DO IT PATENTS MATTER FOR FIRM VALUE? 
THE ROLE OF INNOVATION ORIENTATION AND 
ENVIRONMENTAL UNCERTAINTY

Completed Research Paper

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Abstract

IT industry has become patent-intensive due to the rapid advances in technology and the fierce competition among firms. While prior studies indicate financial returns from investments in IT patents are unclear, recent patent wars in IT industry suggest that IT patents may be of great value. We examine the impact of IT patents as an intangible IT resource on firm value in IT industry, while also considering the moderating effect of firms’ innovation orientation (exploitative vs. explorative). Moreover, we examine how environmental uncertainty influences the relationship between firms’ IT patents, innovation orientation, and performance. Our results suggest that the impact of IT patents on firm value is positive and significant. More importantly, we find that this impact varies depending on firms’ innovation orientation. Further, we find that the moderating effect of innovation orientation is influenced significantly by the two dimensions of environmental uncertainty (i.e., competitiveness and dynamism).

Keywords: IT patent, innovation orientation, environmental uncertainty, firm value
Introduction

Innovation is an important means to achieve competitive advantage. Firms, especially those in knowledge intensive industries, spend a significant amount of resources in conducting R&D activities to design, invent, develop and/or implement new or altered products, services, processes, systems, or business models. The R&D expense in U.S. IT industry reached U.S. $117.4 billion in 2012. On average, U.S. IT firms spend about 8.3 percent of their revenue on R&D, and the R&D spending has increased with an 11.7 percent compound annual growth rate since 2005.1 In order to protect the resulting innovations and prevent other firms from using them, firms frequently rely on patents. Patents are one of the strongest forms of firms’ intellectual property (Teece 1998). In fact, the number of patent applications filed and granted has been increasing over time, and the total US patent applications reached over 576,000 in 2011.2

Patents grant legal authority to the inventor to prohibit others from making or selling the patented invention for a fixed period of time. A firm’s stock of patents can be a significant strategic asset as it provides opportunities to license or to exclude others from using a wide variety of patented products, processes, technologies and other features. Therefore, a firm’s patent portfolio has the potential to increase the firm’s future cash flows (Hall et al. 2005). In addition, such a patent portfolio can be used defensively as a hedge against litigation from competitors and patent “trolls” in order to manage a firm’s risk and liability for patent infringement.

While prior research has examined the value of patents mostly at the economy level (i.e., across various industries), the value of patent may differ across industries (Hall et al. 2005). Not only do the industries vary in terms of the average number of patents generated by each dollar of R&D investment (Scherer 1983), but they also differ significantly in terms of their ability to appropriate the returns from their R&D investments (Levin et al. 1987). Of particular interest is the IT industry, which is characterized by fierce competition and fast technological changes. Until recently, firms in IT industries had not been able to freely patent innovations, especially in the software domain. A few landmark decisions of the U.S. court in late 1990s and the release of new guidelines of the U.S. Patent & Trademark Office (USPTO) in 1996, have nullified earlier restrictions, which, in turn, has led to a deluge of software patents. Recent high profile patent lawsuits (for instance, Apple vs. Samsung) as well as strategic deals to acquire patents (for instance, Google acquiring Motorola Mobility for $12.5 billion and Microsoft spending $1.1 billion for licensing patents from AOL) highlight the importance of patents in IT industry (Duhigg and Lohr 2012; Ovide and Letzing 2012). Not surprisingly, firms in IT industry are dedicating significant resources to build their patent portfolio to counter the fast technological change and to get an upper hand in the competitive market (OECD 2008).3

IT innovations that can generate revenue have been recognized as an important factor in IT management over the past several years (Luftman and Derksen 2012). Recently, IT innovations are believed to have played an important role in enabling firms to safely and efficiently overcome the adverse impact of the recession (Nash 2011). To ensure a continuous stream of high quality innovations that are necessary for sustainable competitive advantage, IT firms invest a significant amount of resources in R&D activities. However, given that IT innovations can be easily reverse-engineered and imitated, IT firms patent their innovations to ensure that their innovations are not imitated or substituted by competitors (Weiss 2011). These IT patents allow a firm to recover its R&D expenses by commercializing or licensing its patented innovation and obtain temporary monopoly rents.

Despite the growing importance of IT patent and the call for research on the impact of IT patent on competitive advantage (Mykytyn et al. 2002), relatively little research efforts have been made to empirically examine whether IT patents actually impacts firm performance; therefore, the financial

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1 Source: Authors’ calculations based on the data from Compustat.
3 The number of IT-related patents grew steadily from the mid-1990s to 2005, at average rate of 4.7 percent a year from 2000. In 2005, more than 50,500 international patent applications were filed under the PCT (Patent Cooperation Treaty) to protect inventions in IT. The number of IT-related patents increased more rapidly than the total number of PCT applications.
returns from investments in IT patents remain unclear. More importantly, we have a limited understanding of how IT patents impacts firm performance. In this paper, we focus on IT industry, which has become patent-intensive due to the rapid advances in technology and the fierce competition among firms, to investigate the impacts of IT patents on firm value. We conceptualize IT patent as a key resource in IT industry for gaining competitive advantage, and adopt the lens of real options to evaluate the impact of IT patents on firm value in IT industry, while also considering the moderating effect of firms’ innovation orientation (i.e., exploitative vs. explorative) (March 1991). Moreover, we examine how environmental uncertainty (competitiveness and dynamism) influences the relationship between firms’ IT patents, innovation orientation, and performance.

Based on a large panel dataset consisting of 697 firms in U.S. IT industries, our results suggest that the impact of IT patent on firm value (as measured by Tobin’s q) is positive and significant. More importantly, we find that this impact varies depending on the innovation orientation of firms’ patent portfolio. IT firms with patent portfolio that has higher levels of exploitative orientation have higher firm value. Further, we find that the moderating effect of innovation orientation of firms’ patent portfolio is influenced significantly by the two dimensions of environmental uncertainty (i.e., competitiveness and dynamism), thereby resulting in three-way interactions among IT patents, innovation orientation, and environmental uncertainty. Specifically, we find that in more dynamic industries (defined as the industries with higher levels of demand and income volatility), the positive moderating effect of exploitative orientation of firms’ patent portfolio is stronger, whereas in more competitiveness industries (defined as the industries with higher levels of competition), the positive moderating effect of exploitative orientation of firms’ patent portfolio is weaker, favoring an explorative approach to innovation.

The findings of this study contribute to the literatures on the economics of patents, IT capability, organizational learning, and environmental uncertainty. Also, our findings can help managers assess the impact of IT patents in terms of the contribution to firm value.

Related Literature

Innovation and Value of a Patent Portfolio

Given the large investments in building a patent portfolio and uncertainty regarding the ability to benefit from the patented innovations, prior research has examined the value of patents to a focal firm. A number of studies have employed market valuation approach to assess the value of a firm’s patents (Connolly and Hirschey 1988; Hall et al. 2005). To the extent that the patent portfolio of a firm influences the expected future profits of the firm, the value of the patent stock should be reflected in the observed firm value. Based on this notion, researchers have examined the impact of the firm’s patents on the firm value using measures such as Tobin’s q.

