix for examples of patents from each subject matter category).

Subsequently, I matched the five groups of subclasses with SIC codes. In doing so, I went through all the US SIC system to identify the industries that could use the inventions described in the subclasses as an input. For example, the insurance subclass was matched with all the SIC codes in the insurance subdivision of the SIC system. Access to complementary assets was operationalized using a dummy variable

[51] Accounting innovations could be characterized as management innovations as they are business services serving all sectors. Results are robust to different definitions of the explanatory variable though.

set equal to one when the assignee's primary or secondary SIC codes[52] were matched to the patent subclass.

Table 5.1 Subject matter – SIC concordance for business method patents

Subject matter description	Patent subclasses	SIC codes
Financial*	14, 16- 18, 21, 33, 35-45, 53-56, 64-79	6010, 6020, 6030, 6060, 6080, 6090, 6110, 6140, 6150, 6160, 6210, 6220, 6230, 6280, 6710, 6720, 6730, 6790
Insurance	4	6310, 6320, 6330, 6350, 6360, 6370, 6390, 6410
Healthcare	2,3	5047, 8010, 8030, 8040, 8050, 8060, 8070, 8080, 8090
Accounting	30-32, 34	8720
Legal	310,311	8110
Management	1, 5, 7, 20, 23, 24, 26-29, 51, 52, 57, 60, 61, 400, 401, 405, 406, 408, 409, 410, 412	*n/a*

*the matching between subject matter description and patent subclasses is based on Hall (2009a)

Finally, for hypothesis 3, I used the natural logarithm of the number of patent grants to the assignee in the 10 years prior the event date. The number of patent grants captures the relative frequency of patenting on the part of the assignee and is thus a good proxy for patenting experience.

5.4.4 Control Variables

It is possible, of course, that additional factors influence firms' abnormal returns. To account for this, I introduced two classes of control variables: patent-specific and firm-specific characteristics.

[52] Secondary SIC codes are reported in Compustat segment data.

Prior studies of patenting activity in the US clearly indicate that there are important differences in the quality of individual patents (Bessen, 2009; Hall *et al.*, 2000). In fact, innovations vary enormously in their technological importance and the distribution of patent value is extremely skewed (Hall *et al.*, 2001a; Scherer, 1965). To control for this heterogeneity, I added eight variables based on observable patent characteristics that have been found to correlate with the technological significance, breadth and centrality of the patented invention (Bessen, 2008; Lerner, 1994; Trajtenberg, 1990; Trajtenberg *et al.*, 1997). These are the number of claims listed, the number of backward citations, the number of forward citations corrected for truncation, the number of US patent classes, backward and forward technological distance, generality and originality[53].

Firm-specific controls were also included in the regressions, including the number of business method patents granted on the event day, firm size (sales), R&D intensity, operating profit margin, debt ratio and the percentage of sales made in the US. I also added the natural logarithm of a measure of the quality of the assignee's patent portfolio, calculated as follows:

$$CWPT_t = \sum_{i=1}^{N} C_i (1-\delta)^{t-T}$$

where $CWPT_t$ stands for citation-weighted patent portfolio in year t up to the grant, C_i denotes the number of forward citations (corrected for truncation) received

[53] See Trajtenberg et al. (1997) for the calculation of backward and forward technological distance, generality and originality.

by existing patents i=1,…,N granted in year T and δ is the annual depreciation rate set equal to 0.15[54].

Finally, to account for unobserved industry heterogeneity and the effects of changing regulation, I included year and industry (two-digit SIC codes) fixed effects in the regression.

5.5 RESULTS

Results of summary statistics from the event study are reported in Table 2. The cumulative average abnormal returns are 1.02% while the median is 0.57%. These results are significant at the 5% level (t-statistic=2.24). Similarly, average standardized cumulative abnormal returns are significant at the 1% level (z=3.45). Finally, results remain significant at the 1% level (z=2.79) when using the standardized cross-sectional test (Boehmer *et al.*, 1991). Hence, these results provide strong support for hypothesis 1, suggesting an increase in the value of the innovative firm resulting from the grant of a business method patent.

Table 5.2 Summary statistics from event study

Summary statistics of abnormal returns and associated economic impact calculated from the event study. Economic impact is calculated by multiplying cumulative abnormal returns with firm's market capitalization 2 trading days before the grant of the patent(s).

	Mean	Median	S.D.	Minimum	Maximum	Observations
Cumulative abnormal returns	0.01028	0.00517	0.05709	-0.11767	0.30650	224
Economic impact ($ million)	67.827	2.378	696	-1,912	5,873	224

[54] A depreciation rate equal to 0.15 is the standard convention in the literature – see Hall et al. (2005) or Bessen (2009).

The economic impact of patent grants, calculated as the product of cumulative abnormal returns and firm market capitalization two trading days prior to the grant day, is substantial. The mean dollar value captured by patent assignees is \$67.8 million, while median value is \$2.37 million. Hence, in this sample of business method patents, mean total patent value is \$65.50 million and median total patent value is approximately \$2.37 million[55]. The skewed nature of the distribution of total patent value is not surprising, given that most studies measuring patent value report distributions skewed to the right (Bessen, 2008; Gambardella *et al.*, 2008; Pakes, 1986). Nevertheless, it is important to emphasize that these are upper-bound estimates of the value of business method patents. All the firms in our sample are listed companies, which tend to hold more valuable patents (Bessen, 2008).

Table 3 provides descriptive statistics and correlations among all variables in the study while Table 4 presents the results of OLS regression analysis. The dependent variable is cumulative abnormal returns (CAR). The first model only includes the explanatory and patent-specific control variables that account for heterogeneity in the technological importance, and thus value, of the underlying invention. In the second model, I add firm-specific controls while in the third model I also include fixed industry and year effects.

[55] The economic impact of patent grants is not directly equivalent to measures of total patent value because there are a few cases where the same assignee receives multiple business method patents on the same day. I assumed that these patents are equally valuable for the calculation of the median.

