



The impact of the timing of patents on innovation performance



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ABSTRACT

In the context of industry standard-setting, firms face the strategic decision of whether to move faster than competitors or wait for more information that reduces uncertainty. These decisions are even more challenging if there are multiple standards, and if there are benefits to belonging to more than one standard. This paper examines the effect of the timing of patents on a firm's innovation performance. The strategic logic of real options posits that patent timing is determined by the tension between the value of preemption and the value of waiting. We analyze 680 DVD disc patents in DVD patent pools to test the effect of the timing of patents on innovation performance. Consistent with real options logic, under high uncertainty, the later the timing of the patent, the higher the innovation performance, while under low uncertainty there is an early-mover advantage.

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1. Introduction

Competitive environments are typically riddled with uncertainties. In technology-driven industries, invention in the early stages of development carries uncertainty about technological effectiveness and manufacturing feasibility. Market uncertainty is also high as users' preferences in demand and the technological means of satisfying those preferences co-evolve (Huchzermeier and Loch, 2001; Ziedonis, 2007). The emergence of industry standards can reduce technological and market uncertainty for all participants. However, the process of arriving at one (or more) standard(s) poses difficult managerial challenges (Warner et al., 2006; Ziedonis, 2007). The potential competitive outcome of a convergence to a single standard increases the risk of failure, because competitors are developing technologies that can be complete substitutes for this single standard. Moreover, many standards in the digital age combine complementary innovations from many sources, such that a firm must be aware of not only its technological issues but also those faced by potential exchange partners as well—partners who could easily turn into competitors. Heterogeneity in demand for the technology can even drive the emergence of multiple standards,¹

which appear frequently in high-tech industries when there are substantial switching costs among technologies (Chiesa et al., 2002; Chiesa and Toletti, 2003).

How then should firms move in the highly uncertain and competitive setting of industry standards? Innovation is often viewed as a race, but perhaps a firm should strategically forego speed in order to wait until more information becomes available, thus enabling the firm to further refine its invention before patenting it. These strategic considerations suggest that the timing of patenting would affect returns to innovation, because the level of uncertainty changes over the technology's evolution. Therefore, filing patents at the right time should be a central consideration of a firm's innovation strategy.² The strategy of simply patenting early and often is not necessarily optimal. For example, during the pre-standard period of GSM (Global System for Mobile communications) technology, there was high uncertainty concerning which of the competing technologies would be adopted as the standard. What later became essential patents to the GSM standard from this period were at the time just one of a number of strategic options for the future. A high number

broadcast standards), video codecs (MPEG-2, H.264/MPEG-4 AVC, and AVS) and audio codecs (MP2, MP3, AC-3, AAC, and HE-AAC). While most modern patent pools are formed around a technological standard, multiple standards can be subsumed into a single patent pool.

² We follow the extant literature that identifies a patent as a codified "invention" that may lead to a commercialized product, which is an "innovation" (e.g., Lemley and Shapiro, 2005). Further, a patent does not equal a technology, but a set of technologies brought together to achieve a purpose.

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¹ Examples of industries with multiple standards are DVDs, wireless telecommunications (CDMA, GSM, TDMA, WiFi, and WiMax), television broadcasting (NTSC, PAL, and SECAM for analog TV; ATSC, DVB, ISDB, and DMB for digital television

of patents during this period did not necessarily lead to later dominance in the industry (Bekkers et al., 2002). A firm's patenting strategy can align with its R&D activities so that the firm can either set technological standards or quickly meet established standards. Moreover, when multiple technological standards persist, whether a firm can join many standards can strongly influence the royalty revenue of its patents via having access to more or fewer licensees.

In the strategic management, marketing, and economics literatures, the impact of the *order of entry into product-market domains* has drawn much research attention with mixed empirical results (Agarwal et al., 2002; Bayus and Agarwal, 2007; Christensen et al., 1998; Lieberman and Montgomery, 1998). At the heart of entry-timing decisions are fundamental tradeoffs between the strategic value of commitment (preemption) and the strategic value of waiting (a form of flexibility) under uncertainty (Ghemawat, 1991; Kulatilaka and Perotti, 1998). However, the *timing of patents* in R&D activities over a technology's evolution has remained as a critical gap in the extant research literature. The barriers to entry into the upstream technology market and into the downstream product market are likely to differ, and hence the nature and extent of competition may also vary (Grossman and Shapiro, 1986). McGrath and Nerkar (2004) examine entry timing into a technological area, but do not empirically test for innovation performance. Oriani and Sobrero (2008) investigate the impact of market and technological uncertainty on the valuation of R&D investments, but do not consider the timing of the patent decision. Further, Ceccagnoli (2009) examines the performance implications of preemptive patenting, but does not consider the relationship between the R&D of the incumbent and the R&D of rival entrants. As a result, little is known about how the timing of a patent in the technology domain influences a firm's innovation performance under different levels of uncertainty in a multiple-standard context.

