**PATENT STRATEGIES: FIGHT OR COOPERATE?**

## PATENT STRATEGIES: FIGHT OR COOPERATE?


**Abstract**

*We consider a dynamic notion of strategy involving a menu of patent leveraging strategies enabling the firm to switch among compete (fight), cooperate or wait (patent sleep) modes under different demand or volatility regimes. We address the optimality of different competitive strategies based on demand and patent advantage, examining the circumstances under which strategic patenting is best used in a fight, such as building a patent wall or bracketing the rivalôs patent, or in a cooperative mode, such as licensing out or cross-licensing patents. Hybrid strategies may obtain, involving switching from one type of fight mode to another or from competition to cooperation as demand rises or as the patent advantage gets small. Higher demand is most peculiar as initially give-up strategies may switch to fighting and then, at higher demand levels, to cooperation. Dynamic patent switch strategy is more valuable in a more volatile market and competitive environment.*


## INTRODUCTION

In an important but largely overlooked research note written a quarter of a century ago, Competitive Strategy Under Uncertainty, Wernerfelt and Karnani (1987) made the following remarks: ñSince strategy is concerned with the future, the strategic context of a firm is always uncertainé under uncertainty there is a tradeoff between focus [commitment] and flexibilityé. this analysis is further complicated by the presence of competitioné the literature on strategic planning has avoided discussing the trade-offs involved in confronting uncertainty.ò In their conclusions, they call for further research to address this ñvery complex problem.ò One potential way offered to escape the trade-offs is ñfor competitors to cooperate with each other in dealing with uncertainty.ò In their call for further research they note: ñwe feel that the cooperation option is very timely and of increasing importance. The article concludes: ñWhile stochastic game theory is difficult to é we feel that the importance of the topic may justify going that extra mile.ò

The strategic management literature has struggled over the decades with these two core dilemmas: (i) commitment vs. flexibility, and (ii) competition vs. cooperation. The first dilemma relates to the choice between commitment (a.k.a. specificity, focus or efficiency), involving early market entry to accumulate knowledge and capabilities, exploit economies of scale, preempt rivals or gain other first-mover advantages, and flexibility in the form of waiting (to make more informed decisions when market uncertainty is resolved), staging or altering the scale of investment decisions to adapt to interim market developments. The second dilemma deals with the why, when and how firms are better off cooperating rather than competing in the marketplace under uncertainty. In this article we address both of these core dilemmas concurrently in a novel context of strategic patent use based on the new ñoption-gamesò methodology (a simplified, discrete-time variant of stochastic game theory developed by Smit and Trigeorgis (2004)), in an attempt to ñgo that extra mile.ò

Strategic use of patents transcends their traditional exclusivity intent meant to encourage innovative activity (Arrow, 1962). Traditional IP --assigned to innovators to provide incentives to engage in costly innovative activities-- covers the right to sell (buy) or license out (in) an innovation. Patent holders are not obliged to commercialize the patent --they often sell or *license out* their patented technology for a fee to third parties, including rivals (Arora and Ceccagnoli, 2006). IP rights and patents are seen as an imitation barrier or isolating mechanism in sustaining competitive advantage (Rumelt, 1984). Licensing involves sharing rights of use with others. Besides conventional uses (1) to commercialize an innovation or (2) to license a technology, patents (developed or *bought*) can be used strategically to fight as a *defense* mechanism (3) preemptively by building a patent wall or (4) in infringement lawsuits (possibly forcing later collaboration, e.g., via cross-licensing); (5) they may be used to fight offensively by blocking a rivalôs patent; or (6) they may be used cooperatively (e.g., in a patent pool or via cross licensing). Patenting is a key mechanism to achieve firm heterogeneity and enhance competitive advantage due to innovation.

Small technology-based firms lacking necessary manufacturing, distribution and marketing capabilities may license their patented technologies to bigger, more established firms with the needed capabilities to bring the product to market. More interesting, however, are the patent leveraging strategies of large established producers and service providers such as DuPont, Boeing, AT&T, IBM and Microsoft (e.g., see Rivette and Kline, 2000). Since 2003 Microsoft signed more than 500 licensing agreements with customers, partners and competitors. Recently, Microsoft signed a patent cross-licensing agreement with Nikon, enabling both firms to innovate openly with each otherôs technologies, bringing new features and products to market. ñThis agreement is another great example of how industry leaders are coming together to collaborate through intellectual property licensing, and by so doing enabling innovation that will ultimately benefit the consumer,ò said Horacio Gutierrez, VP of IP and licensing at Microsoft.ò This agreement is not surprising as Microsoft and Nikon have a history of collaborating to bring consumer products to market. Cooperative cross-licensing agreements are becoming more common nowadays, and not only among amicable firms. Although Intel and AMD in the past engaged in fierce price wars, they kept patents out of their fighting through *cross-licensing* agreements. ñAnything that we patent they can use, and anything they patent we can use. We donôt have to design around each otherôs patents,ò commented John Greenagel of AMD. The two rivals signed numerous patent cross-license agreements since 1976. Samsung of South Korea and Fujitsu of Japan since the early 1990ôs entered a broad cross-licensing agreement allowing each access to the otherôs microchip technologies. Hitachi has had an ñopen patent policyò making its technology available for licensing or cross-licensing since 1970. Following a somewhat different route, defending itself against a lawsuit for patent infringement filed by Yahoo in March 2012 ï after having armed itself with its own arsenal of IP (having bought 750 patents from IBM and 650 from Microsoft)-- Facebook filed a countersuit forcing Yahoo to agree to cross licensing of their patents and entering an advertising alliance.