Table 5.3 Descriptive statistics and correlation matrix

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1.CAR	0.01	0.05	1.00																		
2.Management inn.	0.48	0.50	-0.09	1.00																	
3.Patenting exp.	2.39	2.34	**0.25**	**0.21**	1.00																
4.Compl assets	0.11	0.32	**0.15**	**-0.34**	**-0.21**	1.00															
5.Claims	26.74	23.64	0.06	0.08	0.08	-0.04	1.00														
6.Forward citations	54.02	72.28	**0.32**	**0.15**	-0.00	-0.12	**0.35**	1.00													
7.Backward citations	26.08	34.52	0.00	0.06	-0.03	-0.12	**0.29**	**0.38**	1.00												
8.Generality	0.40	0.23	**-0.14**	0.00	-0.02	**-0.18**	0.07	**0.23**	0.12	1.00											
9.Originality	0.39	0.25	0.00	0.00	**0.19**	**-0.15**	0.12	**0.13**	**0.33**	**0.27**	1.00										
10.Back. tech. dist.	0.28	0.26	-0.04	0.06	**0.16**	-0.11	0.10	0.05	**0.19**	**0.22**	**0.72**	1.00									
11.For. tech dist.	0.28	0.26	**-0.13**	0.02	0.08	**-0.14**	0.01	0.05	**0.14**	**0.51**	**0.32**	**0.52**	1.00								
12.No of classes	1.79	1.03	-0.11	**0.14**	-0.02	**-0.18**	0.08	**0.20**	0.12	**0.17**	0.09	0.10	**0.21**	1.00							
13.No of grants	1.05	0.30	-0.02	**0.17**	0.05	-0.07	**0.20**	0.11	0.10	0.09	0.12	0.08	**0.14**	**0.44**	1.00						
14.R&D intensity	0.12	0.24	0.09	0.07	0.06	-0.03	**0.17**	**0.18**	**0.25**	-0.07	-0.02	0.00	0.02	0.09	-0.07	1.00					
15.Sales(log)	7.23	2.46	-0.03	0.05	-0.01	0.12	**-0.14**	**-0.16**	**-0.23**	-0.04	-0.10	-0.06	-0.06	-0.05	0.12	**-0.66**	1.00				
16.% of sales in US	0.88	0.15	-0.05	**-0.22**	**-0.17**	0.06	0.01	0.06	-0.01	0.10	0.04	0.04	0.02	0.07	**-0.14**	0.06	**-0.18**	1.00			
17.Op. profit margin	0.19	0.16	-0.12	-0.12	**-0.17**	**0.15**	**-0.21**	**-0.22**	**-0.16**	0.02	0.03	0.03	0.11	-0.07	0.05	**-0.39**	**0.52**	-0.02	1.00		
18.Debt ratio	0.64	0.33	0.07	**0.13**	0.02	0.05	-0.04	0.02	**-0.22**	-0.01	-0.06	-0.08	**-0.14**	-0.07	0.07	**-0.30**	**0.53**	-0.01	**0.25**	1.00	
19.Pat. port. qual.(log)	6.38	2.00	0.02	**0.33**	**0.44**	**-0.26**	0.02	**0.13**	**0.13**	0.06	**0.30**	**0.25**	**0.20**	0.09	0.21	**-0.14**	**0.38**	**-0.31**	**0.16**	**0.21**	1.00

Note: Values underlined and in bold denote at least 5% significance level

Table 4. Regression analysis

OLS regression using cumulative abnormal returns $CAR_{(0,1)}$ as dependent variable. Estimates of fixed effects are suppressed. Standard errors clustered by assignee (reported in parentheses) are used in all models.

	(i)	(ii)	(iii)
Constant	0.0065 (0.0122)	0.0372 (0.0278)	0.0455 (0.0599)
No of patents granted	0.0069 (0.0107)	0.0063 (0.0112)	0.0017 (0.0119)
Management innovation	-0.0157* (0.0063)	-0.0162* (0.0067)	-0.0159* (0.0077)
Patent experience	0.0064** (0.0013)	0.0068** (0.0015)	0.0061** (0.0020)
Complementary assets	0.0242* (0.0099)	0.0226* (0.0103)	0.0324* (0.0129)
Patent controls			
Claims	-0.0001 (0.0001)	-0.0001 (0.0001)	-0.0001 (0.0001)
Forward citations	0.0003** (0.0000)	0.0003** (0.0000)	0.0003** (0.0000)
Backward citations	-0.0001 (0.0000)	-0.0001 (0.0001)	-0.0000 (0.0001)
Generality	-0.0339* (0.0154)	-0.0363* (0.0159)	-0.0380* (0.0170)
Originality	0.0056 (0.0177)	0.0121 (0.0185)	0.0102 (0.0210)
Tech distance (backward)	-0.0001 (0.0000)	-0.0044 (0.0183)	-0.0019 (0.0207)
Tech distance (forward)	-0.0085 (0.0148)	-0.0024 (0.0157)	-0.0072 (0.0173)
Patent classes	-0.0057 (0.0031)	-0.0052 (0.0033)	-0.0030 (0.0036)
Firm Controls			
R&D intensity		0.0000 (0.0213)	0.0015 (0.0278)
Sales		0.0003 (0.0021)	0.0019 (0.0033)
% of sales in US		-0.0252 (0.0201)	-0.0320 (0.0244)
Operating Profit margin		-0.0135 (0.0224)	-0.0075 (0.0314)
Debt ratio		0.0093 (0.0106)	0.0051 (0.0154)
Patent portfolio quality		-0.0027 (0.0022)	-0.0048 (0.0030)
Industry & Year fixed effects	No	No	Yes
No of observations	217	217	217
R^2	0.31	0.32	0.40
F-value	7,80**	5.34**	2.62**

* significant at the 5% level, ** significant at the 1% level, standard errors reported in parentheses

Hypotheses 2 suggests that business method patents are less valuable when the subject matter is a management innovation. As shown in Table 4, the coefficient for management innovations remains consistently negative and significant at the 5% level. Hence, these results provide strong support for the claim that patent protection will be less beneficial for management innovators, as compared to business model innovators, because of the difficulty in identifying infringers and engaging in technology transfer agreements. This is in spite of the wider potential applicability of management innovation across various sectors.

Hypothesis 3 posits that experience in the patenting process increases the value of business method patents. Indeed, the coefficient for patenting experience is significant and in the hypothesized direction in all models, suggesting that experienced patentees are better able to profit from patenting business methods and deal with the surrounding regulatory uncertainty. Finally, I also find strong support for hypothesis 4, as the coefficient for access to complementary assets is positive and statistically significant. Hence, complementary assets work synergistically with patenting as mechanisms of appropriability.

From the control variables, two exhibited statistically significant effects on the abnormal returns. Specifically, the number of forward citations has a strong positive effect. This is in line with a number of studies in the literature suggesting that forward citations are good predictors of the technological importance and value of the underlying invention (Bessen, 2008; Harhoff *et al.*, 2003; Trajtenberg, 1990). In addition, generality, that is a measure of concentration of the patents citing the focal patent in different patent classes (Trajtenberg *et al.*, 1997), is negatively correlated with patent value. In other words, business methods patents with wider applicability in different technological fields are less valuable. This effect could be attributed to the increase in the probability of litigation or infringement when business method patents are cited in different technological fields. Given the regulatory uncertainty surrounding the validity of business method patents, assignees of citing patents will have increased incentives to litigate or infringe.