For the most part, these studies have found that the patent portfolio of a firm is positively associated with firms’ performance and market value (Ernst 2001; Hall et al. 2005). Examining the market value of patents, Bessen (2007) suggests that the upper bound of average patent value for a sample of US firms for 1969 to 2001 period was 376,000 US$ (1992 prices). Using a similar approach, Connolly and Hirschey (1988) report a large positive impact of patent on a firm’s financial performance: each unexpected patent increases the value of a firm by roughly $5 million. In a more recent study, Hall et al. (2005) found that an extra citation per patent increased a firm’s market value by 3%, which is consistent with the earlier finding of Harhoff et al. (1999).

A few studies have examined the value of patents in IT industry. Using the patents and citation data for 1963-1995 period, Hall et al. (2005) find that impact of citations/patent on market value is small and lower in the computers and communications industry, compared to almost all other sectors in their sample. The authors suggest that since computers and communication industry deals with complex product where any particular product may rely on various technologies embodied in different patents held by different firms, it is more important to have a larger patent portfolio (that can be used to negotiate cross-licensing agreements) rather than having few patents with high individual quality. In a recent study, Hall and MacGarvie (2010) analyze the value of software patents granted between 1975 and 2002. They find that the market value of software patents was similar to other patents in period prior to 1995 but has
increased vis-à-vis other patents after the change in patentability of software innovations around 1995.
We extend these studies by refining our theorization of IT patents and empirically testing the moderating
mechanisms that influence the firm value of IT patents in IT industry.

**IT Patent as a Key Resource**

Firms patent IT innovations to build competitive advantage around their IT-dependent strategic
initiatives such as business processing reengineering, ERP-enabled business integration, and electronic
supply chain management initiatives (Piccoli and Ives 2005). Such IT-dependent strategic initiatives can
provide competitive advantage and sustainability of that advantage by creating barriers that reduce profit
erosion. Thus, firms patent IT to protect associated unique combinations of hardware, software, and
human resource skills. Accordingly, firms patent when they want to erect barriers to imitation of their IT-based
strategic initiatives so as to protect their revenue generating streams. Moreover, IT patents which are
intangible knowledge asset can be considered system resources (Black and Boal 1994; Miller and
Shamsie 1996), which are connected to other resources such as the underlying IT infrastructure, business
process, software applications or the skill/training of the personnel through a complex resource network
configuration. Therefore, we conceptualize IT patent as a key resource in IT industry for gaining
competitive advantage. Specifically, IT patent can provide competitive advantage for firms in IT industry
in the following two ways.

First, by patenting a specific IT innovation, firms can benefit from the first-mover advantage by
preventing other firms from imitating this technology. This is because IT patents provide isolating
mechanisms that cannot be easily replicated by competitors. Since patents offer protection for that
technology for about 20 years, firm will be able to sustain their competitive advantage for quite a long
period of time. Since the development of patents involve knowledge stock accumulation and
organizational learning processes (Piccoli and Ives 2005), firms are able to build on patented technology
to further consolidate their positions by retaining their customers and providing better products and
services which utilize the patented technology.

Second, by developing IT resources and capabilities, which can be patented, IT firms have a platform for
executing various competitive action repertoires including licensing, trading patents, copyright litigation
and so forth. For example, IT firms have the ability to file lawsuits against competitors who infringe on
their patents. By suing new players in the industry large firms have been able to successfully eliminate
competition from start-up companies (Tam 2013). Firms are thus able to manage a portfolio of patents,
which provide them advantage in specialized areas such as information technology, and license patented
technology to further extract rent. As such, patents have been viewed as firms’ knowledge capital
alongside their physical and human capital (Bloom and Reenen 2002). In particular, in the case of IT
patents, competitors are not able to imitate the technologies easily.

**Patent as Real Option**

The real options theory, which originated from the financial options theory that is widely used for the
valuation of financial securities, extends financial option pricing concepts and tools to real
(nonfinancial/physical) assets (Benaroch and Kauffman 1999; Fichman 2004). A real option creates the
right, but not the obligation, to take an action (e.g., deferring, expanding, contracting, or abandoning the
underlying asset) at a defined cost, called exercise price. Similar to financial option, real option is an
option to do something, but not a requirement to act. The main difference is that, instead of a financial
instrument (i.e., a stock, bond, or some other underlying security), real option is related to a capital
investment/budgeting project.

The real options approach is an effective valuation mechanism for investments that tend to exhibit high
uncertainty and irreversibility (Trigeorgis 1993). Of particular interest to this study is the investment in
R&D activities, specifically related to IT. Researchers suggest that investments in IT projects exhibit the
two essential properties that make them suitable for real option valuation and consequently, they have
employed real options theory to examine the economic value of various types of IT investments, including
ERP (Taudes et al. 2000), decision support systems (Kumar 1999), telecommunication infrastructure
(Panayi and Trigeorgis 1998), ATM banking infrastructure (Benaroch and Kauffman 1999), and virtual
world platforms (Yang et al. 2012).

In this study, we focus on IT patents resulting from the investments in R&D initiatives in IT industry. Given that a patent allows patent owner to choose between exclusively commercializing the patented invention anytime during the patent term or foregoing commercialization altogether (Cotropia 2009), it can be considered as real option. Further, consistent with real options theory, the outcome from commercializing a patented innovation is uncertain due to uncertainty in market demand and future adoption of a new product based on the underlying innovation (Gonzalez 2006). Lastly, in line with the requirements of real option theory, patents involve extensive sunk cost investments and require significant outlays, which are (at least partially) irreversible, for developing and commercializing new product based on patented technology (Bloom and Reenen 2002). The option available to the firms to wait until making these sunk costs investments in commercializing new technologies underlying a patent, generates valuable real options when the market conditions are uncertain and the value of the underlying asset is uncertain at the time of the option’s purchase (Bloom and Reenen 2002; Cotropia 2009).

The option not to exercise the right to take action effectively truncates the left hand tail of a performance distribution (i.e., the unfavorable outcomes). Thus, real options create a performance distribution curve that is skewed to the right (i.e., more favorable outcomes), yielding asymmetric payoffs by providing a firm access to a greater range of potential outcomes on the upside, while containing the exposure on the downside (Cotropia 2009). The value of the option increases with the uncertainty about the value of the asset covered by the option, as it allows the firm to avoid a larger area of highly negative potential outcome distribution while exercising the option only when the potential returns are more likely to fall in the highly positive outcome distribution (Cotropia 2009).

Because of high uncertainty of outcomes and irreversibility of investments in commercializing/developing the patented technology, managers are encouraged to undertake a multiphase implementation process by which they initially draft pilot projects or prototypes and later convert them into full-fledged projects. Such multistage implementation approaches, consequently, create a specific type of real option referred as “growth” option (Fichman 2004; Kogut and Kulatilaka 1994) wherein the underlying resource can generate follow-up investment opportunities, which may subsequently influence a firm’s strategic position.

