BUSINESS METHOD PATENTS AS REAL OPTIONS: VALUE AND DISCLOSURE AS DRIVERS OF LITIGATION

Atul Nerkar, Srikanth Paruchuri and Mukti Khaire

ABSTRACT

This paper proposes that patents are real options that allow holders of patents the right but not the obligation to sue others. We suggest that the likelihood of a patent being litigated is positively associated with value of the patent and the extent of disclosure (prior art cited) in the patent. However, under conditions of greater value, increases in disclosure reduce the likelihood of litigation of the focal patent. Similarly, under conditions of greater disclosure, increases in value reduce the likelihood of litigation of the focal patent. Rare events logit analyses of business method patents that were litigated, compared to patents that were not litigated, offer empirical evidence supporting the hypotheses.

A patent is nothing but the right to sue
– CEO of an Intellectual Property licensing company

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Knowledge codified as intellectual property is considered a key asset that can deliver competitive advantage and superior performance for firms (Argote, McEvily, & Reagans, 2003; Cockburn, Henderson, & Stern, 2000; Spender, 1996). Considerable research exists on the drivers of research and development activities that lead to the creation and protection of such intellectual property (Helfat, 1994; Lanjouw & Schankerman, 1997). That said, this stream of research has typically considered patents as a means of protecting the intellectual property developed by a firm. While we do not take issue with the well-known fact that patents can provide barriers to entry, we incorporate a different but complementary view of patents in this paper; we consider patents to be real options that provide the right to sue other firms but not the obligation. More specifically, we argue that firms sue other firms as a way of exercising the real option represented in the patent granted to them. Our paper suggests that the likelihood of litigation of a patent is a function of the value of the patent as well as the extent of disclosure in the patent. Further, under conditions of greater value, the relation between disclosure and likelihood of litigation is negative as compared to conditions when the value is lower. Similarly, under conditions of greater disclosure, the relation between value and likelihood of litigation is negative as compared to conditions when the extent of disclosure is lower.

Past and recent research on real options has considered a whole host of decisions as real options – joint ventures (Cuypers & Martin, 2007; Kogut, 1991), R&D (Kumaraswamy, 1996; McGrath & Nerkar, 2004), project management (Huchzermeier & Loch, 2001), and venture capital investments (Guler, 2007; Hurry, Miller, & Bowman, 1992). In contrast, this paper contributes to the empirical research on real options by offering new insights into the factors that affect the likelihood of litigation by considering patents as real options (Reuer & Tong, 2007). These insights highlight the duality of the disclosure of information in the patent i.e. prior art cited in the patent can act as a building block of knowledge that allows other firms to imitate and infringe the patent as well as a fence that marks out the boundary of the intellectual property covered by the patent. Our findings are counter-intuitive, as they suggest that patent holders may be hoping for infringement of patents filed as real options in contrast to hoping for protection, which is expected when they are filed as isolating mechanisms. Further, potentially high value patents are more likely to have less prior art disclosed, compared to low value patents as the cost of citing a patent is non-trivial (Trajtenberg, 1990); under conditions of high value prior art is likely to act as a fence, while under conditions of low value prior art is likely to act as a building block. The remainder of the paper is developed as follows. We first make the

argument for patents as real options. In the next section, we develop hypotheses relating the likelihood of litigation of patents with their underlying value and their infringement. In the third section, we describe our data collection procedures, analytical techniques, and results. We conclude with a discussion of the implications for research and practice.

THEORETICAL BACKGROUND

Patents as Real Options

Traditional forms of protecting knowledge include, but are not limited to, patents, trademarks, and trade secrets (Levin, Klevorick, Nelson, & Winter, 1987). The accepted economic reason for allowing patents on inventions and innovations is the 'reward or incentive' hypothesis. This notion suggests thatin the absence of patent protection, inventors would have little incentive to invest in innovative activity (Anton & Yao, 1994). Specifically, given that potential profits accruing from innovations would be rapidly reduced to the marginal cost of producing the innovations, it would not make any economic sense to invest in uncertain activities such as research and development. Also, because mechanisms such as trade secrets are less likely to protect the new knowledge generated, there would be a general tendency in society to be less innovative. Because of the monopoly rights that they grant to the innovator, patents are considered to help public welfare through the requirement of disclosure i.e. the requirement that a patent provide a complete description of the innovation. The implied assumption is that the inventor knows the usefulness and value of the patented innovation even though the underlying process by which such innovation emerges may be uncertain (Nelson & Winter, 1982).

However, the efficacy of patents in preventing imitation or market entry has varied across sectors. Levin et al. (1987) found that patents were effective isolating mechanisms in the pharmaceutical, chemical, and semiconductor industries. In many other industries, however, patenting did not provide any competitive advantage to the holder or assignee of the patent. That said, there has been an upsurge in patenting in the 1990s across all sectors including pharmaceuticals, chemicals, and electronics (Kortum & Lerner, 1999). While this upsurge can be partly explained by the huge changes in technology and R&D, other explanations such as changes in the patenting law itself as well or the motivations of the assignees of the patents are also plausible.

The debate of the efficacy of patents as a method to increase innovative productivity is beyond the scope of this paper.[1] However, it is important to highlight one empirical fact, which has been pointed out by researchers studying R&D, technological change, and patents that majority of the patents granted by patent offices across the world are worthless (Pakes, 1986). This then begets the question why do firms file for patents? The answer lies in a complementary view of patents as real options. According to Kitch (1977), one of the first researchers to formally state this complementary view:

> The importance of the prospect function in the American patent system is argued from three features of the system. The first is the scope accorded to the patent claims, a scope that reaches well beyond what the reward function would require. Second, there are rules, such as priority, time-bar, and patentability rules, which force an early patent application whether or not something of value (and hence a reward) has been found. And third, there is the fact that many technologically important patents have been issued long ago before commercial exploitation became possible.