In this paper we assess the value of optimal patent leveraging strategies under *both* demand uncertainty and competitive rivalry by combining real options analysis and game theory in a comprehensive dynamic strategy framework. The optimal dynamic strategy depends on both the level and volatility of demand as well as on the relative size of competitive advantage arising from the innovation underlying the patent. We address the optimality of different competitive strategies using demand and the competitive advantage inherent in the patent as determining factors of the optimal strategy. A key question we address is, when business conditions are uncertain, under what circumstances should rivals fight and when should they collaborate in using their IP assets, i.e., when should two competitors follow a fighting or a cooperating (e.g., licensing or cross-licensing) patent strategy? We suggest that under demand uncertainty, the nature of competitive strategy and patent leveraging should be *dynamic*, with rivals finding it preferable sometimes to compete (e.g., defending themselves via raising a *patent wall* around their core patent or fighting fiercely by attacking each other via *patent bracketing*) and at other times to collaborate (e.g., via cross-licensing of patents or forming a patent pool). The circumstances under which firms should fight or cooperate are not trivial. Our approach should help advance the understanding of *dynamic* or *hybrid* patent leveraging strategies, clarifying the conditions when to compete or to cooperate, and provide management with guidance on how to *flexibly* exploit its patents accounting for rational reactions in rival behavior under uncertainty given the strength of patented innovation.

## POSITION IN STRATEGIC MANAGEMENT LITERATURE

The various streams of strategy literature and their position relative to the two classic dilemmas (of commitment vs. flexibility and cooperation vs. competition) are shown in Figure 1A. The main body of strategic management literature evolved with primary focus on competition aimed to gain and sustain competitive advantage based on heterogeneous resource positions and capabilities (Peteraf, 1993). This is represented by ***Streams* (1) to (6)** in the top horizontal row in Figure 1A. A second, smaller and somewhat distinct body of literature sought to gain insights into why and how firms resort to cooperation and strategic alliances, represented by ***Streams* (7) to (9)** (bottom row). The main part of the literature focused more on commitment in a predictable environment while the latter part (alliances) involves more flexibility (discussed below). A research gap is identified in the middle space (numbered as **(10)** in Figure 1A) addressing simultaneously both dilemmas and their interaction. Our goal and main contribution is to address this research gap.

Utilizing a new context involving the strategic use of patents, we analyze the dilemma of when firms should compete (fight) and when they should cooperate (e.g., cross licensing their patents), while concurrently capturing and quantifying the tradeoff between commitment (fight/preempt) and flexibility (wait/stage) via the use of a new strategic tool, ñoption games.ò[1]

[INSERT FIGURE 1A ABOUT HERE]

The strategic management field has, in the past two decades, seen development of two related but seemingly contradictory views regarding the tradeoff between commitment and flexibility when a firm competes with rivals to achieve sustainable competitive advantage (top horizontal row in Figure 1A). The predominant view [***Stream*** **(1)**], originating in the economics/I.O. literature (and its extensions or manifestations through game theory), assuming predictable environment and reactions, argues that early commitment is valuable when a competitor enjoys first mover advantages such as scale economies or commits itself in an irreversible way to a strategic path and can thereby favorably influence resource accumulation or the strategic actions of its competitors. Commitment provides an opportunity to realize strategic benefits and enhance firm value. The view that an irreversible investment commitment can influence strategic behavior is firmly anchored in I.O. and game theory, which saw an increasing adoption in strategy (Porter, 1980; Brandenburger and Nalebuff, 1995). These perspectives generally view value creation as arising from *external* factors, such as market structure imperfections, entry barriers and market power, synergies from product market combinations or from strategic behavior. Peteraf (1993) underlines that competitive advantage arises from firm heterogeneity. From an external perspective, heterogeneity is related to market power asymmetries and monopoly rents resulting from output restriction.[2] Advantaged firms with market power restrict output often behaving strategically (accounting for rival behavior) to achieve a price above marginal cost generating monopoly rents. These models strongly emphasize commitment. Porter (1980) [***Stream*** **(2)**] views analysis of the industry and competitive forces as the underlying source of value creation. Early extensions via game theory helped formalize and model intuitive arguments about firm behavior, such as the role of commitment in R&D competition (e.g., Dasgupta and Stiglitz, 1980), patent races, capacity investment, signaling and reputation (Spence, 1979), the type of competition (Fudenberg and Tirole, 1985) and the tradeoff between commitment and flexibility (e.g., Appelbaum and Lim, 1985; Spencer

[1] ñOption games,ò a new methodology described in Smit and Trigeorgis (2004) and Chevalier-Roignant and Trigeorgis (2011), recently gained acceptance both in academia and in practice (e.g., Smit and Trigeorgis, 2009; Ferreira, Karr and Trigeorgis, 2009).
[2] Due to product differentiation, mobility barriers, irreversible commitments and size or first-mover advantages.