To summarize, the real options theory has been suggested as an appropriate mechanism to evaluate the value of emerging, uncertain technological investments such as those manifested in IT patents (Fichman 2004; Kogut and Kulatilaka 1994). Accordingly, we employ real options logic to assess the business value of IT patents. Based on the conceptualization of IT patent as a key resource and the logic of real options, we next develop a set of hypotheses regarding the impact of IT patent on firm value.

Hypotheses Development

IT Patent Stock and Firm Value

IT patent stock generated by a firm is a result of its superior IT infrastructure, IT human resources, and IT related intangibles. However, the financial returns from investments in IT patents remain unclear. Although it has been suggested that IT resources may be imitated and substituted by competitors, and hence may not directly enhance firm performance (e.g., Wade and Hulland 2004), IT resources that are patented may become a source of sustainable value to the firm holding the patent as they provide protection from copycats that try to mimic the patented products and methods. To the extent IT innovations are valuable and patents can help protect this value, an increase in IT patent stock should lead to higher firm value of a firm.

Enabled by a patent’s legal protection, a firm can wait and watch before making extensive, mostly irreversible, sunk cost investments in further research and development, training, as well as expensive marketing and advertising to promote their new products based on patented technology. In the presence of uncertainty about the market conditions, this flexibility to delay investments generates valuable real options (Bloom and Reenen 2002). Thus, the real option lens suggests that IT patent stock should lead to valuable real options. The value of these real options accessible to a firm, in turn, will be reflected in the firm value of the firm. Therefore, we posit:
**Hypothesis 1**: A firm's IT patent stock is positively associated with the firm value.

**Innovation Orientation and Firm Value**

Innovation can be characterized in terms of the nature of learning involved in developing the innovation. Prior research has defined innovation orientation in terms of exploration and exploitation (Jansen et al. 2006; Uotila et al. 2009), which are two important aspects of organizational learning. Based on the extent of these two types of learning involved in developing an innovation, innovations can be characterized as exploitative innovation and explorative innovation. An exploitative innovation improves existing components and builds on existing technological trajectory while an explorative innovation constitutes a shift to a different technological trajectory (Benner and Tushman 2002; Lavie et al. 2010; March 1991). Further, consistent with the conceptualization of Benner and Tushman (2002), we characterize an innovation along a continuum based on the extent to which the patented innovation is anchored in knowledge used in a firm's previous innovations.

There is a scarce literature examining the role of innovation orientation on performance. Katila and Ahuja (2002) employ an orthogonal measure of exploration and exploitation to study robotics industry and find that exploitation has curvilinear relationship with number of new products introduced whereas exploration has a linear relationship with the product development performance. Further, the exploration and exploitation activities were found to have a positive interaction effect on performance. On the other hand, Siggelkow and Rivkin (2006), from their simulation, suggest self-interested managers are more likely to exploit existing opportunities than to explore remote options. Auh and Menguc (2005) demonstrate that exploration contributes to long-term performance, but exploration is associated with short-term performance. Still, empirical research on the performance outcomes by pursuing both exploration and exploitation, or trading off one activity for the other is not always straightforward and relatively limited and idiosyncratic (Lavie et al. 2010).

In this study, we expect that innovation orientation of a firm's patent portfolio can have significant impact on the firm value. Researchers suggest that the outcomes of explorative and exploitative innovations may differ (Levinthal and March 1993; March 1991). Specifically, we argue that exploitative innovation will lead to higher firm value than explorative innovation. As discussed above, a patent creates a real option that reflects the value a firm places on its ability to choose the timing of its investments in its patented technologies (Bloom and Reenen 2002). The option value increases with the increase in the expected value of potential returns, variance of potential returns, and/or managerial flexibility in the structuring/exercise of options (Fichman 2004). The expected value of potential returns will be higher for explorative innovations as these innovations are likely to lead to long-term performance gains due to creation of new knowledge whereas exploitative innovations provide short-term performance gains due to their focus on efficiency (Auh and Menguc 2005; March 1991). Further, the variance of potential returns is also higher for explorative innovation as these gains are more uncertain (Levinthal and March 1993).

The effect of explorative innovation is more likely to be radical in terms of the magnitude of transformation in conjunction with work processes, product or service development, or technology implementation. Such innovations, when successful, can be paradigm breaking, positively rewarding, and long lasting. However, due to the high uncertainty involved in the implementation of explorative innovation, the outcomes are likely to be more volatile than those associated with exploitative innovation. Therefore, as per the real options theory, the value of explorative innovation is greater than exploitative innovation. Accordingly, we posit:

**Hypothesis 2**: The more explorative a firm's innovation orientation, the stronger the association between the firm's IT patent stock and the firm value.

**Moderating Role of Environmental Uncertainty**

One of the most important factors that affect the relative gains from exploration versus exploitation is the environment turbulence (March 1991). In an attempt to reconcile conflicting evidence on the performance outcomes of exploration and exploitation, researchers have considered environment uncertainty as playing a central role in a firm's decision to adopt explorative versus exploitative innovation (Jansen et al. 2006; Lin et al. 2007). Consequently, the performance of a firm depends on the interaction between the
firm's innovation orientation and environmental uncertainty the firm faces.

Environmental uncertainty has been typically characterized in terms of dynamism and competitiveness (Dess and Beard 1984; Keats and Hitt 1988; Randolph and Dess 1984). Dynamism refers to the environmental instability that makes it difficult to predict change, heightens the uncertainty, and affects the volatility that a business unit faces (Child 1972; Dess and Beard 1984). Thus, the volatility of industry sales and income has been used to proxy the dynamism (Castrogiovanni 2002; Xue et al. 2012). Competitiveness refers to the heterogeneity of and range of an organization's activities (Dess and Beard 1984). A concentrated industry is likely to have a less competitive environment because a few firms dominate the industry and the repertoire of strategic actions is small. Industry concentration has been used as an inverse proxy of competitiveness (Keats and Hitt 1988). Prior research suggests that these two dimensions of environmental uncertainty - competitiveness and dynamism – moderate the relationship between innovation orientation and performance (Jansen et al. 2006; Levinthal and March 1993; Lewin et al. 1999).

Given that the environmental uncertainty has been argued to play a significant role in determining the relative value of exploration and exploitation, prior studies have empirically examined the interaction between innovation orientation and the environmental uncertainty in shaping the financial performance of a firm. For example, in a survey-based study of European financial institutions, Jansen et al. (2006) show that the contribution of exploitative innovation to performance is higher in a more competitive environment, whereas the effect of explorative innovation on financial performance is higher when dynamism is higher. Auh and Menguc (2005) develop a contingency model that tests the moderating role of competitiveness on the relative effectiveness of exploration and exploitation on firm performance. The authors find that as competitiveness increases, exploration is positively (negatively) associated with effective firm performance for firms with defender (prospector) strategy profile. We build on and extend these studies by examining the moderating role of the two dimensions of environmental uncertainty in the context of IT patents.