A somewhat unexpected finding is the lack of significance for R&D intensity. A positive effect has been found in other studies suggesting that more valuable patents are correlated with more valuable technology (Bessen, 2008:941). However, in the context of this study the lack of significance is not surprising since a lot of firms in service industries do not report R&D expenses. Moreover, non-technological innovation may result from investing in different activities (e.g. market research) which may not be recorded as R&D. Finally, from the fixed effects included, none was found to have a significant effect on abnormal returns.

Overall, the analysis is highly supportive of all hypotheses. Indeed, business method patents increase the market value of innovators. However, this increase in value is lower when the patentable subject matter is a management innovation. Finally, access to complementary assets and patenting experience further enhance the ability of firms to profit from patenting business methods.

5.5.1 Robustness Checks

Given the correlation reported between some of the independent variables, I tested for collinearity using variance inflation factor. In addition, I ran a series of models with each independent variable included separately along with the control variables (Roberts *et al.*, 2003). Both tests revealed that collinearity was not an issue in any of the models.

To ensure robustness of my results with respect to the choice of market benchmark, I conducted the preceding analysis using CRSP equal-weighted and S&P500 indices. The results of the event study remain positive and significant, although average cumulative returns are slightly lower when using the equal-weighted index.

To check whether outliers are driving the reported results, I excluded the top and bottom 5% of abnormal returns, but event study results still indicated a statistically significant, positive increase in the market value of assignees. Moreover, I used Wilcoxon signed-ranks non-parametric test for Hypothesis 1 and I was able to reject the null hypothesis of zero abnormal returns following the grant of a business method patent.

Finally, results are robust to alternative specifications of the subject matter – SIC concordance (Table 1) for business method patents. In particular, I tested for alternative definitions of management innovations by treating legal and accounting innovations as management innovations. Given that legal and accounting processes are essential corporate functions undertaken by firms, innovations in these areas could be conceived as management innovations according to some criteria. However, the coefficient for management innovations remains negative and significant. Similarly, results remain unchanged when assuming that consulting firms enjoy access to complementary assets in the case of patented management innovations.

5.6 DISCUSSION

In this chapter, I provide a brief outline of the history of business method patents in the US and offer a set of propositions regarding their effectiveness as mechanisms of appropriability. Using an event study, I find that there is a substantial increase in the market value of innovative firms when the grant of a business method patent is announced. Hence, business method patents enhance a firm's ability to profit from non-technological innovation. However, I demonstrate that business method patents are less valuable when the subject matter is a management innovation. In such cases, the use of patents for cross-licensing purposes is problematic and, in addition, the identification of infringers is difficult. Hence the value of patenting is reduced.

I also find that business method patents can be used synergistically with complementary assets to appropriate returns from innovation. Although Teece's (1986) framework has received strong empirical support, this is one of the first studies to highlight the importance of complementary assets in the non-technological domain. Lastly, the findings suggest that the value captured by the assignee firm increases with the number of patents granted to the assignee prior to the grant of a business method patent. Hence, firms with experience in patenting are able to capture more value from business method patents.

More broadly, this chapter adds to the growing literature focusing on business method patents and their usefulness for innovators and the economy (Dreyfuss, 2000; Hall, 2009a; Wagner, 2008). In addition, the results presented here contribute to the debate about how firms capture value from novel business models (Desyllas *et al.*, 2012; Teece, 2010; Zott *et al.*, 2011). As Teece (2010:179) argues, developing a successful business model is not sufficient to assure competitive advantage. New business models need to be coupled with isolating mechanisms that limit the ability of competitors to offer similar value propositions. In this sense, the results here emphasize the role and importance of business method patents and confirm the need to rely on a variety of different appropriability strategies in order to limit competition on new business models.

5.6.1 Business Method Patents and non-Technological Innovators

The findings presented here provide interesting insights for the design of firm innovation strategy. While the increase in the patenting of business methods in the recent years has drastically altered the institutional and competitive landscape, very few studies have considered the implications of such changes for non-technological innovators (Desyllas *et al.*, 2012; Lerner, 2002; Wagner, 2008).

To begin with, regimes of appropriability in the non-technological domain appear to strengthen as the number of business method patent grants increases. Although the difficulty of enforcing property rights in such settings has been noted (Amara *et al.*, 2008; Hipp *et al.*, 2005), the results of the event study suggest that there is significant value associated with the patenting of business methods. Hence, non-technological innovators need to develop the necessary skills and capabilities to manage patent portfolios. In fact, the ability to strategically define intellectual property rights and use cross-licensing contracts is essential for reducing the threat of hold-up and ensuring 'freedom to operate' in environments characterized by multiple holders of vertically-related patents (Grindley *et al.*, 1997; Siebert *et al.*, 2010). As organizations face an increasing number of patented or patentable business methods, the strategic management of patent development and protection will be a crucial success factor.

In addition, with the strengthening of formal protection mechanisms for business model innovations, imitators will find it increasingly hard to keep pace with the latest developments in terms of business model design. At the same time, first mover advantages in the non-technological domain are likely to consolidate, as other forms of 'isolating mechanisms' can be synergistically combined with patenting (Lieberman *et al.*, 1998; Rumelt, 1987). Moreover, the results of the cross-sectional analysis highlight the need for business model innovators to combine their innovative efforts with investments in complementary assets in order to take a larger share of the value created from innovation.

Nevertheless, firms need to be aware of regulatory uncertainty. As mentioned in section 2, successive decisions of the CAFC and the USPTO have changed the criteria for granting business method patents. Hence, the preceding discussion should always be interpreted with a view to the prevailing regulatory conditions in the US. As far as the rest of the world is concerned, there is only a handful of jurisdictions officially granting business method patents, while the European patent office refuses to recognize business methods as patentable subject matter.

5.6.2 Business Methods and Intellectual Property Regulation

These findings have also some interesting implications for the ongoing debate about the patentability of business methods. Ever since the CAFC characterized the business method exception as 'ill-conceived', legal scholars and economists have argued both in favor and against the trend of widening the scope of patentable subject matter. On the one hand, proponents of business method patents argue that in modern economies, a restrictive view of patentable processes would undermine incentives to invest in innovation in new fields (Samuelson, 2009). Their critics, however, emphasize that business method patents suffer from low quality and are often overbroad and invalid, stifling innovation instead of fostering it (Dreyfuss, 2000; Scott *et al.*, 2007).