Based on real options logic, we maintain that the timing of a patent is determined at the margin by the balance between the preemption (early-mover) effect and the learning-by-waiting effect, which has been described as a type of real option (Li et al., 2007; Miller and Folta, 2002). Folta and O'Brien (2004) suggest the presence of "dueling options" in which both the strategic value of preemption and the strategic value of waiting increase with increasing uncertainty, thus predicting that the net impact of increasing uncertainty on entry is theoretically indeterminate and requires empirical investigation. Further, the economic value of waiting may be eroded by competition (Li et al., 2007; Smit and Ankum, 1993; Smit and Trigeorgis, 2004). We show that the level of uncertainty influences the timing of the patenting decision, which subsequently impacts innovation performance (i.e., the revenue impact on the firm of its innovative activities).³ Our measure of innovation performance is the number of licensees (Powers and McDougall, 2005), as licensing data provide objective measures of patent value based on the payment structure of the contract (Arora and Fosfuri, 2003; Kim and Vonortas, 2006).

Patent pool formation is a critical event that significantly reduces technological uncertainty, and our unit of analysis is the patent. Since DVD and other complex, technology-intensive products incorporate many patents, tracing a firm's entry into a particular market or a certain technology field through its products can be misleading; thus, the patent is an appropriate unit of analysis

for determining when a firm enters a technology domain. Our sample includes 680 DVD disc patents filed in the US by 14 DVD device manufacturers in patent pools. We selected the DVD industry to test our hypotheses because it is unique in that its players actively engaged in patenting activity and are "at the forefront of designing and implementing patent pools" (Joshi and Nerkar, 2011, p. 1147). A patent pool consists of two or more companies agreeing to license technology to each other and/or third parties, which is subject to regulatory approval (Lerner and Tirole, 2004). Thus, in addition to technological uncertainty, there was also regulatory uncertainty about the likelihood of a patent pool being approved and formed. Prior to the formation of the DVD patent pools in the 1990s, the US Department of Justice had not authorized the formation of any previous patent pools since the 1950s (Gilbert, 2004); and there was no guarantee that the participants of the precursor industry standard-setting bodies in DVD technology would be eventually allowed to form patent pools.⁴ Our theory regarding the timing of patents in R&D activities posits a First-to-Invent (FTI) system, rather than a First-to-File (FTF) system. The USPTO followed an FTI system until the implementation of the America Invents Act (AIA) in March 16, 2013, which is after the formation of the patent pools in this study. On the other hand, other countries where many of the firms owning the patents included in this study followed and continue to follow an FTF system, and we control for this fact. See Appendix A for more detail on the current study's context.

This study offers the following contributions to the research literature. First, it extends theory and evidence on entry order from the product to the technology domain. We show that the relationship between the timing of patents and innovation performance in the technology domain can be better explained through the concept of a "window of opportunity" (Christensen et al., 1998) rather than simply early- or late-mover advantage. Critiquing the real options literature from within, Folta and O'Brien submit that the empirical focus of real options studies has been almost exclusively on how uncertainty deters investment or entry, thus failing to "empirically consider how uncertainty influences the choice between waiting and immediate entry" (2004, p. 123). We address this tension between waiting and preemption as a determinant of the financial performance of R&D investment under varying uncertainty conditions.

Second, this study explores the relationship between the timing of patent and innovation performance in the context of patent pools, which has rarely been explored in strategic management. Joshi and Nerkar (2011) suggest that the formation of patent pools has a negative effect on the quantity and quality of patents generated by both licensors and licensees. Distinct from that empirical research article, we focus on the relationship between licensors' patenting timing and their innovation performance *prior to* and *after* patent-pool formation. A few research studies of patenting

³ In this context, there are two decisions that the firm must make: (1) when should the firm patent the invention? (2) Should a firm with a patented invention attempt to join a pool (Layne-Farrar and Lerner, 2011)? The main independent variable of our study, "timing of a patent," is measured as the filing date. Therefore, our study addresses the first decision. Our sample includes the patents of the firms that decided to apply and were accepted into a patent pool. We check for sample selection bias to control for the likelihood that any patent in the relevant technological areas ended up in a patent pool (the second decision).

⁴ Strictly speaking, the Moving Picture Experts Group 2 (MPEG-2) pool became the first patent pool to receive approval in June 1997, but the number of patents (18) is too small for detailed analysis. MPEG and DVD technology overlap slightly, but MPEG is also applied to other consumer electronics. The DVD patent pools bundle essential patents, which are required for manufacturing the DVD players and discs. The DVD patent pool approval signaled a shift in U.S. government policy and became a precedent for patent pools in other industries and countries (Joshi and Nerkar, 2011). Since the late 1990s, U.S. Department of Justice (DOJ) and the U.S. Federal Trade Commission (FTC) have given favorable treatment to patent pools as long as they serve no ancillary purpose (i.e., traditional collusion or market division) and allow for independent licensing of the individual patents by their respective owners (Lerner and Tirole, 2004). DVD patent pools received clearance because they limited the patent portfolio to technically essential patents, which are not competitive with each other, and they can help overcome economic holdup problems due to interdependent and overlapping patents (Gilbert, 2004; Heller and Eisenberg, 1998; Merges, 1999). We are grateful to an anonymous reviewer for clarifying the issue of regulatory uncertainty.

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