If patents are prospects, firms need to explore these prospects to generate revenue. There are three lines of action before a patent holder. First are the rights but not the obligation to leverage a patented invention into a commercial product. Second are the rights but not obligation to license the invention to other firms by using the patent to resolve the 'trading in knowledge' problem (Arrow, 1962). Both the rights of licensing and leverage are helped by a third line of action available to a patent holder i.e. the right to sue (litigate against) any party that infringes the patent and seek damages and/or royalties. This right, though primarily an enforcement mechanism for the other two rights (leverage and licensing), has in itself become a line of action in the pursuit of profit. Other researchers studying patents through the options lens as well as other theoretical approaches have focused on the right to license and leverage the technology underlying the patent (Shane, 2002; Ziedonis, 2003a), while scholars in legal studies and economics have studied the determinants of patent litigation without invoking a real options framework (Lanjouw & Schankerman, 2001). In contrast, this paper focuses on the right to litigate that is offered by a patent through a real options framework.

There are issues with testing this complementary view of patents as a prospect system that allows the grant of real options. A real option as defined in the literature is the right but not an obligation bought for a small investment (also known as option price) on the part of a firm or entity to continue or not continue with a set of activities in the future (Mitchell & Hamilton, 1988). Any real option decision has four features to it: a relatively small investment, uncertainty with respect to the course of future action associated with the patent, boundedly rational decision makers, and a time frame in

which the decision has to be made. A patent is analogous to a real option as it allows the firm that files the patent the right to license, litigate, or leverage the patent for a small investment (filing fee along with attorney fees) compared to the costs of subsequent litigation, licensing, or leverage.[2] Further, the carrying costs of this option are presumably small or trivial compared to the gains from exercising the right to sue. There is uncertainty with respect to the course of action to be followed and finally patent validity is limited to 20 years.

Scholars have criticized research in the real options area as not having shown evidence ruling out alternative explanations (Adner & Levinthal, 2004; Coff & Laverty, 2001; Garud, Kumaraswamy, & Nayyar, 1998). More specifically, for a decision to have a real options explanation, researchers should be able to demonstrate the opening of the option as well as its exercise. Further, the exercise of the option has to be connected with the value of the asset covered by the option. Research on patents as options in general alleviates the first criticism by examining the exercise of the right to sue conferred by a patent. However, the right to sue is not exercised with the intention to profit in some sectors, especially those that involve systemic technologies such as semiconductors, as the patent instead of being an option on methods of increasing profits acts as a defensive mechanism to protect existing profits. Further, in these sectors the right to sue is also a function of a host of other factors other than the value of the option. For instance, the large pharmaceutical companies are more likely to sue or get sued since they maintain huge legal departments. While these firms may adopt real options reasoning in their investments, it is difficult to separate the 'prospective profit' motive from defensive intentions of patenting (McGrath & Nerkar, 2004). We handle these issues by choosing a sector, business method patents (described in greater detail in the methods section), which represents a level playing field with respect to all firms irrespective of sector or size. By level playing field we mean that investments in the underlying technology of business method patents in the form of physical plant, equipment, and/or personnel are not huge as in the case of research and development in areas like pharmaceuticals and chemicals.

Given a situation, where firms file patents as options with expectations of profit through litigation, which patents do get litigated and why?

HYPOTHESES DEVELOPMENT

Considerable research exists on the enforcement of property rights, both real and intellectual. We draw from this theory to develop specific

hypotheses linking patent attributes to likelihood of litigation. The rights to intellectual property are protected in two ways: by court orders that stop infringement and by holding the infringer liable to damages (Schankerman & Scotchmer, 2001). The damages are decided on the basis of lost profits of the patent holder and unjust enrichment enjoyed by the infringer. In the context of patents, a necessary condition for filing a suit is the *belief* that the property rights of the patent holder have been violated or infringed upon by another firm or entity (Cooter & Rubinfield, 1989). In the absence of this belief a suit will not be entertained in any court. Given that a patent has been filed explicitly with the intention to explore the right to sue, a firm looking to gain from such litigation is more likely to enforce patents through litigation if they have been infringed.

However, research on litigation shows that in many cases firms file law suits (in spite of clear lack of evidence) where the issue at stake is of considerable value. Such litigation has also been called 'bounty hunting' (Besaha, 2003). The intention is to try for settlement without taking the suit to adjudication. In the case of computer software, submarine patenting is often resorted to in order to harvest the benefits of such litigation. For instance, Unisys filed a suit for infringement against Compuserve after obtaining a patent on an algorithm that formed the basis of the graphics interchange format (GIF) protocol (Lerner & Conway, 1996). GIF had become a de facto standard in the computer graphics area because of its 'public' nature at the time of its initial development. This did not prevent Unisys from filing suits of infringement against users. The value resulting from such settlements is an important reason for exercising the option to sue independent of whether the patent has been infringed.

Financial options theorists have used the Black-Scholes model for valuing financial options (Black & Scholes, 1973). However, the application of this model for valuing real options is impractical as the estimates for the various parameters involved in the Black-Scholes formula are at best assumptions (Black, 1992). However, one can use the logic behind the Black-Scholes formula to understand the reasons for litigation. According to this model, an option will be exercised when the option is 'in money' i.e. the benefits from exercising the option are greater than holding it. Researchers studying real options are unequivocal about the factors that drive option value (Pitkethly, 1997). The four factors that are considered key to option value as per the Black-Scholes formula are the stock price (value of the knowledge contained in the patent), exercise price (preliminary filing costs for legal action to sue), time to expiration of the patent, and volatility of the returns (Black & Scholes, 1973). A patent is valid for 20 years from filing date after

it has been granted, while the cost of filing a suit would be similar across patents in a technical area (as in business method patents).[3] Finally, the volatility of the returns would be similar for patents in the same technical area. After controlling for the technical area in which a patent is granted, the decision to sue is dependent on the value of the option, which in itself is dependent on the stock price or the value of the patent.

The two factors – infringement and the value of the intellectual property covered in the patent – are therefore independently and jointly associated with the likelihood of litigating a patent.