In a sense, these contrasting views are newer versions of a rather old, albeit still pertinent, discussion centering on the costs and benefits of having a patent system. In the following passage, Hall (2009b:2) nicely summarizes the conundrum faced by regulators when it comes to designing a patent system:

> *'The patent system can generate both benefits and costs, for both innovation and competition. Economic analysis says first that competition may suffer when we grant a monopoly right to the inventor of a business method but it will benefit if this right facilitates entry into*

> *the industry by new and innovative firms, and allows the development of markets for technology. Second, innovation will benefit from the incentive created by a patent but may suffer if patents discourage or raise the cost of combining and recombining of inventions to make new products and processes. Thus, the relationship between patents, competition, and innovation is guaranteed to be a complex one, and one that may vary over time and across industries'.*

By drawing attention to the inherently multifaceted effect of patents on the economy, Hall suggests that we should look into the specific characteristics of management processes and services in order to decide if the competitive protection of business methods is justified. Although a comprehensive analysis and review of this topic is beyond the scope of this study, one thing is made clear from the results presented: business method patents can generate significant value for innovators. This finding, simple as it sounds, is still contested, as most critics of business method patents agree that these are often, vague, invalid and poor in quality. According to this view, business method patents only increase the systemic costs of intellectual property rights protection without producing any benefits for the economy (Barton, 2000; Dreyfuss, 2000). Yet, the event study results indicate that capital markets attach significant value to business method patents that may increase incentives to innovate in the non-technological domain.

It is important to emphasize though that this is not a call for IP regulators to reinforce the patenting of business methods as there are additional issues that need to be considered. First, it is not clear if business method patents create additional incentives to innovate as lock in, network effects, lead time and customer loyalty are thought to provide sufficient scope for appropriating returns from innovation (Dreyfuss, 2000). Second, the rapid diffusion of management innovations has been shown to contribute to important advances in the productivity and governance of corporations, thus generating substantial benefits to the economy as a whole (Chandler, 1962, 1977). Third, when innovations are incremental and when many different innovations must be combined to make a useful product, like in the case of business methods, it is less obvious that the benefits of the patent system outweigh its costs (Hall, 2003:16). Therefore, although this study provides some arguments in favor of business method patents, a more holistic approach is required to determine their overall usefulness to the economy.

5.6.3 Limitations

The results presented in this chapter have some limitations. First, because of the methodology employed, all the patents included in the sample were assigned to listed companies. Consequently, this study says little about innovation and appropriability in private companies.

Second, the estimates of business method patent value are not representative of the value of the entire population of business method patents. As explained before, listed companies tend to have more valuable patents. In addition, sampling was limited to patents applied before 2000 and granted until 2003. This could also result in overestimating the mean and median of the patent value distribution as inventors rushed to patent their most valuable business method innovations following the State Street vs. Signature CAFC decision.

Third, I used the stock market's reaction to the grant of a patent to estimate the total value of business method patents. This approach assumes rationality in the marketplace, i.e. the effect of an event will be immediately reflected in asset prices. Yet, it is important to emphasize that event studies reflect market's expectations about future profit resulting from the grant of a business method patent given the prevailing regulatory environment. Therefore, the impact of future changes in legislation is not reflected in the measures of patent value presented here. The patents analyzed were granted at a time when regulation was much more favorable in terms of their validity and protection. Hence, there are additional reasons to believe that estimates of patent value will be lower if patents granted in subsequent years are included in the sample.

5.7 CONCLUSION

To conclude, this study conducted additional empirical work focusing on business method patenting and its impact on non-technological innovators. Although recent work has focused more on highlighting the costs and benefits of USPTO's decision for the economy as a whole, there are fewer studies at the firm level. This is especially true for the relationship between innovation and appropriability. Hence, building a strong body of evidence is essential for understanding the process of non-technological innovation and for comparing the benefits of different strategies of appropriability. This is an important undertaking for innovation scholars given that business method patents are probably here to stay. As Hall (2009a:467) explains, excluding business methods *per se* from patentability is not really feasible given the difficulty of defining what they are. Indeed, intellectual property is becoming ever more important for competition and non-technological innovators should take note.

CHAPTER 6

DISCUSSION AND CONCLUSION

6.1 RESEARCH CONTRIBUTION

This dissertation builds on and expands the literature focusing on the strategic aspects of patenting. Although there is a voluminous literature exploring how patent rights help firms appropriate returns from innovation across different industries, technology sectors, jurisdictions etc, researchers have paid less attention to intra-firm differences in patenting strategies. This is despite the fact that we have good reasons to believe that a firm's resources and capabilities affect value captured through patenting – see for example Teece (1986), Somaya *et al.* (2007), Reitzig *et al.* (2009) and Somaya (2012) for a review. This dissertation then is part of a growing body of scholarship that attempts to uncover the mechanisms through which firms employ complementary resources and capabilities in conjunction with patent rights, in an attempt to increase appropriability.

The first empirical study presented in this thesis essentially provides the justification for a better understanding of patent strategies. It focuses on measuring patent value and demonstrates that the importance of firm resources and capabilities for patent valuation is much higher than previously thought. In particular, I performed a variance decomposition analysis and was able to assess the relative importance of firm resources for patent valuation by comparing heterogeneity in patent value across firms and technology fields. Given the emphasis in the existing literature on differences in patent use and value across technology fields, it would be reasonable to expect that technology characteristics are the main drivers of patent value after controlling for the quality of the patented invention. Surprisingly, I find that firm characteristics account for the largest portion of explained variance. I interpret these results as providing strong support for the view that complementary resources and, more generally, the design of patent strategy are crucial for profiting from innovation.

The second study builds on the insight that patents are differentially valuable to firms and explores the effect of changes in patent ownership resulting from corporate mergers and acquisitions. I find that the merging of overlapping patent portfolios in complex technology industries generates unique synergies that can be appropriated by the acquiring firm. This result emphasizes the interdependences developed between patent rights and the importance of combining internal and external patented technologies for appropriability.

Besides that, I identify the factors affecting the target selection strategies of technology acquirers. In particular, I find that firms are more likely to acquire targets with patents when (a) their patent productivity is low, (b) they have a technologically diverse patent portfolio in complex technology industries, and (c) they face an increased threat of being involved in patent suits. These results suggest that technology acquirers look into external technologies in order to complement a diminishing patenting output. In addition, the potential for creating synergies among patent rights is a strong motivation for targeting firms with patents. Finally, technology acquirers are actively trying to reduce their exposure to patent suits by strengthening their patent portfolios. Hence, corporate acquisitions should be seen as an integral part of patent strategy.