and Brander, 1992; McGahan, 1993; Sadanand and Sadanand ,1996).[3] Since the 1980s interest grew in the intuitive appeal of game theory concepts in strategic management, such as the role of commitment (Boyer, 1997), first-mover advantages (Lieberman and Montgomery, 1988), the trade-off between cooperation and conflict (Schelling 1980; Brandenburger and Nalebuff, 1995), innovation, intellectual property and in other applications (Arend and Seal, 2005; Arend, 2009; Arora and Fosfuri, 2003; Goyal and Netessine, 2007). The alternative view recognizes that flexibility is valuable proposing a wait-and-see or staged approach to decision making (e.g., Dixit and Pindyck, 1994; Trigeorgis, 1996; Ghemawat and del Sol, 1998). As the competitive environment of many firms changes rapidly, investment flexibility enables firms to adapt their future decisions in response to a changing environment, thereby optimizing their investments and value creation.

Both views draw in part on different streams within the broader resource-based view (RBV) and the core competence paradigm that shifted the focus from external factors to heterogeneous internal resources and capabilities (Penrose, 1959; Wernerfelt, 1984; Rumelt, 1984; Barney, 1986; Dierickx and Cool, 1989). RBV is consistent with a Ricardian view where firm heterogeneity arises from superior productive factors and resources being in limited supply, with room for inferior productive resources at the margin (Peteraf, 1993). In industry equilibrium inefficient (high-cost) firms just breakeven while advantaged firms with access to unique or scarce resources (non-replicable by rivals) can charge higher prices earning Ricardian rents. Economic rents (internal view) arise out of inherent resource supply scarcity whereas monopoly rents result from deliberate output restriction associated with market power asymmetry (external view). Four streams arose out of (extended) RBV, with somewhat varying positions on the commitment vs. flexibility spectrum. Although Barneyôs (1986) focus on resource acquisition in imperfect strategic factor markets (SFMs) based on superior information about the *expected* value of (mostly tangible) assets [***Stream* (3a)**] represents some form of commitment (e.g., Folta (1998) and Tong and Li (2011) argue that acquisitions represent high commitment), the resource accumulation stream (Dierickx and Cool, 1989) [***Stream* (3b)**] and the knowledge-based theory (KBT) (Grant, 1996) [***Stream* (3c)**] tilted leftward toward more commitment (and path dependence), while dynamic capabilities (Teece, Pisano and Shuen, 1997) [***Stream* (4)**] flirted a bit more with flexibility to the right. Dierickx and Coolôs (1989) resource accumulation process [***Stream* (3b)**] offered an alternative mechanism for creating and preserving heterogeneity and inimitability of mostly intangible or nontradable resources (in presumed incomplete markets) contributing to sustainability of competitive advantage.

[3] Fudenberg and Tirole (1985) examine strategic investment on second-stage value in a two-stage game when firms' actions are strategic substitutes or complements. In Appelbaum and Lim (1985) a firm faces a trade-off between preemptive investment and the value of waiting while in Spencer and Brander (1992) between a Stackelberg leadership and a wait-and-see strategy. They also deal with timing rivalry in the first stage and the timing of output decisions.

Using the bathtub metaphor, managers make commitments in strategic investments (flows) to accumulate intangible resources (stocks). A firmꞌs resource stocks are a cumulative result of past strategies and investments made over time. From a commitment perspective, the building of resources and capabilities charting a strategic path today defines not only available investment alternatives now but it also shapes the firmꞌs resource accumulation path and therefore the investment opportunities and strategies in the future. According to KBT variant of RBV [***Stream* (3c)**], knowledge, intangible assets and IP like patents represent crucial inimitable resources to be managed in achieving sustainable competitive advantage (Grant, 1996; Rumelt, 1984). While management of (tacit) internal knowledge is key, the strategic leveraging of firm knowledge and IP externally through inter-firm relationships is as important. A critical aspect in the management of knowledge or IP assets is their appropriability (Rumelt, 1984; Grant, 1991). As knowledge becomes more explicit and protectable via IP rights, such as patents, the strategic management and leveraging of IP assets becomes a key part of the RBV. KBT helps the firm decide whether to license a new technology or develop it in-house (Peteraf, 1993). Patents and other IP assets can be leveraged strategically in the firmꞌs external relationships to further its strategic objectives. Use of patents across organizational boundaries extends to strategic alliances and licensing, accompanied with appropriate complementary assets (Teece, 1986; Grindley and Teece, 1997).

From a flexibility viewpoint, multi-stage investments are seen as links in a chain of interrelated, contingent strategic path segments, each stage being an option on the next, developing competences, resources and capabilities that generate new opportunities (Trigeorgis, 1996). In this vein, internalization of production, for example, is seen as an option to participate in subsequent generations of a product (Leiblein and Miller, 2003). Value derives not only from *expected* rents from existing resources and assets, but also from the firmꞌs *dynamic capabilities* to adapt its strategy and renew itself. Dynamic capabilities (Teece, Pisano and Shuen 1997) [***Stream* 4**] views competitive advantage as resting on distinctive processes shaped by the firmꞌs accumulated asset position and the evolutionary paths adopted (Rahmandad, 2012). The flexibility argument received more attention in the 1990s with the advent of real options theory (Trigeorgis and Mason, 1987; Dixit and Pindyck, 1994; Bettis and Hitt, 1995; Trigeorgis, 1996; McGrath, 1997) [***Stream* (5)**]. Real options spread to management extending the applications of strategy (Bowman and Hurry, 1993; McGahan, 1993; McGrath, 1997; Bowman and Moscowitz, 2001; Miller and Folta, 2002; McGrath, Ferrier and Mendelow, 2004; McGrath and Nerkar, 2004; Miller and Arikan, 2004; Wang and Lim, 2008) and testing its boundaries (Adner and Levinthal, 2004).