Above all, firms in industries that have high competitiveness face a more competitive environment, and it is difficult to predict its competitors’ action. Lewin et al. (1999) argue that high competitiveness leads to more explorative innovation as firms attempt to compete by engaging in radical organizational adaptations through intensified exploration strategies. Since high competitiveness leads to erosion of profits, a firm can protect and grow its market share and profits by differentiating from other firms. This requires investment in innovation, in particular heavy investments in explorative innovation (Rowley et al. 2000). Consequently, firms in a highly competitive environment need to focus on building exploratory innovations that differentiate them from the competition and improves their financial performance. Therefore, we posit:

**Hypothesis 3**: In industry environments exhibiting higher levels of competitiveness, the moderating effect of explorative innovation orientation (on the relationship between IT patents and firm value) will be stronger.

Environmental dynamism may result from changes in technologies, variations in customer preferences, and fluctuations in product demand or supply of materials (Jansen et al. 2006). Given that dynamic environments make current products and services obsolete, researchers suggest that a firm should create new products and services for meeting the needs of emerging markets by engaging in explorative innovation (Gupta et al. 2006; Zahra 1996). Based on a survey of firms in software industry, Zahra and Bogner (2000) find that firms operating in a dynamic environment can get higher profits by developing radically new products, which are more likely to be a result of explorative innovation. Rowley et al. (2000) also suggest that firms operating in unstable environments should focus on explorative innovation due to the high uncertainty about future directions and high likelihood of environmental disturbances. The primary argument in these studies is that the existence of environmental uncertainty increases the rate of radical innovation required to survive and therefore firms need to invest in exploration. Accordingly, we posit:

**Hypothesis 4**: In industry environments exhibiting higher levels of dynamism, the moderating effect of explorative innovation orientation (on the relationship between IT patents and firm value) will be stronger.
Data and Methods

Data

Our data come from two sources. First, the patent data, originally constructed by Hall et al. (2001), were obtained from the National Bureau of Economic Research (NBER). Second, we obtained various firm-level financial data from the Compustat database. Because the USPTO does not provide a unique identifier for each firm from year to year, and patenting firms may change company names over time, Hall et al. (2001) provide a method to match the assignees of the patents in the NBER data to firms in Compustat (see also, Hall et al. 2005; Hall and MacGarvie 2010). Following their method, we matched the NBER patent data with financial data from Compustat for publicly traded firms. Because the USPTO published new guidelines for software patentability on March 29, 1996, we chose 1998-2006 as our sample period. We recorded patents by their filing year, rather than granted year, as there may be arbitrarily long lags between the application year and granted year (see Benner and Tushman 2002). In this study, we focus on IT industry which consists of 13 sub-industries based on the 2002 four-digit North American Industry Classification System (NAICS).

IT Patent

One difficulty associated with studying IT patents is that the definition of IT patent is rather unclear (e.g., Bessen 2011; Bessen and Hunt 2007; Hall and MacGarvie 2010). Researchers have classified patents using keyword searches (Bessen and Hunt 2007) and using patent technology classes (Graham and Mowery 2003; Hall 2003).

To identify IT patent, we first classified software patents by combining four ways of defining software patent. The four definitions, which are based on patent technology class (either International Patent Classification or U.S. patent classes), come from Graham and Mowery (2003), Hall (2003), Bessen (2011), and our own definition, which is broader than the other three. In our own definition of software patent, similar to Graham and Mowery (2003), we identified all the US patent classes in which any of the top 20 software firms have patented, and excluded those classes where less than 20% of these firms have patented. Then, we categorized patents falling in the remaining classes as software patent. Top 20 firms were selected by sales of their 2006 revenues from NAICS 511210 group (software publishers). For hardware patent, we adopted U.S. patent classes used in previous studies (Choi et al. 2007; Schaeper 2003). By combining the patent classes for hardware and software, we have come up with patent classes corresponding to IT patent.

For those patent classes that were not identified as software or hardware patents by prior studies, three coders who are experts in IT validated and re-classified them by carefully examining the class definitions. The inter-rater reliability for the coding of IT patent was 0.94, suggesting a high level of agreement. This procedure resulted in 25 hardware patent classes and 22 software patent classes.

We computed the patent stock measure in year t for firm i using a single depreciation rate, ρ, for patent value (Hall et al. 2005; Hall and MacGarvie 2010; Liu and Wong 2011). Following prior research, we used a depreciation rate of 20%. We calculated the R&D stock in year t for firm i using the same depreciation rate. We scaled the patent stock by the R&D stock and take a log, as in previous research (e.g., Griliches

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4 The NBER data have been updated through 2006 and are available on websites: https://sites.google.com/site/patentdataproject/Home.

5 From U.S. BEA’s guideline, ICT industries comprise following 2002 NAICS codes: 334, 511, 516, 518, 519, and 5415.

6 Based on USPTO technology classes that are titled data processing (classes 700-707 and 715-719), electrical computers and digital processing systems (classes 708-714) and several classes that are reliant on IT and in which IT companies obtain patents (235, registers; 318 and 361, electricity; 341, coded data generation; 340, 342, 343, and 367, calculation; 345, computer graphics processing; 348, television; 349, liquid crystal cells; 353, optics; 358, facsimile; 365, static information; 370, multiplex communications; 375, pulse or digital communication; 379, telephonic communications; 381, electrical audio signal processing; 386, television signal processing; 395, information processing systems; 438, semiconductor device manufacturing; 455, telecommunications; 595, superconductor technology; 380, cryptography; 382, image analysis).

7 Our empirical results are not sensitive to the chosen value of depreciation rate (e.g., 0.2, 0.15, etc.).
In order to account for the quality difference across patents, and to fix the biases due to the use of simple patent counts, we constructed a citation-weighted patent count by considering the number of citations a patent receives (Hall et al. 2005; Hall and MacGarvie 2010). Then, we computed the citation-weighted patent stock, scaled by R&D stock (Liu and Wong 2011). Using patent stock measure in our observation windows (1998–2006), our final panel dataset, excluding firms that have no patent stock, contains 2,668 firm-year observations with 697 unique IT firms.

**Innovation Orientation**

We measured the innovation orientation of a firms’ patent portfolio as the extent to which firms’ patenting efforts are anchored in its existing knowledge. Following Benner and Tushman (2002), we coded the prior patents cited by a patent as existing firm knowledge if they were either repeat citations (patents the firm had previously cited) or self-citations (the firm’s own previous patents). We then calculated the degree of exploitation for each patent by dividing the number of existing firm knowledge by the total number of citations to prior patents (e.g., as a continuous variable ranging from zero to one, 0 indicates that the patent was highly explorative; pure exploration, whereas 1 indicates that the patent exploits the prior patents totally; pure exploitation). By focusing not only on self-citations but also on repeat citations by a firm, we can capture both external and internal innovation orientation (exploitation versus exploration).