The third empirical study explores patenting strategy in the non-technological domain. I demonstrate that recent regulatory changes enabling the patenting of business methods can in fact help patentees capture value from business model and management innovations. Moreover, I find that patenting experience and access to complementary assets are both crucial elements of a patenting strategy aimed at increasing appropriability. Importantly, this study argues that patent strategies are not just relevant to high tech industries, but to a wide range of sectors in the economy.

6.2 IMPLICATIONS FOR THEORY

Taken together, the results of the empirical studies included in this dissertation have significant implications for theories of strategy and appropriability. To begin with, a reconceptualization of the concept of patent value is proposed, with the emphasis put on the interactions between firm resources and patent rights. Although it is obvious that different firms profit from patents differently, here I emphasize the magnitude of complementarity developed between patents and firm resources. Hence, when measuring patent value it is important to bear in mind that such estimates are unlikely to be relevant for a wide range of firms. Indeed, measuring patent value could be likened to estimating random variables, where there is no fixed value attached but rather a set of possible different values. In the case of patent rights, the ‘stochastic’ or variable component is substantial and is attributed to differential access to complementary resources and capabilities by the potential assignee firms.

Related to that, a more general point about regimes of appropriability is worth noting. Although Teece’s (1986) framework suggests that the efficacy of legal mechanisms for protecting innovation is exogenously determined, my results suggest that patent effectiveness is better understood as determined, at least partly, by interactions with other firm resources. Hence, the implicit model of appropriability presented here endogenizes patent effectiveness. Thus, it would be useful to ask not only ‘whether patenting is a good strategy for technology A’, but also ‘whether patenting is a good strategy for firm A with given resources and capabilities’.

This point has also implications for the way we understand the role of complementary assets, one of the building blocks of Teece’s theory of appropriability. A corollary of my analysis is that, like patent rights, the value of complementary assets has an idiosyncratic component, which depends on the patenting resources/capabilities of the firm. Hence, when considering their effect, it is important to bear in mind that complementary assets develop important interdependencies with intellectual property rights. For example, a number of studies explain that complementary assets shape firm growth trajectories by demonstrating that manufacturing or marketing assets are important determinants of market entry (Helfat *et al.*, 2000; Morton, 1999; Tripsas, 1997). Patent strategy should be seen as an important moderating variable in this relationship though as it determines jointly with complementary assets profit opportunities from entering into new market segments.

Here, I emphasize the positive interaction between patent rights and complementary assets. Of course, this is a well-established fact as innovators are found to increase appropriability through owning both patents and complementary assets (Arora *et al.*, 2006; Pisano, 2006; Rothaermel, 2001). Nevertheless, my results provide further support to this finding as I test this link across various different industries. Importantly, I demonstrate that this relationship holds for non-technological innovations. This is a key extension of Teece's framework as chapter 5 is the first study to provide support for the existence of synergistic gains from patents and complementary assets in the non-technological domain.

Patent strategy then should be seen as a crucial component of a firm's technology strategy as it enables assignee firms to enhance appropriability through the deployment of complementary resources and capabilities. These are likely to affect the various domains of patent management, including acquisition, licensing and enforcement (Somaya, 2012), and generate important synergies with patent rights. Importantly, such resources are not necessarily developed internally, but firms regularly acquire these from their external environment. For example, patenting experience is a capability developed internally and helps firms capture more value from business method patents – see chapter 5. In contrast, chapter 4 suggests that corporate acquisitions are an important channel through which firms strengthen their patent portfolios.

This last point highlights the link between patent and corporate strategy. Although theories of vertical and horizontal scope explicitly acknowledge the role of synergies, studies of patent rights as sources of synergy in high tech sectors are not common. This might sound counterintuitive given the plethora of papers using patent-based measures to theorize about diversification decisions, acquisition benefits etc. However, such studies primarily use patent data to proxy other unobservable firm characteristics, such as knowledge expertise, innovative capabilities etc. Instead, I emphasize in this dissertation the role of patents as property rights, that is rights over a specific part of the technology space, and suggest that there are important synergies from combining previously separate patent rights.

6.2.1 Implications for the Resource-Based View of the Firm

Although this thesis is primarily concerned with the design of patent strategy, the results and empirical design have some interesting implications for RBV. In chapter 2, I explain how RBV has been criticized for its poor operationalization of resources and the inability to provide empirical support for its various predictions (Arend, 2006; Kraaijenbrink *et al.*, 2010; Priem *et al.*, 2001). These criticisms are evident in chapter 4 where I describe the problems associated with testing Barney's (1988) hypothesis. This hypothesis focuses on the generation of unique synergies between acquirer and target but the literature offers competing explanations about whether unique synergies are attributed to resource similarity or complementarity. In chapter 4, I demonstrate that a simplistic approach to resource comparison is bound to cause confusion as these measures fail to account for the underlying mechanisms of value creation and capture.

Instead, an emphasis on the micro-processes of resource interdependence is necessary in order to improve the predictive power of RBV.

Of course this is just an example of how to approach the empirical testing of resource-based propositions, in this case the resource-based view of acquisitions. Patent data are ideal in this respect with the depth and breadth of information they contain. However, other questions can be tackled with a similar focus on detailed accounts of resource interdependence. Although such datasets are unlikely to be readily available for all possible questions, it would be worthwhile to invest in creating more detailed accounts of firm resources and the interactions developed between them.

6.3 IMPLICATIONS FOR EMPIRICAL METHODOLOGY

In this dissertation I use fairly well established methods to analyze my data, including the event study methodology, variance components analysis and OLS or logistic regression analysis. Although my analytical approach is not novel in the sense of offering new methodological tools, a number of insights related to the design of empirical studies within the technology strategy area are worth noting.

First, patent rights do not necessarily 'behave' in the same way across sectors or industries. As demonstrated in chapter 4, patent-based measures can exhibit dramatically different outcomes depending on the nature of the underlying technology. Hence, it is important to take into account the differences in complex- and discrete-technology industries and check the robustness of the results across different settings before offering any generalizations. Besides measures of synergy, innovation cumulativeness and the resulting interdependence among patent rights are likely to affect measures of knowledge flows, knowledge foci etc. In fact, important theoretical insights might lie in the differential effect of patent-based measures across technology sectors.