Traditional real options theory (e.g., Dixit and Pindyck, 1994), however, was not a panacea as it focused excessively on the value of timing flexibility (waiting), ignoring or deemphasizing the role of strategic commitment and the dynamic treatment of the competitive setting. This shortcoming is addressed by a recent extension of real options, *option games* (e.g., Smit and Trigeorgis, 2004, 2009; Ferreira, Karr and Trigeorgis, 2009; Chevalier-Roignant and Trigeorgis, 2011) [***Stream* (6)**], that attempts to quantify the tradeoff between commitment and flexibility, mostly in competitive settings such as in Cournot duopoly. Our article extends this literature ñverticallyò (in Figure 1A) capturing the commitment-flexibility balance under competitive vs. cooperative strategies and the conditions making one strategy mode preferable over the other.

The bottom part in Figure 1A focuses on cooperation strategies and related literature streams. ***Stream* (7a)** dealt with strategic alliances and JVs. Gulati (1998) provides an overview and insights on strategic alliances. From an external I.O. view where monopoly rents arise out of output restriction, market power asymmetry is not necessary. Cournot behavior among symmetric rivals may also yield prices above marginal cost. Collaborative or collusive behavior may achieve similar results if there are barriers to entry, giving justification to alliance formation. Symmetric firms in an industry may also collaborate, creating asymmetry vs. potential entrants (Peteraf, 1993). From an internal RBV, collaboration may secure better access to resources or a unique set of complementary assets. I.O. and game theory were used early on to analyze the trade-off between cooperation and competition (Schelling, 1980; Camerer, 1991; Brandenburger and Nalebuff, 1995). When early-mover advantage is strong, commitment can be an important isolating mechanism for capturing growth opportunities (Lieberman and Montgomery, 1988).[4] JVs and strategic alliances also allow partner companies to more flexibly pursue growth opportunities and appropriate future value more efficiently (Smit and Trigeorgis, 2004). The decision to compete or collaborate via a JV influences the trade-off and exercise of follow-on options depending on pre-empting advantages (Harrigan, 1988), signaling aspects (Reuer and Ragozzino, 2012), relative market power and the ability to jointly appropriate resulting benefits (Smit and Trigeorgis, 2004).

Recognizing that alliances are a way to enhance flexibility to share and jointly exploit growth opportunities, the treatment of strategic alliances and JVs has been recently extended with use of real options theory (***Stream* (7b)**). This resulted in novel theoretical guidance and empirical evidence in better understanding JV structures and alliance decisions (Kogut 1988, 1991; Chi, 2000; Reuer and Tong, 2005).[5] Real options logic and related evidence (e.g., Reuer and Tong, 2005;

[4] They highlighted it is not always desirable to keep options alive (Schelling 1980; Shapiro 1989). When a general invading an island cuts the only bridge behind, leaving no options to his army but fight to the bitter end, it signals (costly) commitment and influences the enemyôs morale and behavior in battle. Similarly the irreversible nature of certain strategic investments and reputational considerations affect credibility in preemptive strategic moves and the balance between commitment and flexibility (Ghemawat and del Sol, 1998).

[5] Offsetting the above benefits, alliances and joint ventures may suffer from several drawbacks. An alliance often forces parties to exchange considerable information, and independent firms may lose control over certain proprietary information. The governance structure of the alliance may not provide a proper mechanism for effective decision-

Tong, Reuer, and Peng, 2008) enhanced our understanding of option value and characteristics of JVs (Folta, 1998; Chi, 2000; Kumar, 2005) and minority equity stakes (Reuer and Tong, 2010). JVs offer a credible alternative to acquisitions (Vanhaverbeke *et. al*, 2002) and corporate venture capital (Tong and Li, 2011). A JV can be a first step towards eventual acquisition of the venture by a partner. Chi (2000) analyzes options to acquire or divest a joint venture. JVs may also deter entry by third parties or erode rivalsô positions. In a JV the partners not only affect each otherôs value via todayôs agreement but also via the expected value of follow-on opportunities. Evidence generally confirms JVs offer valuable growth options (Tong, Reuer and Peng, 2008). An important issue here concerns the ability to appropriate the benefits of the shared growth opportunity. Miller and Folta (2002) examine alliances in research-intensive industries and find that the threat of preemption induces early commitment. Option games suggests a complementary perspective where JVs can modify the partnersô strategic paths, their shared flexibility value and their collective ability to jointly appropriate growth option value under demand uncertainty, avoiding premature commitment in fear of prisoner-dilemma type rival preemption (Smit and Trigeorgis, 2004**).**