INFRINGEMENT, DISCLOSURE, AND LIKELIHOOD OF LITIGATION

The cost of obtaining the patent is miniscule compared to the cost of starting and continuing the litigation (Llobet, 2003). A patent holder needs to decide whether or not to exercise the right to sue other firms for damages and/or royalty payments. Patents grant a temporary monopoly (right of excluding others from using, selling, or in any other way distributing the ideas covered by the patent) to the owner. The price of this protection is disclosure about the invention by the inventors. The monopoly provides the inventor with the incentive to make the invention public, while the disclosure helps spur innovation by other inventors who can now use the patented knowledge in subsequent work (Scotchmer & Green, 1990). The disclosure of the invention is thus a double-edged sword. The formal objective of the patent system is to increase innovative productivity while providing property rights to the patent holder. However, the nature of the disclosure in the patent can lead (as described later) to imitation, reengineering, and consequently infringement.

Disclosure of a patent typically contains details of the inventive process as well as the references or knowledge on which the inventive process is based. The nature and disclosure of prior art can lead to infringement of the intellectual property covered by the patent in three ways and consequent exercise of the option to sue. First, prior art provides a link to the building blocks of the innovation that have been recombined. R&D processes are recombinant in nature, and by examining the prior art provided in the focal patent, other firms can imitate the invention by recombining the same prior art (Fleming, 2001). This may lead to infringement and decision by the firm holding the patent to sue. Second, the presence of prior art is also an indicator of other firms that are active in the area covered by the focal patent.

Technological crowding is likely to lead to infringement and exercising the right to litigation. Third, prior art that is public knowledge and is well established is more likely to be part of the building blocks of other patents leading to increases in infringement. This infringement may happen knowingly as well as unknowingly.

However, the disclosure of prior art in the patent can also decrease infringement or the possibility of infringement. Firms active in the area covered by the patent may decide to be careful in their activities, as they understand the boundaries of the patent. If the prior art cited in the patent is well known or old, it is possible that competing firms may respect the boundaries of the property as they believe that the recombination effort is something that is novel and non-obvious. The above reasoning is best explained by comparing a patent to a piece of real estate. To the extent the real estate is surrounded by other occupied pieces of real estate or connected to other public properties, the owner will have to fight encroachment efforts by exercising right of litigation embedded in the patent. However, if the boundaries of the real estate are clearly defined and fenced, such encroachment efforts and litigation are less likely. Prior art disclosure in a patent thus serves two roles: (1) as a building block and (2) as a fence that defines the intellectual property covered in the patent. The greater the number of building blocks available to competition, the more likely it is that infringement of the patent and consequently the right to litigation will be exercised. In contrast, the more clearly demarcated the fences that surround the patent are, the less likely it is that infringement and litigation will take place. Thus we hypothesize:

H1a. The greater the disclosure in the patent, lower the likelihood that the right to litigate provided by the patent will be exercised.

H1b. The greater the disclosure in the patent, greater the likelihood that the right to litigate provided by the patent will be exercised.

VALUE AND LIKELIHOOD OF LITIGATION

Patents are filed at a time when firms are unsure about their commercial value. Past research shows that most patents are worthless in terms of their commercial value but the few that are valuable make it worthwhile to file the others. The options logic underlying the filing of patents suggests that firms are likely to exercise their right to sue other firms when they believe that the potential benefits accruing from litigation far outweigh the costs of litigation that in turn is largely a function of the value of the patent. The value of the

intellectual property is determined by what the patent covers and the extent to which it is relevant to the rest of the world.

To continue with the analogy from real estate, while prior art defines the fences of the property, the claims define what is within the fences of the property. The claims are a map of the property whereas citations represent the number of times people have walked on the property. The more claims a patent makes, the greater is the delineation of the intellectual property covered by the patent (Tong & Frame, 1994). In contrast, the citations that a patent receives determine its actual relevance to the rest of the world. The greater the number of citations, the more useful the technology covered by the patent is to the rest of the world (Albert, Avery, Narin, & Mcallister, 1991). A firm that holds a patent may decide to sue firms that are citing its work even though such citations may not represent infringement. The intention would be to obtain a licensing contract in its favor (Anand & Khanna, 2000). Greater claims in a particular area will help a firm to identify potential infringers or licensees even though such infringement may not have necessarily taken place. For instance, Jerome H. Lemelson, one of the most prolific independent inventors of the 20th century frequently filed patents in technological areas (not necessarily business method areas) where the likelihood of litigation leading to licensing fees and damages was much higher (Baker & Ertel, 2002)

H2. The greater the value of a patent as seen in its claims and citations subsequent to grant, greater the likelihood that the right to litigate provided by the patent will be exercised.

INTERACTION BETWEEN VALUE AND DISCLOSURE

Our arguments so far have hypothesized a direct association between disclosure, value, and the likelihood of exercising the right to litigate. Further, the association between disclosure and the likelihood of litigation can be either positive or negative. In this section we try to resolve this duality by examining the interaction effects between the above constructs. Under conditions of high value, increases in disclosure in a patent will lead to such disclosure acting as a fence. Competitors will be careful about using the knowledge disclosed in it, as the cost of such infringement may far exceed the potential benefits that would accrue from such imitation. Also, the more established the knowledge cited in the disclosure, the greater the understanding of this knowledge by other firms and hence, the lower is the

likelihood that they will encroach on the intellectual property covered by the patent. Finally, increases in disclosure in the presence of value may help a court to decide in favor of the patent holder. In contrast, under conditions of low value, competitors are less likely to be worried about damages resulting from any infringement and may use the disclosure as a building block to imitate or reengineer the technology covered by the patent leading to increases in infringement and consequently in the likelihood of litigation.