Second, in chapters 3 and 5 I argue that the event study methodology can be usefully employed for measuring patent value. As explained before, there are various challenges when trying to infer the impact of an event or corporate announcement based on the reaction in the stock exchange (Campbell *et al.*, 1997; MacKinlay, 1997). Here, however, I suggest that some of these problems can by addressed when using pre-2001 US patent data. It would be worthwhile to consider other jurisdiction where regulatory or other characteristics allow for event studies to be used in the context of patent valuation.

Third, the results presented here highlight the importance of combining data on patent litigation in studies of acquisitions in high tech sectors. In chapter 4, I demonstrate that the number of patent suits preceding an acquisition is a key determinant of whether a target with patents (as opposed to a target without patents) is selected. Interestingly, the impact of patents suits on the likelihood of acquiring a target with patents is far more important than that of R&D spending, patent portfolio quality, patent productivity etc. Hence, future studies should incorporate this dimension and treat patent litigation as important antecedent of technology acquisitions.

6.4 IMPLICATIONS FOR PRACTICE

The results presented here have also important implications for practice. First, when choosing between patenting and other strategies of appropriability, R&D managers should consider whether the firm has sufficient complementary resources and capabilities that will allow them to capture value from patenting. Hence, the decision of whether to file for a patent or not should not be taken solely with reference to industry characteristics, such as the nature of the underlying technology, the licensing opportunities available, the competitors' patent strategies etc. Firm characteristics, such as ability to enforce and commercialize the patented invention, are important determinants of the patenting decision.

In more detail, the research findings in this thesis confirm the importance of complementary assets for capturing value from patents (Arora *et al.*, 2006; Teece, 1986). Hence, firms are better off when they are able to combine the in-house commercialization of innovation with the limits to competition resulting from patent protection. In addition, I provide results consistent with suggestions that firm size matters for patenting (Lanjouw *et al.*, 2004b; Lerner, 1995). In particular, I find positive correlations between patent value and firm size in chapter 3 which could be interpreted as evidence that larger firms are better able to enforce their patent rights. Finally, I provide new evidence in chapter 4 suggesting that the technological interdependencies developed among patent rights can be harnessed by patentees. This point is particularly relevant to complex technology industries where firms can benefit by blocking certain parts of the technology space through the ownership of overlapping patents.

Second, the design of patenting strategy should be seen by managers as a balancing act between acquiring resources from strategic factor markets and internally developing the resources and capabilities that increase appropriability. Importantly, the two approaches should not be seen as mutually exclusive. Firms should invest in identifying imperfections in strategic factor markets, including the market for corporate control and the market for patent rights, that allow them to profit by complementing their patent portfolios. As suggested in chapter 4, simply identifying synergies is not enough though. These need to be unique in order to ensure that the excess value will be distributed between both acquirer and target.

Third, I emphasize that patent strategies are relevant to sectors other than pharmaceuticals, semiconductors etc that are traditionally associated with patenting as important means of competition. Non-technological innovators are now able to rely on patent protection, at least in certain jurisdictions, and as a result increase appropriability. This is especially important for service providers, who usually lack the skills required to utilize and enforce patent rights. Although the boundaries of such protection are unclear, as the definition of what kinds of non-technological innovation constitute patentable subject matter constantly changes, non-technological innovators need to build the skills and capabilities required to manage the patenting process. This will allow them to capture additional value from their management or business model innovations while successfully navigating an increasingly fragmented technology space.

These insights suggest that the strategic management of patents requires increased attention by senior management and the establishment of managerial systems that will allow firms to increase value appropriation. A number of specific recommendations can be put forward. To begin with, the role and importance of the general counsel in the corporate hierarchy needs to be upgraded. This will bring important patenting expertise in the top management team and result in better-informed corporate decision-making. For example, when evaluating potential acquisition targets, the general counsel can bring important insights regarding what kind of synergies can be achieved by merging the patent portfolios of the two entities. In addition, the general counsel can help design the organizational structure of the firm with a view to increasing the interaction between the R&D, legal and other departments.

Besides that, other members of the top management team or the board of directors would benefit from increased expertise in patenting. This could be done, for example, through recruitment or through corporate training programs and result in increases in both technological and financial performance. As suggested in this thesis, value appropriation through patenting is a function of various different resources – technological and non-technological – and an understanding of the patenting process across the different corporate functions is essential. Indeed, Somaya *et al.* (2007) have found that the patenting output of firms increases with the level of in-house patent law expertise and the top management team's patent law background.

Finally, firms will benefit from building interdisciplinary teams, including patent lawyers, scientists and general managers, that will monitor the technological space and identify threats or opportunities related to patent rights. Such diversity is important, as this dissertation makes clear that patent value is comprised of many different elements. Hence, it is crucial to gain a good understanding of all the interdependencies between patents and other resources and communicate these insights to the top management layers. For example, such teams can scan the environment in search of opportunities to acquire patents in markets for technology or markets for corporate control. In addition, they can customize strategies of appropriability according to both firm- and technology-specific characteristics and assess ways to manage litigation risk.

6.4.1 Implications for Policy

This is a strategic management dissertation and does not attempt to directly contribute to issues related to public policy. However, given the emphasis on patents, there are some implications for intellectual property rights regulation. To begin with, policy makers should note that the strength of intellectual property rights is not just a function of the regulatory environment, e.g. the definition of patentability, the enforcement of patent rights by courts etc. In fact, firms face different regimes of appropriability depending on their ability to enforce their patent rights. For example, small firms are limited in their ability to enforce their patents given the high cost of monitoring infringers and engaging in patent litigation. It is important to acknowledge this given that the patent system's primary role is to incentivize innovators. If it provides different incentives according to some characteristics (e.g. access to complementary assets or ownership of overlapping patents), then innovation will be encouraged amongst this group of firms.

Chapter 5 focuses on the patenting of management and business model innovations and touches upon the question of whether patentability should be expanded to the non-technological domain. As suggested before, this study demonstrates that business method patents provide value to innovators but does not attempt to compare their costs and benefits to society. However, it would be interesting to consider their impact, especially taking into account the effects of previous patent reforms. In particular, there is evidence that the strengthening of intellectual property protection does not necessarily increase innovative output. Studies of patent law reforms in Japan (the 1988 patent reform significantly expanded the scope of patent rights) and the US (introduction of CAFC in 1982) have reached similar conclusions (Jaffe, 2000; Kortum *et al.*, 1998; Sakakibara *et al.*, 1999). Moser (2003) though demonstrates that patent laws have important effects in changing the direction of innovation. Hence, providing the results of these studies are applicable to business method patenting, the expansion of patentability to the non-technological domain is likely to result in innovative resources being transferred from the technological to the non-technological domain.