To measure the innovation orientation of a firms’ patent portfolio in year \( t \), we aggregated all the patents the firm filed in year \( t \) and calculated the average of the degree of exploitation. Though, a firm’s patents in year \( t \) may vary in terms of exploitative level, given that such variations are very small in our dataset we expect that the average of patents’ exploitative level in each year captures the general tendency of innovation orientation of a firms’ patenting in a year. This continuous measure of innovation orientation (exploitation and exploration as two ends of a continuum) echoes prior definitions used in the literature (Gupta et al. 2006; March 1991; Sørensen and Stuart 2000).

**Environmental Uncertainty**

We characterized environmental uncertainty in terms of competitiveness and dynamism based on the extant literature (Dess and Beard 1984; Keats and Hitt 1988; Xue et al. 2012). We adopted two indicators to measure competitiveness. The measures are four-firm concentration ratio (CR4) and the Herfindahl index (HHI). We calculated CR4 and HHI for each NAICS four-digit industry and each year. Lower value of CR4 and HHI represent an industry that is less concentrated and more competitive (Han and Mithas 2013).

Dynamism was measured as the volatility in industry sales and volatility in industry operating income (Keats and Hitt 1988). We measured the volatility of industry sales using a two-step procedure. First, the natural logarithm of the total sales of four-digit NAICS industries was regressed against an index variable of years, over a period of past five years with rolling windows. We expect that the standard error of the regression coefficient captures the unpredictability or volatility of the sales growth rate. Then, we took the antilog of the standard error of the regression coefficient as the measure of sales volatility. The same approach was used to derive the volatility of industry operating income. Because the two measures for each construct were highly correlated with each other and are interchangeable in reflecting the environmental uncertainty, we converted the multi-item measures of each dimension of uncertainty into

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8 When calculating the amount of existing firm knowledge at the patent level, we subtract the number of self-repeat citations from the sum of the number of self-citations and the number of repeat citations.

9 Benner and Tusman (2002) constructed this measure at the 10, 20, and 40 percent levels, represented as the number of patents by year for each firms that constitute 10 percent or less, 20 percent or less, and 40 percent or less, respectively, of the citation to prior knowledge of the focal firm. In this study, we employed this measure as a continuous variable. For instance, when a certain patent has one citation, if this citation comes from a firm’s prior knowledge, then the degree of exploitation for this patent is one, however, if this citation does not come from firm’s prior knowledge, then the degree of exploitation (exploration) is one (zero).
single-item measure.

Using principle component analysis (PCA), we extracted two factors from the measures identified above. The pattern of factor loadings supports the existence of two dimensions corresponding to competitiveness and dynamism. Subsequent confirmatory factor analysis (CFA) supports the overall validity of the two-factor model (Chi-square = 388.70; GFI = 0.96; CFI = 0.94; NFI = 0.94). Cronbach’s Alpha for the two factors are above 0.6, suggesting acceptable reliability for exploratory analysis. In the main analysis, for each dimension of environmental uncertainty, we take a weighted average of the measurement items (weighted by their loadings in the underlying principle components) as the single-item measure (e.g., Xue et al. 2012).

**Firm Value and Control Variables**

Tobin’s q, which captures the financial performance of a firm, is our main dependent variable. Given that it offers the advantage of capturing short-term performance and long-term prospects based on market value, it has been widely used in prior IS literature (e.g., Bharadwaj et al. 1999) as well as strategy literature examining performance of exploration/exploitation (e.g., Uotila et al. 2009), to capture intangible asset and business value of information technology (e.g., Bardhan et al. 2013; Kohli et al. 2012). Moreover, Tobin’s q covers a market-based measure of a firm’s both tangible and intangible value due to its characteristics which is forward-looking, risk-adjusted, and less volatile to changes in accounting practices. Thus, to successfully measure the firm value of IT patent, which is the potential intangible asset of firms and not recorded in the financial statements, we use Tobin’s q as a measure of firm performance.

We included several variables to control for firm, year, and industry effects. To control for the growth opportunities available to a firm, we included R&D intensity which was computed as the total amount of R&D expenditures in a given year divided by total sales for each firm and industry Tobin’s q (Bardhan et al. 2013; Bharadwaj et al. 1999). We also used the total number of employees as a measure of firm size, included advertising intensity and market share (Hitt and Brynjolfsson 1996; Xue et al. 2012). Finally, a set of dummy variables was used to control for time-invariant sector-specific effects. Sectors correspond to the 2002 NAICS four-digit level. Year dummies for sample years from 1998 to 2006 were included in our model to control for year-specific effects. Table 1 presents the descriptive statistics for the key variables and the correlations among them.

| Table 1. The descriptive statistics and correlations |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean | Std. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1. Tobin’s q | 3.03 | 5.57 | | | | | | | | | 1.00 |
| 2. IT patent stock | 0.44 | 1.32 | 0.07 | | | | | | | | 1.00 |
| 3. IT patent citation stock | 4.73 | 20.13 | 0.07 | 0.84 | | | | | | | 1.00 |
| 4. Innovation orientation | 0.36 | 0.29 | -0.02 | 0.12 | 0.10 | | | | | | 1.00 |
| 5. Competitiveness | 0.27 | 0.12 | 0.02 | 0.10 | 0.05 | 0.03 | | | | | 1.00 |
| 6. Dynamism | 1.10 | 0.06 | -0.16 | -0.07 | -0.10 | 0.03 | -0.21 | | | | 1.00 |
| 7. Employee | 3.15 | 14.19 | -0.05 | -0.01 | -0.02 | 0.07 | 0.20 | -0.01 | | | 1.00 |
| 8. R&D intensity | 0.32 | 1.07 | 0.05 | 0.00 | 0.00 | 0.05 | -0.02 | -0.01 | -0.06 | | 1.00 |
| 9. Advertising intensity | 0.04 | 0.15 | 0.02 | -0.01 | 0.02 | -0.10 | -0.01 | -0.15 | -0.04 | 0.16 | 1.00 |
| 10. Market share | 1.64 | 3.79 | -0.03 | -0.02 | -0.03 | 0.07 | 0.36 | -0.01 | 0.68 | -0.05 | -0.02 | 1.00 |
| 11. Industry Tobin’s q | 2.09 | 0.26 | 0.42 | 0.01 | 0.06 | -0.03 | -0.04 | -0.28 | -0.04 | 0.00 | 0.28 | -0.03 |
Empirical Models and Estimation Procedure

To examine whether IT patent is associated with firm value (H1), and whether firms’ innovation orientation moderates this relationship (H2), we use the following empirical specification:

\[
Tobin's\ Q_{i,t} = \beta_0 + \beta_1 IT\ Patent_{i,t} + \beta_2 Innovation\ Orientation_{i,t} + \beta_3 (IT\ Patent_{i,t} \times Innovation\ Orientation_{i,t}) + \sum \beta_j Firm\ Controls_{j,t} + \sum \beta_s Year\ Dummies + \sum \beta_k Industry\ Dummies + \epsilon_{i,t} \tag{1}
\]

We first estimate the model without the interaction term to examine the unconditional effects of IT patent stock. Then, we re-estimate the model with the interaction term to examine the moderating effect of firms’ innovation orientation.