Similarly, the relation between value and likelihood of litigation will be moderated by the extent of disclosure in the patent. However, the disclosure in this case acts as a fence and not as a building block. In a situation where disclosure is minimal, other firms are more likely to imitate or reengineer the patent with increases in value, thus causing patent holders to litigate to recover damages and/or royalties. In contrast, with greater disclosure, competitors are less likely to cross the fence with increase in value and hence the likelihood of litigation is lowered.

H3. The value of a patent and extent of disclosure of knowledge in the patent will interact with each other in their relationship with likelihood of litigation i.e.

- Under conditions of high value (disclosure), increases in disclosure (value) will lead to decreased likelihood of litigation.
- Under conditions of low value (disclosure), increases in disclosure (value) will lead to increased likelihood of litigation.

DATA

Our theory suggests that patents are real options, which confer the right but not the obligation to sue others who have infringed or are likely to infringe the patent (Bloom & Van Reenen, 2002). Each patent contains extensive information about the inventor, the company to which the patent is assigned, and the technological antecedents of the invention in the form of other patents that it cites. The above information can be accessed in computerized form. Every patent is assigned to a three-digit technical class, which we use for the purpose of identifying distinct technical areas being developed by the firms in our sample. At this level, there are currently 400 such technical three-digit classes. We follow other researchers who have used information on the front page of the patent relating to technological classes, subclasses, assignee names, grant dates, application dates, and the geographical locations of

inventors and patents cited while studying corporate entrepreneurship, technology licensing, and related issues (Ahuja & Lampert, 2001; Almeida & Kogut, 1999; Henderson & Cockburn, 1996). The issuance of a patent to a firm provides archival evidence of the grant of a real option (Pakes, 1986).

Choosing a random sample of patents as has been done by other researchers studying patent litigation (Lanjouw & Schankerman, 2001) or focusing on technological sectors where patenting has been prolific and useful, such as pharmaceuticals, may make it difficult to disentangle whether such litigation is a result of defensive efforts versus litigation as a result of 'prospecting' efforts or real options logic. To overcome this problem, we focus on a new class of patents on 'business methods'. In 1998, the United States patent system underwent a change whereby patents on 'ideas' or business methods that were non-obvious, non-trivial, and of some value were granted (Keeley-Domokos, 1999). Prior to this 'State Street Decision' as it is now known, patents could not be granted purely for ideas; the invention had to manifest itself in a physical prototype or architecture.[4] As a result, a large number of companies involved in commerce on the Internet (e-commerce) filed for patents in this area (Allison & Tiller, 2003). Recent anecdotal evidence suggests that these companies intended to use these patents as profit-generating mechanisms by suing other firms (Caruso, 1999).

A second reason for focusing on business method patents is that it allows us to test for the direct effect of the characteristics of the patent on the likelihood of litigation without considering factors such as industry structure and competition that are very important in other sectors (Kamien & Schwartz, 1974). More specifically, patents in the chemical and pharmaceutical sectors are the result of many years of sustained R&D in the presence of essential expensive complementary assets such as R&D laboratories and well-trained scientific personnel (Arora, 1995; Teece, 1986). Patents in the semiconductor sector are primarily used as a defensive mechanism i.e. to prevent other companies from entering the area and the likelihood of litigation in such sectors is as much a function of the industry structure as it is with the value associated with a patent (Ziedonis, 2003b). In contrast, business method patents are the result of predominantly mental activity on the part of the inventor without the use of expensive complementary assets. The costs of developing an idea that will lead to the filing and subsequent grant of a business method patent are correspondingly lower than those associated with physically intensive sectors, such as chemicals, pharmaceuticals, and semiconductors (Merges, 1999). This is also evidenced by the fact that a substantial percentage of the business method patents have been granted to independent inventors and companies that are small and privately held

(Allison & Tiller, 2003). Thus, the cost and time required for generating intellectual property in this area are relatively less and in some sense the market for business method patents mimics a situation where size does not matter and all firms are created equal.

To test our hypotheses, we collected all business method patents (US patent class 705) granted between 1971 and 2000. The unit and level of analysis are the individual patents and their associated content. We consider only patents filed in the United States. The sources for this information include the US Patent Office and online databases. We first identified the entire lot of business method patents from the US Patent Office for the last 30 years numbering 4071. These 4071 patents were then compared with Lexis-Nexis records to identify those patents that were litigated. On the basis of this comparison, we identified the 76 patents that were litigated by patent holders for infringement.[5] These patents were litigated by distinct companies and did not include any countersuits filed by the infringers.

MEASUREMENT

Dependent Variable

The dependent *status* variable is a categorical variable and is coded as 1 if the patent was litigated as infringed upon by the patent holder and 0 if the patent was not litigated till the end of year 2002.

Independent Variables

The main independent variables in the model are operationalized as follows:

Disclosure

An ideal approach for understanding the extent of disclosure would be to read each and every patent and develop a measure of disclosure based on this analysis. However, given huge numbers of patents in the area and the technical expertise required we chose to measure disclosure in three ways: patented prior art, academic prior art, and age of patented prior art, respectively. *Patented prior art* is the number of patent references in the focal patent, while *academic prior art* is the number of non-patent references in the patent (Fleming & Sorenson, 2004). The *age* of the patented prior art is measured as the average age of the patent references i.e. difference between grant date of

the focal patent and each patent reference (Nerkar, 2003). We use age as a proxy for disclosure as older knowledge would have had more time to be disseminated or flow in contrast to new knowledge. Each of these indicators provides information about the origins of the invention covered in the patent.

Value of a Patent

The two measures of value that we used are the number of *claims* in a patent and the number of *citations per year* since time of grant.[6] This is consistent with past research that has found strong empirical evidence supporting the link between value and citations received and claims (Albert et al., 1991; Tong & Frame, 1994).