Licensing (***Stream* (8)**) acquired importance as a means of inter-firm cooperation and technology transfer, been subject of theoretical inquiry and empirical analysis in several disciplines, including I.O. and strategic management. The former focused on issues like the relationship between the number of licensees and industry structure (Arrow, 1962; Katz and Shapiro, 1986), the division of value between licensor and licensees (e.g., Kamien and Tauman, 1986), or the likelihood of licensing (Gallini, 1984; Gallini and Winter, 1985). Patent licensing was seen as a means to restrict output and achieve collusive rents (Shapiro, 1985). Several scholars examined the incentives to ñshareò patented innovation with others. If the innovation advantage is ñlargeò or disruptive it may enable the innovator to drive out competition and enjoy monopoly rents (Arrow, 1962; Wang, 1998). Firms would be unwilling to license out patents with which they pursue a proprietary strategy and prefer to commercialize themselves (Teece, 1986). Gallini (1984, 1992) and Katz and Shapiro (1985) argue that licensing should always be preferred to capture royalty payments that might otherwise be lost to imitating rivals. Innovators would give up the advantage of a new technology to mitigate the damage of R&D-based competition (Gallini and Winter, 1985). Kamien and Tauman (1986) and Katz and Shapiro (1986) argue that exclusive licensing is preferable for drastic innovations, forcing nonlicensees to exit. However, firms inventing complementary technologies may choose to license non-exclusively to promote industry standard setting enabling participants to capture an enlarged market value pie (Katz and Shapiro, 1985). Anand and Khanna (2000) suggest that, under weak IP rights protection, exclusive licensing is to be avoided to prevent

---

making. Agency costs can arise because the benefits of the alliance are split among two or more firms, giving rise to potential free-rider problems.

leakage of proprietary information when other parties can invent around the technology. They argue JVs are preferred as they allow better monitoring of partner activities while cross-licensing can reduce the risk of reciprocal imitation. Somaya, Kim and Vonortas (2010) argue that exclusivity structures are used to address contractual challenges in collaboration agreements.

Strategy scholars examined alternative uses of patenting such as patent preemption strategies and (cross) licensing. Early on patents were seen as a mechanism of commitment and entry deterrence (Gilbert and Newbury, 1982). Shapiro (1985) discusses patent protection and licensing in relation to R&D rivalry. A firm can protect its own invention by creating a patent fence or wall with own substitutes to prevent rivals from introducing their competing substitutes (e.g., Giletteôs *Fusion* razor is protected by 70 patents while Nestleôs coffee machine system *Nespresso* by 1700 patents). Cohen *et al.* (2000) review various strategic uses of patents. Ceccagnoli (2009) finds that preemptive patenting improves the appropriability of returns to R&D especially for incumbents with stronger market power. Hill (1992) notes that a firmôs decision to license to rivals is influenced by the speed of imitation, first-mover advantages and transaction costs. The slower the diffusion of technology (high barriers to imitation), the more time the innovator has to exploit first-mover advantages by keeping the technology proprietary (Lieberman and Montgomery, 1988). But when rivals have strong incentives to imitate, licensing is more appealing to enable early standard-setting or rent appropriation via royalty payments and reduce damage from preemption. Fosfuri (2006) develops a framework that helps predict a firmôs rate of technology licensing based on the level of competition, market share and product differentiation. Licensing out foregoes the ability to preempt the rival, so it not advised unless the innovation advantage is small. Davis (2008) notes that the licensor (IP vendor) and would-be licensee engage in a license negotiation process and contract design to deal with various market imperfections, including market and technical uncertainties, appropriability hazards, costs of technology transfer, agency and hold-up problems. Based on the type of relationship and degree of technological cumulativeness, IP vendors may pursue different licensing strategies. Grindley and Teece (1997) note IP management became ñmore proactiveò extending to field-of-use cross-licensing enabling IP protection and ñfreedom-to-manufactureò against infringement. They highlight the importance of cross-licensing as part of todayôs business strategy favoring a portfolio approach where firms concentrate their R&D efforts to develop patents potential partners might need. Cross licensing plays a crucial role in protecting a firmôs innovation, reducing its royalty payments and enabling further funding of internal R&D (Teece, 2000).

Finally, an emerging stream examines the real-world phenomenon of coopetition (Brandenburger and Nalebuff, 1996; Lado, Boyd and Hanlon, 1997) [***Stream* (9)**]. Coopetition arises when both the competitive and collaborative features of inter-firm dynamics coexist thereby defining a game configuration (*coopetitive game*) where firms consider new ways to simultaneously compete and interact cooperatively for rent appropriation. We extend the above investigation trying to fill the identified research gap [(10) in Figure 1A] addressing the question of when to cooperate or compete while simultaneously balancing commitment and flexibility. Our approach offers new insights on path dependence and value appropriation in collaborative strategies under different demand or volatility regimes and illustrates conditions where collaboration (such as cross-licensing alliances) is preferable to fighting strategies in addressing the tradeoff between commitment and flexibility when market structure is endogenously determined.