To test H3 and H4, we use the following specification that includes the environmental uncertainty variable:

\[
Tobin's\ Q_{i,t} = \beta_0 + \beta_1 IT\ Patent_{i,t} + \beta_2 Innovation\ Orientation_{i,t} + \beta_3 Environmental\ Uncertainty_{i,t} + \beta_4 (IT\ Patent_{i,t} \times Innovation\ Orientation_{i,t}) + \beta_5 (IT\ Patent_{i,t} \times Environmental\ Uncertainty_{i,t}) + \beta_6 (Innovation\ Orientation_{i,t} \times Environmental\ Uncertainty_{i,t}) + \beta_7 (IT\ Patent_{i,t} \times Innovation\ Orientation_{i,t} \times Environmental\ Uncertainty_{i,t}) + \sum \beta_j Firm\ Controls_{j,t} + \sum \beta_s Year\ Dummies + \sum \beta_k Industry\ Dummies + \epsilon_{i,t} \tag{2}
\]

When we estimate the model, we replace Environmental Uncertainty with competitiveness and dynamism. Note that due to multicollinearity, we can include one uncertainty variable at a time.\(^\text{10}\)

We center the variables comprising the interaction terms by calculating the deviations from their respective mean values to reduce the multicollinearity between the main terms and interaction terms (Pinsonneault and Kraemer 1997). The variance inflation factors (VIFs) of all the independent variables do not exceed 10. For testing heteroskedasticity, we run the Breusch-Pagan test and we reject the null hypothesis that the error variances are all equal ($\chi^2 = 316.87, p < 0.01$). In addition, for testing autocorrelation, the Wooldridge test confirms the presence of first-order autocorrelation (AR1) in our panel dataset ($F = 86.85; p < 0.01$). In the presence of heteroskedasticity and autocorrelation, pooled ordinary least squares (OLS) regression may be problematic, and although the OLS estimators will still be unbiased and consistent, they will no longer be efficient and the standard errors will not be correct. Thus, we employ feasible generalized least squares (FGLS) estimations (Wooldridge 2002).

Results

Table 2 presents the results of estimating (1) and (2) based on competitiveness and Table 3 shows the estimation results based on dynamism. Model 1, 2, and 3 show main (unconditional) effects of independent variable. Model 4, 5, and 6 include the pairwise interactions among IT patent, innovation orientation, and environmental uncertainty. Model 7 presents the result of the three-way interaction between IT patent, innovation orientation, and environmental uncertainty.

\(^{10}\) The variables in interaction terms were mean-centered to mitigate the potential threat of multicollinearity, however the mean-centering technique only reduces correlation between IVs and the related interaction terms, not the correlations between interaction terms. If all interaction terms associated with competitiveness and dynamism entered the model simultaneously, the high correlations between interaction terms would overinflate the standard error of the regression coefficient estimates, rendering them insignificant. For example, when we test all the hypotheses in a single model, the variance inflation factor between three-way interaction terms (i.e., “IT patent × innovation orientation × competitiveness” and “IT patent × innovation orientation × dynamism”) was above the cut-off value of 10.
### Table 2. FGLS Regression with Competitiveness

<table>
<thead>
<tr>
<th>Variable</th>
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<td>ln(Y)</td>
<td>ln(Y)</td>
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<td>ln(Y)</td>
<td>ln(Y)</td>
</tr>
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<td>0.03**</td>
<td>0.03**</td>
<td>0.03**</td>
<td>0.03**</td>
<td>0.03**</td>
<td>0.03**</td>
</tr>
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<td>-0.03</td>
<td>-0.03</td>
<td>-0.03</td>
<td>-0.03</td>
<td>-0.03</td>
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</tr>
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<tr>
<td>IT patent × Competitiveness</td>
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<td>(0.24)</td>
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<tr>
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<td>0.05**</td>
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<td>0.05***</td>
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<tr>
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<td>0.01</td>
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### Table 3. FGLS Regression with Dynamism

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<th>5</th>
<th>6</th>
<th>7</th>
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<td>ln(Y)</td>
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<td>ln(Y)</td>
<td>ln(Y)</td>
<td>ln(Y)</td>
<td>ln(Y)</td>
<td>ln(Y)</td>
</tr>
<tr>
<td>IT patent</td>
<td>0.03**</td>
<td>0.03**</td>
<td>0.03**</td>
<td>0.03**</td>
<td>0.02**</td>
<td>0.03***</td>
<td>0.03***</td>
</tr>
<tr>
<td>Innovation orientation</td>
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<td>-0.03</td>
<td>-0.03</td>
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<td>-0.02</td>
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<tr>
<td>Dynamism</td>
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<tr>
<td>IT patent × Innovation orientation</td>
<td>0.05**</td>
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<td></td>
</tr>
<tr>
<td>IT patent × Dynamism</td>
<td>0.23**</td>
<td></td>
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<tr>
<td>Innovation orientation × Dynamism</td>
<td>-0.29</td>
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<td></td>
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<td>-0.10</td>
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<tr>
<td>IT patent × Innovation orientation × Dynamism</td>
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<td></td>
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<td>0.49*</td>
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<tr>
<td>Firm size</td>
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<td>-0.03**</td>
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<tr>
<td>R&amp;D intensity</td>
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<td>0.05***</td>
<td>0.04***</td>
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<tr>
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</tr>
<tr>
<td>Market Share</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
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<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Industry Tobin’s q</td>
<td>0.94***</td>
<td>0.91***</td>
<td>0.99**</td>
<td>0.90***</td>
<td>0.94***</td>
<td>0.96***</td>
<td>0.96***</td>
</tr>
<tr>
<td>Wald $\chi^2$</td>
<td>1556.44</td>
<td>1649.79</td>
<td>1513.61</td>
<td>1650.78</td>
<td>1668.49</td>
<td>1613.51</td>
<td>1715.61</td>
</tr>
</tbody>
</table>

**Note:** ***p < 0.01, **p < 0.05, *p < 0.10. Models include year and industry (NAICS 4-digit) dummies. All of the variable in the interaction terms have been centered.
**IT Patent and Firm Value**

In all Models (1 to 7) of Table 2 and 3, the results suggest that IT patent is positively associated with the firm value (all $\beta$s > 0, $p < .01$). The results show that a firm’s IT patent stock is an important intangible asset that contributes to the firm value. Specifically, a one-unit increase in IT patent is associated with a 3% increase in firms’ value. Using an alternative measure, IT Patent Citation Stock (cumulative citation-weighted patent stock) instead of IT Patent Stock, also produced consistent results. Thus we find support for Hypothesis 1. Our result is consistent with the results reported in Hall et al. (2005), who found that the ratio of patents to R&D, and citations to patents significantly affects firm value, with an extra citation per patent boosting market value by 3%.