Finally, chapter 4 points to some potential benefits of mergers and acquisitions in high tech sectors. In general, mergers and acquisitions are considered problematic by regulators due to their anticompetitive effects. Here, however, I suggest that they are likely to reduce the costs of patent litigation when they help balance the relative strength of patent portfolios between two suitors (and as a result achieve settlement). Patent litigation costs are systemic costs arising from imperfections in the function of the patent system and impose a deadweight loss to society. Reducing such costs is likely to benefit competition and consumers alike. Hence, in any jurisdiction, the design of regulation over patents should be more closely linked with competition policy.

6.5 AVENUES FOR FUTURE RESEARCH

The findings presented here provide an interesting set of questions that need to be addressed by future research.

In chapter 3, I was able to demonstrate the interdependence between patent value and patent portfolio composition. However, my analysis suggests that additional firm characteristics mediate this relationship. Hence, it would be interesting to discover what other organizational resources and capabilities increase the value of patenting. In addition, how can the insight that patent value varies according to assignee firm characteristics be incorporated in formal models of technology licensing? Existing models tend to emphasize the trade-off between licensing revenues and increased competition while assuming that a patented technology is equally valuable to both transacting parties. It would be interesting to see if their results hold when relaxing this assumption. Finally, to what extent does a large idiosyncratic component affect patent litigation process? If patent value varies considerably according to observable firm characteristics, it would be interesting to understand how changes in those affects assignee firms' propensity to enforce their patents.

In chapter 4, I focus on the antecedents and synergy opportunities of technology acquisitions. However, the literature on technology acquisitions would benefit by further exploring the heterogeneity of target firms. The majority of studies in the literature view targets as inputs to the acquirers' innovation function with little or no consideration for their characteristics. Here, I demonstrate that the ownership (or not) of patents by the target significantly affects acquirers' selection. Additional characteristics are likely to affect target selection and acquisition performance though. For example, what types of acquirers select targets with diverse patent portfolios? Or, how does the selection of targets with a focus on radical innovations affect acquirers' subsequent inventive performance?

Chapter 5 takes an important step in extending the study of appropriability in the context of non-technological innovation, but much work remains. Future research could explore the third building block of Teece's appropriability framework, the dominant design paradigm, and its implications for profiting from non-technological innovation. Although this is a heavily researched topic in various manufacturing industries (Suarez *et al.*, 1995; Tegarden *et al.*, 1999), dominant designs and their implications for profitability and survival are not well understood in the non-technological domain. For example, is there scope for the emergence of multiple designs in services and how does this affect value creation and appropriation?

Another area for future research would be to further explore the patenting behavior of non-technological innovators. While this study demonstrates that business method patents are valuable, a more detailed survey of business method patent assignees would help better understand their role, use and effectiveness in the innovation process. For example, are business method patents licensed and what are the challenges, if any, in this process? How does patenting compare to other method of appropriability in the non-technological domain? Are business method patents perceived to be as effective as patents in manufacturing industries? Further work in this field could also look at the effect of regulatory uncertainty on the incentives to innovate. Given that the definition of patentable subject matter has changed repeatedly in the past decade, it would be interesting to consider the impact of such decisions on the innovative output of the economy.

Besides these ‘chapter-specific’ suggestions, interesting research ideas arise from combining insights from all three chapters. In particular, chapter 3 explores the idiosyncratic component of patent value but sample selection is limited to technological innovations. It would be interesting then to examine the idiosyncratic value component of business method patents and compare that to the idiosyncratic value of technology patents. The literature on business model and management innovation puts emphasis on their path dependent nature and interdependence with other system components (Birkinshaw *et al.*, 2008; Teece, 2010; Zott *et al.*, 2010), thus implying a large idiosyncratic value. It would be interesting nevertheless to empirically verify this proposition.

Moreover, chapter 3 predicts that the demand for patent rights in markets for patents will be reduced because of the idiosyncratic value component of patent value. Instead, we should observe the transfer of patent rights via other channels such as corporate acquisitions. Chapter 4 demonstrates that technology acquisitions are a major channel through which changes in the ownership of patent rights occurs, but does not formally test the choice of acquisition strategy. That is, why would acquirers choose to buy individual patents or collection of patents in markets for patents versus buying the whole company, including its patent rights, in markets for corporate control? The higher the interdependence between patents and firm resources, the higher the level of aggregation we should observe in such transactions. This is a crucial question for strategic management, focusing on how firms identify and take advantage of profit opportunities in strategic factor markets. Hence, additional work exploring this question would benefit both the literature on markets for technology and more broadly the resource-based view of the firm.

6.6 CONCLUSION

This dissertation contributes to the study of appropriability by exploring the role and importance of patent strategy for capturing value from innovation. I define patent strategy here as the actions undertaken by firms to employ resources and capabilities, in conjunction with patent rights, in order to increase appropriability. Although the existing literature focuses on some aspects of patent strategy, it is unclear how much it matters for profiting from innovation. Hence, I set out to explore two questions:

first, what is the contribution of patent strategy to performance and, second, what are the constituent elements of patent strategy.

By combining insights from RBV and the patenting literature, I demonstrate that firm resources and capabilities develop important interdependencies with patent rights that shape a firm's ability to capture value from patenting. Hence, the design and execution of patent strategy is a key component of competitive advantage, especially in industries where patents are important means of competition. In addition, I find that patent strategy involves both the acquisition of resources from the environment and the internal development of resources and capabilities. I also demonstrate that patent strategy is not just relevant to high tech sectors, but also to non-technological innovators given that patentability is expanding to management and business model innovations.

Taken together, these results provide more clarity to theories of appropriability by bringing a resource-based logic to the study of patenting. Of course, much work remains in order to fully understand how firms use and profit from patents. In fact, given that competition in modern economies is becoming increasingly reliant on knowledge and its protection, exploring the various facets of patent strategy is crucial for strategy and innovation scholars alike. Hence, this dissertation concludes by highlighting the importance of patent strategy and the need to further explore its various components.

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APPENDIX

Examples of patents in subject matter categories as defined in Table 5.1

A) Financial

United States Patent	6,009,415
Shurling , et al.	December 28, 1999

Data processing technique for scoring bank customer relationships and awarding incentive rewards

Abstract

A Relationship scoring and Incentive Reward awarding process determines a Relationship score for the Relationships between a Bank and each of its customers. Such Relationships may include deposit accounts, loan accounts, and customer referrals. Customer data describing the Relationship between the Bank and its customers is furnished by the customers and extracted from a Bank customer information file. Incentive Rewards, such as reduced loan rates or increased deposit account interest, are awarded to customers based on the Relationship scores. Management reports summarize the Relationships between the Bank and its customers and provide marketing information.