Control Variables

We use four control variables that control for other characteristics associated with a patent. *Patenting experience* is measured as the number of business method patents that a firm was granted before the patent under consideration was litigated. By including this variable we control for the possibility that a patent may or may not be litigated because the experience a firm possesses in the area. *Scope* of the patent beyond business methods is measured as the number of technological classes that a focal patent is classified in other than '705,' which is the business methods class (Lerner, 1995). By including this measure, we take into account the possibility that broad-scope patents, which have technological applications beyond business methods, are more likely to be litigated. Third, we include a control, *time to grant*, which measures the time the patent took to be approved by the patent office. This control takes into account the fact that complex patents may take more time to grant and are also more likely to be litigated. Finally, we include, *inventor locations*, a variable that measures the number of distinct geographic inventor locations (cities) represented on the patent. By including this variable we hope to control for the geographical diversity and its influence on the likelihood of litigation of a patent (Almeida & Kogut, 1999).

ANALYTICAL TECHNIQUE

Numerous statistical models such as discriminant analysis, probit analysis, and logit analysis exist for the classification of dichotomous data.[7] Logit analysis is the main technique used in this paper. While discriminant

analysis, a popular technique in classifying dichotomous outcomes, generally performs well in classification accuracy, it assumes that the independent variables are multivariate normal and that the covariance matrices of the two groups are equivalent. To avoid the restrictive assumptions of discriminant analysis, we use logit analysis since it is a conditional probability model that uses maximum likelihood estimation. It has the objective of providing the conditional probability of an observation belonging to a certain group, given the values of the independent variables for that observation. Logit analysis is based on cumulative probability function and does not require that the independent variables be multivariate normal or that the groups have equal covariance matrices ensuring that we do not have to transform any of our independent variables.

Two approaches have been used in past research to conduct logit analysis. The first approach uses the entire lot of business method patents, while the second adopts a 'case-control' or matched sample approach. We cannot use either of these approaches in our analyses, as business method patents litigations are rare (76) compared to the number of patents granted in the area (4071) due to which our parameter estimates would be biased.

Fig. 1 shows the number of business method patents granted is far more than those that get litigated. Rare events underestimate the probability of an

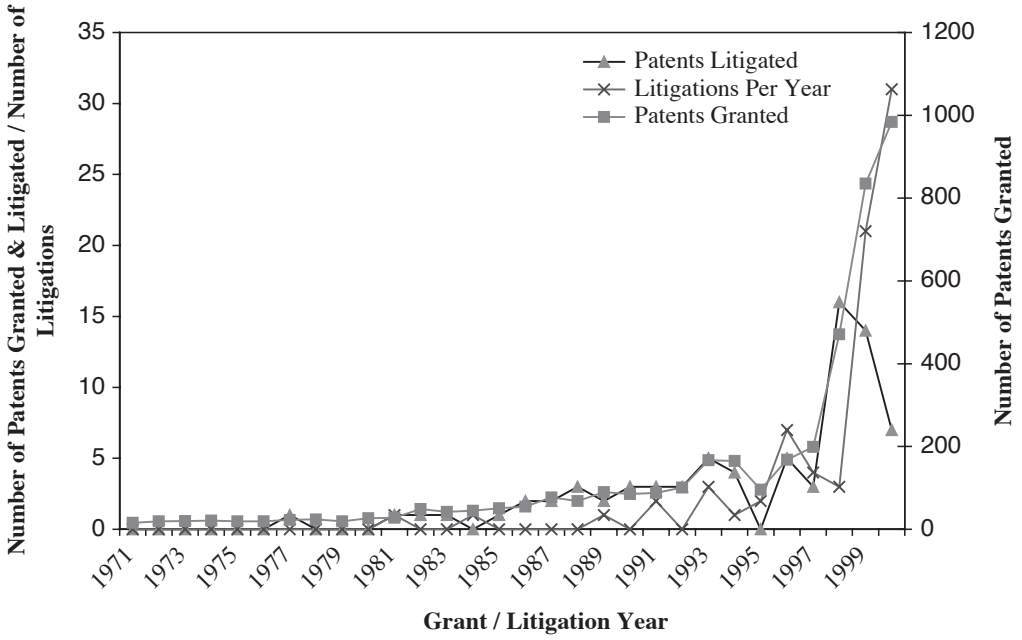

Fig. 1. Litigation and Business Method Patenting.

event and do increasingly as the event becomes rarer. We follow Sorenson and Stuart (2001) who adopt a methodology to generate unbiased estimates under such conditions of ''rare events.[8]'' Under this methodology, a correction is applied by using weighting mechanism for the estimation that accounts for oversampling of the ''rare'' events (King & Zeng, 2001). This procedure entails two things. First, a sample of all ''events'' and a fraction of non-events are selected. In this particular case, we select those patents that are litigated and a fraction of patents that are not litigated. This sample of nonevents is selected randomly. Next, a method is applied that corrects the bias and generates consistent estimates. We use the statistical analysis program 'Stata' that has a correction procedure called 'relogit' (Tomsz, 1999).

RESULTS

The correlations and descriptive statistics are presented in Table 1. None of the bivariate correlations are above 0.40, alleviating concerns of multicollinearity. Results of multivariate analysis are presented in Table 2. Model I consists of only control variables and none of these are significant. Model II presents control variables along with the value variables, citations per year and claims, both of which have a positive and significant effect on litigation. That is, the more the value of the patent, the more the probability that it will be litigated. Further, the citations per year have a higher effect on the likelihood of litigation than do claims. Models III through V introduce each of the disclosure variables into the analysis. All three disclosure variables – academic prior art, patented prior art, and age of prior art – have a positive and significant effect on probability of litigation, suggesting that disclosure in the form of prior art acts as a building block of knowledge as opposed to a fence. The full model is presented in Model VI. The coefficients are positive but the significance of the disclosure variables is reduced i.e. only age of prior art is significant. We also computed the relative strengths of each of the variables on the likelihood of litigation. Based on Model VI keeping all variables at their mean level, we computed the increase in log likelihood of litigation with an increase of 1 unit in citations per year, claims, and average of patented prior art. We find that a 1-unit increase in citations per year, claims, and average age of patented prior art leads to a 45, 4.35, and 12.5% increase in log likelihood of litigation. Citations per year lead to the most significant increase in log likelihood of litigation.