**IT Patent, Innovation Orientation, and Firm Value**

Model 4 and 7 (in Table 2 and 3) present the results of estimating the interaction effects between IT patent and innovation orientation. The coefficients on the interaction term are positive and significant (in Model 4 of Table 2, $\beta = .05, p < .05$, and in Model 7, $\beta = .05, p < .05$). Contrary to Hypothesis 2, our results indicate that the impact of IT patent on firm value is greater for firms with more exploitative (less explorative) innovation orientation. In other words, increase in a firm’s exploitative orientation of innovation strengthens the positive impact of the IT patents on the firm value. Thus, Hypothesis 2 is not supported.

This finding suggests that IT innovations that are based more on previously used knowledge makes a greater contribution to IT firms’ financial performance.11 These effects exist even after controlling for size, year-fixed effects, sector-fixed effects, and R&D intensity. While this finding does not support our argument based on the real option lens, which favors explorative innovation, it can be understood based on the nature of IT innovations, the focus of our study. IT innovations are often described as complex combinations of hardware and software to solve a particular problem. Due to the competitiveness of IT innovations, firms’ IT patenting activities involving modifying or expanding existing knowledge is likely to be more effective in achieving a synergy with existing technologies, thereby contributing to firm performance.

**The Role of Competitiveness**

We first present regression results where we examined the competitiveness dimension of environmental uncertainty in Table 2. Model 5 assesses the pairwise interactions between IT patent and competitiveness, and Model 6 assesses the pairwise interactions between innovation orientation and competitiveness. In Model 5, we find that the interaction between IT patent and competitiveness is not statistically significant. This suggests that without considering innovation orientation, IT patent and competitive environment do not have an interaction effect on firm value. Similarly, innovation orientation and competitiveness do not have an interaction effect on firm value without considering IT patent (Model 6).

Model 7 in Table 2 applies a test of the three-way interaction effects among IT patent, innovation orientation, and competitiveness on the firm value. Similar to what we found in Models 5 and 6, there is no evidence of an interaction effect for a firm value where only two of the three main explanatory components are used. As shown in Model 7 in Table 2, the interaction of IT patent, innovation orientation, and competitiveness on the firm value is positive and statistically significant ($\beta = 0.29, p < .10$), providing some boundary conditions of the interaction between IT patent and innovation orientation (see Model 4). Specifically, this result indicates that the complementary relationship between IT patent and exploitative

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11 Given that we measure innovation orientation as a continuous variable with two extreme values (pure exploitation and pure exploration), we also tested for the possibility of an inverted U-shaped relationship between the degree of exploration (or exploitation) and firm performance reflecting the presence of an optimal balance between exploration and exploitation (Gupta et al. 2006). Specifically, we incorporated the quadratic terms for innovation orientation in the model. However, the results indicate that there are no curvilinear exploration-performance effects for IT patent in the IT industry.
(explorative) orientation of a firms’ patent portfolio is more beneficial to firm value in less (more) competitive environment. This finding suggests that exploration-oriented firms with IT patent outperform in more competitive industry that in less competitive industry. This is consistent with our argument that in competitive environment, firms need to differentiate themselves from their competition by engaging in more explorative innovation. In other words, competitive environment demands relatively high IT capability in exploration to stay ahead of the competition (Rowley et al. 2000). These findings provide support for Hypothesis 3.

**The Role of Dynamism**

Our regression results in Table 3 focus on dynamism. Model 5 assesses the pairwise interactions between IT patent and dynamism, and Model 6 assesses the pairwise interactions between innovation orientation and dynamism. In Model 5, we find that the interaction between IT patent and dynamism is statistically significant ($\beta = 0.23$, $p < .05$). This suggests that even without considering innovation orientation, IT patent and dynamic environment have an moderating effect on firm value. The positive coefficient means that, under a more dynamic environment, IT patent is more beneficial to firms’ financial performance. However, we do not find evidence that innovation orientation and dynamism have an interaction effect on firm value without considering IT patent, because the coefficient of their interaction term is not statistically significant (Model 6).

Model 7 in Table 3 tests the three-way interaction effects of IT patent, innovation orientation, and environmental dynamism on the firm value. Recall that the higher index of dynamism represents more unpredictable and dynamic industry. Similar to what we found in Model 5 and 6, there is still evidence of an interaction effect for a firm value where IT patent and dynamism are used, but no evidence that innovation orientation and dynamism have an interaction effects for a firm value. Interestingly, the interaction of dynamism and the complimentary relationship between IT patent and innovation orientation (IT patent × Innovation orientation × dynamism) is positive and statistically significant ($\beta = 0.49$, $p < .10$), suggesting that in more dynamic environments firms engaging in more exploitative innovation of patenting tend to benefit more from IT patents in terms of firm value. This finding suggests that exploitation-oriented firms can get higher returns from IT patents in more dynamic industry, which is contrary to Hypothesis 4. This result may explain that dynamic environment increases the complementarity between IT patent and exploitative orientation of a firms’ patent portfolio, that is, it leads to a threat rigidity (Staw et al. 1981), which motivates firms to give more weight to the exploitation of their existing knowledge (Podolny 1994) when they innovate through the IT patent. Thus, Hypothesis 4 is not supported.

Together, these findings provide evidence for the three-way interaction effect of IT patent, the innovation orientation of a firms’ patent portfolio, and environmental uncertainty on firm performance. Our results indicate that when firms innovate on their IT capability through patenting, the market performance of firms operating in more competitive or less dynamic environment is substantially higher if the firms focus on explorative IT innovation rather than exploitative innovation.

**Robustness Checks**

To check the robustness of our results, we re-estimated our models using fixed-effects and random-effects with AR1 adjustment, which control for unobserved heterogeneity across firms. Also, to address the concern of potential endogeneity of IT patent, we used dynamic GMM model, and we obtained similar results, which indicates that endogeneity is not a serious concern. In addition, we used OLS with panel-corrected standard errors (OLS-PCSE) following previous studies (Beck and Katz 1995; Han et al. 2011). The results based on these different specifications are broadly similar to the FGLS results (see Table 4) and demonstrate the robustness of our results.

In addition, we estimated the effects of environmental uncertainty on the complementarity between IT patent and innovation orientation using single-item measures of competitivenes (i.e., HHI, the log value of the reciprocal of HHI, and CR4). The overall results based on single-item measures are qualitatively similar to our main results. All these results suggest that our results are robust.
value between firms with and without IT patent stock indicates that IT patent has a significant influence on the firm value. These results also confirm that IT patent is not endogenous in our analysis.

Table 4. Robustness Check Results

<table>
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<th>Variable</th>
<th>1</th>
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Note: ***p < 0.01, **p < 0.05, *p < 0.1. Model 1-4 are reported using fixed-effects (Model 1), random-effects (Model 2) with AR1 adjustment (xtregAR procedure in STATA), OLS-PCSE with AR1 adjustment and assume panel-level heteroskedastic errors (Model 3, xtptcse procedure), and dynamic GMM estimation (Model 4, xtdpdsys procedure).