Inventors:	**Shurling; Larry W.** (Barnesville, GA), **Nimis; Gregory R.** (St. Paul, MN), **Reagle; Granville S.** (Littleton, CO), **Motschenbacher; Darlene M.** (Burnsville, MN), **Hansen; Wayne P.** (Shakopee, MN)
Assignee:	**The Harrison Company, LLC** (Denver, CO)
Appl. No.:	**07/808,324**
Filed:	**December 16, 1991**

Current U.S. Class:	***705/35***
Current International Class:	G06Q 30/00 (20060101); G06Q 40/00 (20060101); G06F 157/00 ()
Field of Search:	364/405,408 395/235 705/35,30

B) Insurance

United States Patent	6,009,402
Whitworth	December 28, 1999

System and method for predicting, comparing and presenting the cost of self insurance versus insurance and for creating bond financing when advantageous

Abstract

A system and method for predicting, comparing, and presenting the cost of self insurance versus insurance for property, casualty, or employee benefit liabilities, and for creating bond financing when advantageous. For a self insured entity, the cost of insurance is estimated by reviewing available data from actuarial studies, claims audits, loss runs, similar self insureds, recent similar insurance deals and rating agencies. These preliminary pricing estimates are used to decide if pursuing insurance is likely to provide savings to the self insured. Suggested pricing estimates are also provided to facilitate marketing the program to insurance carriers. If a carrier offers an insurance program which provides savings and the insured entity requires bond financing, the system is adapted to calculate bond payments based on budget constraints or claims payout patterns.

Inventors:	**Whitworth; Brian L.** (Malibu, CA)
Appl. No.:	**08/901,762**
Filed:	**July 28, 1997**

Current U.S. Class:	**705/4** ; 705/400
Current International Class:	G06Q 40/00 (20060101); G06F 017/60 ()
Field of Search:	705/1,4,36,400

C) Healthcare

United States Patent	**6,003,006**
Colella , et al.	**December 14, 1999**

System of drug distribution to health care providers

Abstract

A system and method are described in which a drug distribution center operates a computer software drug inventory management program in electronic communication with a health care provider computer software program for drug distribution to patients. The system and method preferably incorporate low unit dose measure drug packaging including bar codes. The bar codes may be scanned into either software program for automatically tracking such information as drug lot numbers and expiration dates.

Inventors:	**Colella; Salvatore J.** (New Kensington, PA), **Lawrence; Stephen M.** (Lexington, KY), **Widenhofer; Gerald J.** (Dublin, OH)
Assignee:	**Pyxis Corporation** (San Diego, CA)
Appl. No.:	**08/762,041**
Filed:	**December 9, 1996**

Current U.S. Class:	***705/2*** ; 700/237
Current International Class:	G06Q 10/00 (20060101); G06F 19/00 (20060101); A61J 1/00 (20060101); A61J 1/03 (20060101); A61J 7/00 (20060101); G06F 017/60 ()
Field of Search:	705/2,26,28,29,30,34,14,8 364/479.07

D) Accounting

United States Patent	**5,724,523**
Longfield	**March 3, 1998**

Electronic income tax refund system utilizing the tax refund to underwrite issuance of a secured credit card

Abstract

Electronic data processing system for preparation of electronically filed tax returns and authorization and payments of refunds based on the data supplied in those returns. Electronic data processing programs are provided for creating an electronic tax return that is filed with a tax collecting authority. At the same time as the electronic tax return is created a loan application is processed to create an electronic deposit/loan account for the tax filer at an authorized credit institution. The tax filer can receive a loan or use the tax refund as collateral for a secured credit card. As early as the day after completion of the tax return and loan application, the tax filer receives initial refund payment from the loan account. The authorized credit institution electronically files the electronic tax return with the tax collecting authority which processes the return and transfers by electronic fund transfer the refund amount to the deposit/loan account at the authorized credit institution. Any refund in excess of the initial refund payment is then forwarded to the tax filer. Provision is also made for checking the credit worthiness of the tax filer.

Inventors:	**Longfield; Ross N.** (Far Hills, NJ)
Assignee:	**Benefical Franchise Company, Inc.** (Wilmington, DE)
Appl. No.:	**08/491,615**
Filed:	**June 19, 1995**

E) Legal

United States Patent	**5,999,907**
Donner	**December 7, 1999**

Intellectual property audit system

Abstract

An intellectual property computer-implemented audit system for valuing an intellectual property portfolio includes a first database storing first information relating to the intellectual property portfolio and a database access and collection device connected to the first database and accessing the first database and retrieving the first information. In addition, the intellectual property audit system also includes a second database storing empirical data relating to known intellectual property portfolios, and a comparison device connected to the database access and collection device and to the second database, the comparison device receiving the first information from the database access and collection device and comparing the first information to the empirical data retrieved from the second database producing an intellectual property worth indicator indicating the worth of the intellectual property portfolio.

Inventors:	**Donner; Irah H.** (Silver Spring, MD)
Appl. No.:	**08/161,816**
Filed:	**December 6, 1993**

Current U.S. Class:	***705/310***
Current International Class:	G06Q 10/00 (20060101); G06F 153/00 ()
Field of Search:	364/401,406,408,710 705/1,10,22,24

F) Management

United States Patent	**6,009,408**
Buchanan	**December 28, 1999**

Automated processing of travel related expenses

Abstract

A system (10) for facilitating the processing of travel related expenses includes a database (40) which stores a traveler profile (50), a customer profile (52), and a traveler category rule set (56). A controller (36), connected to the database (40), receives travel itinerary information for a traveler associated with a customer (12). The controller (40) determines a specified amount of funds to be allocated to the traveler and transfers the specified amount of funds from an account of the customer (12). In addition, the controller (40) provides at least a portion of the transferred funds to the traveler, for example, through an automatic teller machine network (20). The controller (40) receives a record, for example, via an electronic data interchange interface (24), of any transactions in which the traveler spends the portion of transferred funds, thereby facilitating the processing of travel related expenses.

Inventors:	**Buchanan; Carla C.** (Mission, KS)
Assignee:	**Electronic Data Systems Corporation** (Plano, TX)
Appl. No.:	**08/625,971**
Filed:	**April 1, 1996**

Current U.S. Class:	***705/5***
Current International Class:	G06Q 40/00 (20060101); G06F 017/60 ()
Field of Search:	705/1,5,6,7,11 235/375,376,379,380