Table 3 presents results of rare events logistic models that include interaction terms. Models VII through X consist of interaction terms of citations

Table 1. Statistics and Correlation Matrix (All Business Method Patents).

	Variable Description	Mean	SD	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	Status (litigated = 1, not litigated = 0)	0.02	0.14	0	1	1.000								
(2)	Citations per year	1.87	2.36	0	32.43	0.127	1.000							
(3)	Claims	21.13	20.08	1	375	0.044	0.162	1.000						
(4)	Academic prior art	10.61	50.05	0	784	−0.005	0.080	0.120	1.000					
(5)	Patented prior art	12.77	16.60	0	266	0.000	0.138	0.223	0.349	1.000				
(6)	Age of prior art	6.66	4.03	0	75.90	0.006	−0.038	−0.002	0.032	0.205	1.000			
(7)	Inventor locations	2.32	1.77	1	15	−0.009	0.046	0.097	0.028	0.044	−0.049	1.000		
(8)	Time to grant	2.55	0.98	0	11.04	0.002	0.007	0.072	0.060	0.036	0.140	0.057	1.000	
(9)	Scope	2.31	1.15	1	10	0.000	0.013	−0.048	−0.035	0.022	0.069	−0.027	−0.083	1.000
(10)	Patenting experience	19.31	46.53	0	289	−0.013	−0.125	−0.071	−0.031	−0.004	−0.017	0.084	0.036	−0.040

Note: All correlation coefficients above $|0.1|$ are significant at $p < 0.05$.

Table 2. Rare Events Logit Model Predicting Likelihood of Litigation[a].

Variable Description	I	II	III	IV	V	VI
Citations per year		0.2469***				0.3768***
		(0.0901)				(0.1020)
Claims		0.0426***				0.0273**
		(0.0126)				(0.0115)
Academic prior art			0.0262**			−0.0046
			(0.0123)			(0.0128)
Patented prior art				0.0448**		−0.0135
				(0.0209)		(0.0114)
Age of patented prior art					0.1051**	0.1180**
					(0.0502)	(0.0544)
Inventor locations	−0.0751	−0.0762	0.0081	−0.0837	−0.0204	−0.1010
	(0.0981)	(0.1325)	(0.0795)	(0.0764)	(0.0968)	(0.1287)
Time to grant	−0.0826	−0.0192	−0.0598	−0.0090	−0.0492	0.0064
	(0.1644)	(0.1198)	(0.1597)	(0.1608)	(0.1584)	(0.1762)
Scope	0.0558	−0.0115	0.0586	0.0459	0.0630	0.0395
	(0.1262)	(0.1547)	(0.1319)	(0.1365)	(0.1381)	(0.1581)
Patenting experience	0.0004	−0.0006	−0.0007	−0.0009	−0.0011	0.0020
	(0.0036)	(0.0033)	(0.0037)	(0.0037)	(0.0039)	(0.0035)
Constant	−3.6224***	−5.1998***	−4.0475***	−4.2439***	−4.5019***	−5.9268***
	(0.5394)	(0.6348)	(0.5810)	(0.5960)	(0.6103)	(0.6414)
LL	−125.4115	−99.4761	−119.8964	−118.4125	−116.9104	−101.4657
Improvement		25.9354***	5.5150**	6.9989**	8.5010	23.9458***
Comparison model		I	I	I	I	I

**$p<0.05$ (two-tailed tests).

***$p<0.01$ (two-tailed tests).

[a]Number of patents litigated for infringement was 76. Values in parentheses are robust standard errors.

Table 3. Rare Events Logit Model Predicting Likelihood of Litigation.

Variable Description	VII	VIII	IX	X	XI	XII	XIII	XIV
Interaction effects								
Citations per year	0.4392***	0.4693***	0.7372***	0.7221***	0.3905***	0.3451***	0.3019*	0.1779**
	(0.1094)	(0.1338)	(0.2332)	(0.1899)	(0.0881)	(0.0847)	(0.1681)	(0.0758)
Claims	0.0236**	0.0329**	0.0249*	0.0368***	0.0191*	0.0686***	0.0381**	0.0124
	(0.0119)	(0.0128)	(0.0133)	(0.0133)	(0.0117)	(0.0204)	(0.0189)	(0.0298)
Academic prior art	0.0426*	0.0059*	0.0025	0.0817***	0.0846***	0.0091	−0.0035	0.0327**
	(0.0237)	(0.0034)	(0.0099)	(0.0248)	(0.0292)	(0.0180)	(0.0078)	(0.0144)
Patented prior art	−0.0041	0.0215	−0.0162	−0.0304	−0.0150	0.1052***	−0.0127	0.0214
	(0.0120)	(0.0167)	(0.0134)	(0.0277)	(0.0146)	(0.0436)	(0.0108)	(0.0338)
Age of patented prior art	0.0099	0.0101	0.2022***	0.0489	0.0211	0.0281	0.2593***	−0.0678
	(0.0536)	(0.0423)	(0.0762)	(0.0373)	(0.0430)	(0.0306)	(0.0977)	(0.0780)
Citations × academic prior art	−0.0120**			−0.0161***				
	(0.0047)			(0.0050)				
Citations × patented		−0.0117**		−0.0067				
		(0.0055)		(0.0063)				
Citations × age			−0.0494**	−0.0079				
			(0.0220)	(0.0186)				