Figure 1B provides a complementary perspective to parts of the literature reviewing the four main ways of obtaining access to (or using) a resource, such as a patent, as part of the firmsô growth strategy: (i) buy (sell), (ii) build/develop, (iii) rent/lease/contract, or (iv) share/ally. RBVôs main streams, resource acquisition in SFMs [***Stream*** **(3a**)] and resource accumulation (extended with KBT) through internal development (build) [***Streams*** **(3b**), **(3c)**] occupy positions in the first two quadrants (first row). In a sense, core RBV streams (focusing on buy or build internally) represent forms of commitment in attempts to secure exclusive use of scarce resources in pursuit of competitive advantage in a compete mode. The alternative modes in the bottom row (lease/contract or share/ally) involve more flexibility and use or leveraging of external resources, often through cooperation with other firms, as warranted in more uncertain and dynamic environments. They are more often redeployed strategically in a cooperate mode. Capron and Mitchell (2012) refer to the last two ways combined as ñborrow,ò i.e., when to contract or ally with other firms to borrow resources, suggesting that a ñmultidexterousò organization that employs all modes wisely is more likely to succeed. A strategic resource such as a patent can be rented or leased (in-licensing) as part of traditional use [***Stream*** **8**]. Arora, Fosfuri and Gambardella (2001) suggest that markets for technology increase the strategy space for innovating firms by offering the choice between developing the knowledge internally, purchasing it on external markets or licensing it. Finally, a resource or knowledge can be acquired through cooperation in a JV or strategic alliance (e.g., R&D or HR alliance, patent pool or cross-licensing) (***Stream*** **7**].

Unlike traditional use of patents focused on the patent holderôs exclusive right to either commercialize or license the invention (to prevent appropriation or imitation by others) [build or lease in Figure 1B], *strategic patenting* focuses on leveraging or extending the function of patents beyond exclusive use (Rivette and Kline, 2000; Arundel and Patel, 2003; Reitzig, 2004: Somaya, 2012).[6] Early treatments typically assumed predictable conditions and did not consider the impact

[6] The notion of IP value chain is considered the locus of value creation and appropriation from innovation (Reitzig, 2004; Reitzig and Puranam, 2009). Strategy research mostly focused on IP generation and protection leaving aside broader IP exploitation via implementation of leveraging strategies (an exception is Somaya, 2012).

and role of uncertainty and the value of flexibility, which is a key aspect of our analysis. Recent strategy work has extended real options thinking ñdownwardò to understand flexibility in JVs and strategic alliances under conditions of uncertainty (e.g., Kogut, 1991; Chi, 2000), mostly ignoring strategic commitment or game theoretic factors, with few exceptions.[7] As noted, we aim to help remedy the above identified ñgapò (position **(10)** at the center of Figure 1A) by simultaneously addressing the dilemma of whether or when to use a patented innovation strategically (as part of the firmôs arsenal or portfolio of other patents and complementary resources) to fight or to cooperate (vertical axis), while integrating the use of game theory and real options tools to also capture the tradeoff between strategic commitment and flexibility (horizontal axis).

Since both commitment vs. flexibility arguments and competition vs. cooperation positions in the literature each have their own conceptual justifications, a key question is, under what circumstances should they inform strategy decision-making? These are fundamental issues in business strategy that, surprisingly, have not been adequately addressed decades after Wernerfelt and Karnani (1987) highlighted them as an ongoing research gap. We extend the boundaries of real options applicability and revisit dynamic strategy within a new context of strategic use of patents to incorporate endogenous strategic reactions, emphasizing that path-dependent investment commitment and resource accumulation often involve not only a tradeoff between adaptability and commitment (whose net impact must be quantified) but also a potential occasional shift among competing and cooperative strategy modes under uncertain conditions.[8] Our extended *option games* approach can be seen as complementary to and an extension of the notion of dynamic capabilities (Teece, Pisano and Shuen, 1997) to account for strategic interactions. It should enable scholars and decision makers to move from concepts and propositions to strategy valuation and implementation through use of mechanisms that can quantify strategy development and adaptability under collaborative or competing modes. It thus provides a coherent integration and synthesis of the above two classic dilemmas by modeling the options and game structure along each scenario or strategic path under the best of a collaborative or fighting mode.

[INSERT FIGURE 1B ABOUT HERE]

[7] The strategic management of intangible resources and inter-firm cooperative interactions have been analyzed more recently using game theory or I.O. models. Alliances are seen as amenable to game-theoretic modeling exhibiting prisonerôs dilemma-type payoffs (Parkhe, 1993). Arend and Seale (2005) show how partners choose actions to cooperate, defect or exit at each stage of an alliance, while Arend (2009) examines how reputation may affect cooperation. Goyal and Netessine (2007) analyze a three-stage game (involving technology, capacity and production) assessing the value of product flexibility and the impact of competition on a firmôs choice of technology intangibles.

[8] To integrate the flexibility and commitment perspectives within a holistic framework that addresses the dilemma between competition and cooperation and can provide more precise insights regarding path dependency in strategic investments we use an expanded or strategic NPV criterion. Besides capturing the value of expected rents from preset capabilities, operations and strategies, this criterion also incorporates the dimensions of flexibility and strategic commitment. New and less obvious variables, such as firm demand regimes, volatility or investment exercise timing and staging may help explain more subtle differences in investment behavior.