To address the issue of potential endogenous selection, we re-estimate our models using a propensity score matching method (Dehejia and Wahba 2002). The basic principle of the propensity score is to use some observable variables (e.g., firm size, R&D intensity, advertising intensity, market share, and environmental uncertainty) to predict the probability of possessing IT patent in the firm. This allows a direct comparison of firm value between firms that have similar characteristics (propensity scores), where one group of firms have IT patent stock while the other does not. Matching firms in this way should substantially reduce any remaining selection bias issues. We used logit regression to calculate propensity scores for whether IT patent stock exist in the firm or not with observed explanatory variables. After matching based on propensity scores, the estimate on the difference in firm value (i.e., Tobin’s q) for these two groups is positive and significant (Diff. = .15, S.E. = .04, t = 9.54, p < .01). This difference in firm value between firms with and without IT patent stock indicates that IT patent has a significant influence on the firm value. These results also confirm that IT patent is not endogenous in our analysis.
Another concern may be the effects of idiosyncratic economic events (e.g., dot-com crash, the 9/11 terrorist attacks, and the ensuing recession) on IT firms’ firm value in our sample period (1998-2006). Although we control the impact of specific year using year dummies in our model, we conducted a time-based split analysis to examine whether the contribution of IT patent was affected by economic events. Thus, we ran regressions for the two periods before and after 2001 (period 1: 1998-2001, period 2: 2002-2006). The results in the two time periods are qualitatively similar. Thus, we conclude the economic events such as a dot-com crash do not affect our results.

Discussion and Conclusion

Our study makes important contributions to the literature. First, our findings offer additional evidence of the important role of IT patent in firms’ financial performance. Consistent with prior research on the economics of patents (Ernst 2001; Hall et al. 2005; Hall and MacGarvie 2010), our findings demonstrate that IT contribute to IT firms’ performance in terms of firm value. Although considerable research has been conducted on the market performance of patent, little empirical research has directly examined the influence of IT patent on market performance in IT industry. Using a sophisticated method for classifying IT patent based on patent classes, this study broadens the scope of enquiry in patent literature by validating the conjecture that IT patent increases the firms’ financial performance, especially in IT industry. Our findings provide an explanation for why IT firms dedicate substantial resources in building their IT capability through IT patents.

Second, our study provides new insights into the relationship between IT patent and firms’ innovation orientation. Our measure of innovation orientation at the firm-level provides a fine-grained measure of relative exploitative and explorative orientation (see Gupta et al. 2006). Based on this measure, we find that the impact of IT patent on firm performance is more salient in firms with more exploitative orientation for innovation (relying more on pre-existing knowledge and incremental innovation), compared to firms with more explorative orientation for innovation (relying more on new knowledge and radical innovation). Our results suggest that when IT firms build IT capability through IT patents, doing too much exploration may not contribute to firm performance much. Given IT firms’ challenges in developing complex technologies involving various software and hardware components, innovations that rely on pre-existing knowledge may enhance their performance, compared to those that rely on new knowledge that they have not used before. In this respect, our study makes a meaningful contribution to both organizational learning literature and IT capabilities literature.

Finally, our findings suggest that firms should tailor their approach to IT-based innovations (i.e., exploitation vs. exploration) depending on the nature of their industry environment. Specifically, we find that IT firms operating in more competitive environments can increase their financial performance by pursuing explorative innovations in their IT patents rather than pursuing exploitative innovations. In competitive environments, continuous improvement based on existing IT knowledge may be insufficient for staying ahead of competition. Intensifying competitive pressures requires IT firms to be more explorative and radical in their IT innovations. In other words, they need to nurture new sources of competitive advantage using distant search (Levinthal and March 1993). On the other hand, our results suggest that IT firms operating in more dynamic environments can increase their performance by pursuing more exploitative IT innovations. When environmental changes are fast and dynamic, outcomes of explorative IT innovations tend to rapidly become diffused over such an environment (Levinthal and March 1993), resulting in a “threat rigidity” which motivates firms to give more weight to the exploitation of their existing IT knowledge (Podolny 1994; Staw et al. 1981). Our results related to environmental uncertainty are not consistent with some prior studies that examined multiple industries (e.g., Jansen et al. 2006). This suggests that the interaction between innovation orientation and environment uncertainty may substantially vary across different industries.

Our study offers managerial implications as well. First, our findings can help managers gauge the impact of IT patents in terms of their contribution to IT firms’ financial performance. In particular, the findings suggest that a firm’s IT patents, a form of intellectual property rights on intangible IT assets, improves firm value. Our results provide an explanation for why many firms have adopted a system of effective redress for the patent in their compensation and performance management policy, and filed a lawsuit against patent infringers to protect their intangible assets (e.g., Nielsen 2013). Firms in knowledge-
intensive IT industry face a number of problems associated with the valuation of their assets that are largely intangible. Our findings can help to mitigate these problems by providing evidence supporting the positive role of intangible assets like IT patents on the firm value. Second, our study findings can help managers in formulating their IT strategies and building organizational culture that would affect firms' innovation orientation. Our results suggest that IT firms need to encourage their R&D departments to build on prior technologies and existing knowledge, which will lead to larger performance than pursuing explorative and radical innovations.

We note some limitations of our study and opportunities for future research. First, we captured the innovation orientation from IT firms that are active in patenting activities. While a diverse ways of operationalization has emerged for the exploration/exploitation concepts, including the use of objective proxies such as the depth and breadth of technological search activity (Katila and Ahuja 2002) and the use of annual relative amount of explorative orientation of the company through content analysis (Uotila et al. 2009), we sought to quantify firms’ innovation orientation from patenting activities using a novel methodology. Future research should develop additional measures of innovation orientation that can be broadly applied. For example, using patents' citation history to operationalize relative exploration and exploitation can offer a relatively easy way to capture these concepts objectively. Second, in our sample, there may be some patents that have little commercial value and this can influence our results. Although we have tried to address this issue by using an alternative measure that can account for the relative importance of patents (i.e., a citation-weighted patent stock), we cannot completely control for the commercial value of each patent. Future research should examine the transaction of patents as commodities via M&A, or strategic alliances. Further, it will be interesting to examine whether and how IT inventors’ turnover affect market performance and innovation outcomes (Palomeras and Melero 2010). Finally, although we have tried everything we can to address the reverse causality and endogeneity issues, we cannot claim causality similar to other empirical studies using secondary data. Our study needs to be complemented by longitudinal research based on detailed data on patents and firm performance.

In conclusion, this paper investigates whether and how IT patent impacts firm performance in IT industry. Theoretically, we conceptualize IT patent as a key resource that can provide competitive advantage and that can lead to valuable real options in IT industry. Our results suggest that IT patent plays an important role in increasing firm value. We also uncover the mechanisms by which internal (innovation orientation of firms’ patent portfolio) and external (environmental uncertainty) factors influence the relationship between IT patent and firm value. Given the growing importance of IT patent and the lack of comprehensive research on the impact of IT patent, our study makes meaningful contributions to the literature and provides useful implications for practitioners.
References