Claims × academic prior art					−0.0012***			−0.0016**
					(0.0004)			(0.0007)
Claims × patented prior art						−0.0025**		−0.0007
						(0.0013)		(0.0009)
Claims × age of patented prior art							−0.0041*	0.0053
							(0.0022)	(0.0041)
Inventor locations	−0.0813	0.0317	−0.0142	0.0090	−0.1258	−0.1571	−0.1151	−0.1390
	(0.1245)	(0.1039)	(0.1048)	(0.1127)	(0.1045)	(0.1073)	(0.0898)	(0.0887)
Time to grant	−0.2170	−0.1307	−0.1180	−0.3972	−0.1361	−0.2203	−0.0622	−0.0601
	(0.1460)	(0.1384)	(0.1342)	(0.1894)	(0.1545)	(0.1470)	(0.1510)	(0.1615)
Scope	−0.1727	−0.1484	−0.1911	0.0174	−0.0589	0.1188	−0.1333	0.0068
	(0.1475)	(0.1535)	(0.1542)	(0.1588)	(0.1420)	(0.1728)	(0.1476)	(0.1345)
Patenting experience	0.0038	0.0020	0.0040	0.0058	0.0012	−0.0007	0.0060	0.0004
	(0.0042)	(0.0033)	(0.0036)	(0.0045)	(0.0038)	(0.0039)	(0.0038)	(0.0031)
Constant	−4.4961***	−5.1637***	−5.8975***	−5.3522***	−4.7472***	−6.2366***	−5.6843***	−4.4826***
	(0.6505)	(0.6748)	(0.7400)	(0.7891)	(0.7347)	(0.8158)	(0.8006)	(0.8256)
LL	−94.3608	−93.5253	−99.9226	−87.5634	−98.6129	−92.2304	−98.2913	−95.6733
Improvement	7.1048**	7.9403**	1.5431*	13.9023***	2.8527*	9.2352***	3.1743	5.7923**
Comparison model	VI	VI	VI	VI	VI	VI	VI	VI

Note: Values in parentheses are robust standard errors.
*$p < 0.1$ (two-tailed tests).
**$p < 0.05$ (two-tailed tests).
***$p < 0.01$ (two-tailed tests).

per year with each of the disclosure variables. In Model VII, the interaction of citations per year with academic prior art is negative and significant, indicating that the effect of academic prior art on the probability of litigation is negatively moderated by the value, citations per year. The inflection point at which the relation changes between likelihood of litigation and academic prior art changes from positive to negative is 3.55 citations. Model VIII presents the parameter estimates of the interaction of citations per year with patented prior art, which is negative. The inflection point at which the relation between likelihood of litigation and patented prior art changes sign from positive to negative is 1.83 citations. The same effect holds for the age of patented prior art as shown in Model IX and the inflection point is 4.09 citations.

The inflection points at which the number of claims causes the relation between the disclosure variables and likelihood of litigation were computed and are 71, 42, and 63 for academic prior art, patented prior art, and age of patented prior art as seen from Models XI, XII, and XIII, respectively. The corresponding inflection points for patented prior art, academic prior art, and age of prior art where the association between value (citations and claims) and likelihood of litigation changes from positive to negative are 37, 2, 4 and 9, 42, and 36, respectively. All these inflection points are within the range of the data. When all these interaction terms are included in one model, Models X and XIV, only the interaction of value (claims and citations per year) with academic knowledge remains significant.[9] All the inflection points are within the range of the data.

DISCUSSION

The results presented earlier support most of our hypotheses. We had hypothesized a bidirectional relation between disclosure and likelihood of litigation. Our results suggest that prior art and age of patented prior art act as building blocks of knowledge rather than as fences. But with the introduction of increased value, these building blocks become signposts that define the technology and act as fences. While we cannot see evidence of actual infringement, the act of litigation with increase in disclosure is consistent with our theorizing. In particular, our results are largely consistent with the results of Lerner (1995) and Lanjouw and Schankerman (2001) and go beyond them by examining the interaction between knowledge on which a patent is built (disclosed) and the value seen in it. However, Model VI offers some non-results that need further explanation. While all our hypotheses are

supported in the individual models, the full model supports the hypothesis associating value (both citations per year and claims) and disclosure (only age of patented prior art) with likelihood of litigation. We believe that this is because firms looking to exercise the right to sue are more likely to consider signals of value than signals of potential infringement. Schankerman and Scotchmer (2001) point out that there are two liability doctrines, lost profits and unjust enrichment, which determine damages in patent litigation suits. A patent of negligible commercial value that is litigated purely on the basis that it has been infringed will lead to a patent holder's gaining only 'lost profits'. In contrast, signals of value suggest that a patent holder could gain from the 'unjust enrichment' aspect of damages by settling before adjudication in case of lack of clear evidence of infringement or by gaining substantial damages resulting from both 'lost profits' and 'unjust enrichment' awarded at the time of adjudication in case of clear infringement. The age of the patented prior art continues to be positive and significant, suggesting that patents based on established knowledge are more likely to be infringed and litigated even in the presence of indicators of value.

Our results, while largely consistent with Lanjouw and Schankerman's (2001) findings, have one important difference. We find that prior art disclosed in the patent has a positive effect on likelihood of litigation that disappears only in the presence of signals of value. This – and the finding that in the presence of value, prior art disclosed, instead of providing building blocks of knowledge that can lead to infringement, becomes a fence that prevents infringement and consequently litigation – suggests that the drivers of business method patent litigation are more subtle and nuanced than those in other sectors. The marginal effects of citations and claims are far stronger in the context of business method patents than in the sectors reported by Lanjouw and Schankerman (2001). This offers strong support for our rationale that business method patents are real options that firms take out under situations of uncertainty with the intention of exploring the upside through litigation while limiting the downside.