## THE STRATEGIC PATENT USE MODEL

In this section we develop a conceptual framework employing a dynamic notion of competitive strategy in the context of patent leveraging. Dynamic strategy here refers to the ability to switch among competitive modes (e.g., fight, collaborate or wait) under different contingent circumstances, such as future states of demand (high, medium or low), depending on the relative advantage of the new innovation (acquired via a new patent by firm A) compared to the old technology (exploited via an existing patent by incumbent rival firm B).

### Basic setup

Consider three outcomes (types) of a patented *process* innovation resulting in no, small or large competitive advantage.[9] [10] If the new innovation has negligible or no cost advantage over the rivalôs existing technology, and the two rivals are otherwise symmetric in market power, competitive strategy is best exercised in a collaborative mode (e.g., via licensing out or cross-licensing patents).[11] [12] On the other extreme, if innovation is large and potentially disruptive a fighting mode may dominate. For example, under high demand (with enough profits for both firms to be in the market), either fighting (e.g., via patent bracketing) or a degree of collaboration may take place; under moderate demand (allowing room for only one firm to produce), the firm with the stronger technology can strengthen its core patent advantage (e.g., by putting a patent wall around it) driving out the rival to exploit a monopoly position.[13] Under low current demand (insufficient for any firm to produce profitably at present, but with potential for higher future demand) and in light

---

[9] The type of patented innovation we focus on here involves a cost-reducing *process* innovation under quantity competition involving strategic substitutes. The analysis may also be extended to a revenue-enhancing *product* patent that allows the possibility of selling a product at a higher price. If the latter is under Bertrand price competition (strategic complements), the results may differ. Process and product patents are often used in different ways in a firmôs appropriability strategy (see Cohen *et al.*, 2000).

[10] The distinction between ñsmallò vs. ñlargeò cost advantage relates to the innovatorôs ability to disrupt the process or preempt the rival. Large competitive advantage is related to *disruptive* process innovations, while small advantage is associated with *small* process innovations. *Disruptive* process innovations reduce the innovating firmôs marginal costs giving it a monopoly position in the industry for some time. *Small* process innovations are associated with marginal cost advantage over competitors with no possibility of setting a monopoly-type price that undercuts rivals. If the degree of cost savings from the innovation is $s$, the marginal price is $\boldsymbol{d}$ and the marginal production cost $c$, the criterion for distinguishing large (disruptive) from small process innovation is: if $s \geq \theta - c$, the process innovation is large, else it is small innovation. See also Arrow (1962) and Wang (1998).

[11] If the old technology owner has a dominant market share it may still be induced to cross-license for the freedom to invent or to prevent other potential third entrants. If the new technology has no real advantage over the old one, adopters might require some discount or incentives to switch to the new (but not superior) technology.

[12] Some aspects of the model should be interpreted with caveats. Cross-licensing, for example, might also be influenced by the nature and complexity of the product. In industries with complex products formed by several different components, cross-licensing might be used to assure freedom to invent among roughly equal rivals (Grindley and Teece, 1997). The decision to license may also depend on several other factors related to industry structure (Fosfuri, 2006). The model is thus simplified and only partially covers the real-life features of patent strategies.

[13] Under moderate demand, collaborative activity may sometimes also result, e.g., by two incumbents developing a patent wall or a joint patent against new entrants.

of its large technological disadvantage the rival may be forced to exit (abandon), with the firm with the superior technology maintaining a growth option on potential future monopoly profits.

In-between, when the competitive advantage is small, a hybrid or more-flexible strategy may be most effective. Under normal (medium or low) demand a cooperative outcome may be preferable whereby firm A licenses out its incrementally superior technology to firm B. However, if demand or volatility is very high the marginally weaker competitor may put up a fight, resulting in a fighting equilibrium outcome (e.g., patent bracketing). Therefore, the notion of strategy needs to be extended to incorporate compete (fight), cooperate or wait (patent sleep) modes that may prevail under different future scenarios depending on the relative competitive advantage and other factors.

We consider below the situation where two patent-holding firms, A and B, are involved in a two-stage strategic patent use game. The timing of the game among the two patent-holding firms, summarized in Figure 2, is as follows:

I. At time 0 (beginning of stage I), firm A acquires a new core patent resulting from its earlier innovative investment activity that may (or may not) be superior to the patent already held by incumbent rival firm B based on an existing alternative technology. In the base case, the two rivals are assumed to be of equal market power prior to the new patent acquisition by firm A so firm A potentially gets an asymmetric advantage over B; the case that incumbent firm B may have more prior market power is considered in the extension.

II. At time 2 (after two subperiods, beginning of stage II), each firm makes a decision on its best patent-leveraging strategy vis-à-vis its rival (fight, cooperate or wait), depending on firm Aôs relative patent cost advantage and the state of demand (High, Medium or Low).