Our results have important implications for different areas of research in strategic management. Barney (1986) states that any competitive advantages that can be obtained by getting resources in the strategic factor market will be competed away and consequently luck plays an important role in the acquisition, retention, and application of resources that provide superior performance. Our results suggest an alternative explanation to luck to the acquisition of such resources in factor markets such as markets for business method patents. These markets are as close to being perfectly competitive as compared to other sectors. Participants adopt a real options approach

whereby they spend small amounts of money that provides them the right to prospect certain actions. A real options perspective allows firms to retain decision-making rights with respect to resources even though the process underlying the development of such resources is stochastic, uncertain or, in other words, driven by luck. A second application of our finding is related to the criticism of the resource-based view of the firm in recent times as tautological (Bromiley & Fleming, 2002; Porter, 1991; Priem & Butler, 2001). Our findings suggest that the common problem of conflating value and performance in the RBV can be resolved by allowing value to vary on a continuum. Similarly, the requirements of inimitability and substitutability, which are normally considered to be essential for competitive advantage to be derived from resources, are not essential in the case of business method patents when considered as real options that provide the right to sue. Finally, our paper offers a response to the comments and suggestions made by scholars on how real options logic should be researched (Adner & Levinthal, 2004; Li, James, Madhavan, & Mahoney, 2007). Our findings show that patents can be considered as real options and the grant of business method patents and their litigation is consistent with such logic.

The study suffers from limitations on a few fronts that help in identifying areas where future research could be conducted. Methodologically, the research would benefit from examining patents in all areas and comparing the results to the business methods area. Also, we focus on infringement actions while ignoring challenges. This level of detail was considered sufficient for the purposes of the present study. However, greater rigor can be introduced in a later research by examining the differences in likelihood of litigation across sources of legal action i.e. a patent holder or a competitor. From a conceptual angle, what may be of greater interest would be the settlement of these legal actions. It may be easier to start litigation but may be more difficult to sustain it. Future research could examine whether the results of this study extend to settlement of legal actions (Shavell, 1989; Somaya, 2003). While the focus of this paper has been on the right to sue, firms do have other lines of action such as licensing and leveraging technology into their own products. Future research should look at the link between these different choices and the manner in which firms makes decisions with respect to choosing one over the other.

There are other ways in which this research can be extended in the context of strategy and entrepreneurship research. The enforcement of intellectual property has been a topic much studied by economists from a welfare and public policy perspective. Management researchers have recently begun exploring the strategic implications of these and related issues. Our research

contributes to this small but increasingly important stream of research. For instance, Somaya (2003) finds that settlement outcomes in patent litigation are a function of the strategy adopted by the patent holder, while Ziedonis (2004) shows that firms patent more aggressively than otherwise expected when markets for technology are highly fragmented. We have used citations to indicate value but some citations are more valuable than others. Also, the dispersion of these citations matters (Chi & Levitas, 2007). For instance, is a firm more likely to sue based on who cites it? Some business method patents can also be connected to systemic aspects of technology. Research suggests that such technologies have more partners and strategic alliances involved in their development (Chesbrough & Teece, 1996). Such partnerships and alliances may lead to a dampening of exercising the right to litigate. Future research could extend the findings of this paper by examining these effects. Challenges and reexaminations of patents need to be included in any future extensions. Finally, settlements and adjudications of these suits would be an important topic that could shed light on whether such options logic does lead to systematic sustained rents for patent holders. Our approach has been to consider litigations as the exercise of the option but one can also consider such decisions to be part of multistage options.

CONCLUSIONS

This study examines a relatively new patenting phenomenon, namely that of business method patents, and more specifically, the litigation activity within this patent class. The huge upsurge in business method patents can be explained by the 'prospective nature' of the patenting done in the area. Recent research has shown that business method patents are not deficient in terms of the prior art that they build on thus ruling out the lacunae in the patenting that allowed such patents to be granted (Allison & Tiller, 2003). Also, more of these patents have been granted to small and independent inventors compared to patents in other sectors, suggesting that these inventors are indeed looking at these patents as real options. Our findings extend previous research on patent litigations by exploring how the nature and strength of the knowledge base affects litigation activity. The results are therefore relevant to all firms that participate in patenting activity in emergent technology areas such as biotechnology or genetic engineering.

The main finding of this paper has practical implications for two constituencies. One, managers of business units should be careful while patenting intellectual property in the area of business methods especially if they

are taking an options approach to such patenting. A business method patent provides the right to sue but the exercise of this right is not appropriate under all circumstances. Our findings suggest that a firm holding a high-value patent should disclose as little as possible while a low-value patent should have as much information as possible. Two, researchers and administrators of US R&D policy need to ensure that patent examiners have done due diligence in terms of prior art search to ensure that such patents are not likely to be litigated. Both the above implications are reflected in announcements by firms and recent policy changes announced by the U.S Patent and Trademark Office (Bukeley, 2001). These announcements suggest that more attention is being paid to business method patents both during the application process as well as after their grant.

NOTES

1. See Lerner (2002) and Boldrin and Levine (2002) for a recent discussion on these issues.
2. It can be argued that the purchase price of the real option should also include the expenses incurred in developing the underlying technology. That said, such expenses should be included only when the investment is to be considered as an option. In our paper, we consider the patent as an option to sue, which is distinct from the option to invest.
3. This is different from costs of continuing with the litigation that could be substantially higher and a function of not only the type of intellectual property involved but also the parties involved.
4. Business method patents have been issued only after February, 1998. However, the US Patent Office reclassified patents issued before this date. We include these patents in our analyses.
5. This may not seem like a high number but is significantly higher than the pharmaceutical sector that had 252 litigations for approximately 50,000 patents.
6. We computed the citations per year variable based on citations up to the end of year 2002. We are not concerned about publicity effects (citations post-litigation) as Lanjouw and Schankerman (2001) demonstrate that such effects are minimal (accounting for a maximum of 10% of citations) and tend to wear off with time. We could compute citations up to the point of litigation for patents that get litigated, but given our rare event methodology we could not compute equivalent values for the randomly chosen sample.
7. An ideal approach would be to use an event history model to test the likelihood of litigation. However, given the small number of events and the large number of spells, we prefer using a far more conservative and robust modeling approach of rare events logit analysis.
8. See Fleming and Sorenson (2002) for an excellent application of rare events to a situation similar to this paper.

9. It is interesting to note that in the full Models X and XIV the only interaction that remains significant is that of value with academic knowledge. This suggests that disclosure through academic prior art is the one that is most easy to understand for infringers from a 'fence' perspective as well as a 'building block' perspective.

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