Firm A can extract significant strategic value if its innovative process is effectively protected by a superior patent relative to its rival´s existing patent. We here assume there is perfect legal protection.[14] Firm A´s patent is functioning as a legal resource converting its R&D activity into a strategic proprietary investment giving it a distinct advantage over its rival. If market demand for the product is favorable, the firm may choose to exploit the new patented technology itself in a traditional way making commercialization investment ($I$ = \$80 m). At time 2 each firm may alternatively use its patent in strategic ways. For example, it may follow a defensive patent strategy (e.g., building a patent wall around its own core patent) or engage in an offensive fight with its rival (ñbracketingò each other´s core patents). If demand is highly uncertain or demand conditions are not favorable (e.g., the patent involves a new yet-unproven standard for a new technology), firm A may

[14] Imperfect patent protection will impact the size of the competitive advantage embedded in the patent: the size effect will be scaled down. If the (average) size shifts from the disruptive (large) type to the small one, the result may also differ qualitatively. The analysis may further be extended to account for asymmetric information (where the average cost advantage accounting for the probabilities of successful or ineffective patent enforcement is used in a playerôs reaction function) and the use of mixed strategies.

wait and keep its patent ñsleepingò until market uncertainty is resolved (or it may pursue a cooperative cross-licensing patent strategy) reconsidering the situation next period.

The situation is complicated when market demand uncertainty gets exacerbated by strategic competitive uncertainty. Supposing firm A is facing an incumbent firm B with an alternative old technology after the same product market, each competitorôs patent strategy may also depend on its rivalsô patent-leveraging moves.[15] When the competitive setting involves such strategic uncertainties, firms may be better off to flexibly exploit patents as *strategic leveraging options.* In such situations where competition is endogenous, a game-theoretic treatment of the patent-leveraging problem is required. Firm A must consider *both* how its investment decision affects its rival and how it may be impacted by rival reactions. A number of interesting issues need to be addressed. What type of patent-leveraging strategy (cooperative or fighting, defensive or offensive) should firm A pursue in stage II depending on its relative competitive advantage (determined by the degree of its own innovation and/or the relative prior market power of incumbent firm B), the state and volatility of demand and the nature of competition in the industry? Should it fight to keep any competitive advantage resulting from its superior technology for its own proprietary use or should it share it with its rival through licensing out its technology or agree to cross-licensing each other´s patented-technologies? Should the strategy change in different circumstances and if so, how?

[INSERT FIGURE 2 ABOUT HERE]

Figure 2 illustrates the basic two-stage strategic patent game and the underlying market value evolution tree, under High (H), Medium (M) or Low (L) demand scenarios. Holding the new patent gives firm A the exclusive right to build capacity for commercializing the new technological process by making an investment of $I$ = \$ 80 m by period 2 (end of stage I). The (gross) present value of expected future cash inflows from patent exploitation is currently $V_0$ = \$100 m, and is expected to fluctuate with annual volatility ů = 0.60 or 60% moving up by a multiplicative factor u = e$^{ů}$ = 1.8 or down by 0.6 (=1/1.8) each period, ranging by period 2 (end of stage I) from a low value of $V^{--}$ = 36, to $V^{+-}$ = 108, and a high value of $V^{++}$ = 324.

### The static value of the patent

If the firm were to follow a standard Discounted Cash Flow (DCF) approach to valuing the patent, the static value of the patent would be determined by discounting its expected future cash

[15] If firm A is a potential entrant into the market, it may not know the precise market structure upon entry and the resulting reaction of the incumbent rival (or future competitors). Even as an incumbent, it may not anticipate the patent-based entry mode and response of potential entrants to its action in the first place.

flows (net of the investment outlay, *I*, of $80 m) back to the current time (*t* = 0), using the cost of capital (*k* = 20%). Expectations are taken assigning appropriate probabilities to the occurrence of each scenario at the end of period 2. The static NPV of the patent, assuming immediate investing, is thus estimated at $20 m (= *V* ï *I* = 100 ï 80). This analysis ignores the dynamics and options resulting from the second-stage patent-leveraging game among the two rivals.

**The basic patent-leveraging game**

The patent will have a higher value if it is recognized that during the second stage it can be strategically leveraged against (or to the benefit of) competition. This involves ascertaining the size of relative cost advantage afforded by the new patent (over firm Bôs existing patented technology) and the nature of competition in the industry, accounting for rivalsô strategic moves under different demand realizations. Assuming rationality of the players in strategic interaction permits deriving each player´s payoff values in industry equilibrium. The menu of alternative patent leveraging strategies firm A may choose from (when making its second-stage strategic investment in period 2) includes the following: 1. abandon or sell (under very low demand conditions); 2. wait or let the patent sleep (under low demand); 3. cooperate (e.g., via licensing out or cross-licensing); and 4. fight (defensively or offensively). These patent-leveraging strategies correspond to four types of strategic leveraging options that the firm may exercise over the patent value (underlying asset): 1. option to abandon (reposition in the best alternative use) or sell the patent; 2. option to defer exploitation of the patent by waiting and monitoring future market conditions; 3. option to extend the patent potential cooperatively via licensing-out or cross-licensing; 4. option to expand the patent potency either through building a defensive patent wall around its own core patent (*clustering/fencing*) or by preventing the opponent from market exploitation by filing complementary patents to exploit or fill gaps around the rival´s core patent (*bracketing*).

In selecting one of these patent leveraging strategies, firm A must take into account the size of its cost advantage (zero, small or large) in relation to the existing market power of the incumbent and the state of demand (low, medium or high) when accessing the rivalôs likely response to its strategic move. The same reasoning process applies to the rival. Each firm must decide which strategic patent-leveraging move to make on the basis of its information and beliefs about what the other will likely do. Different combinations of the above factors may produce different types of equilibria. From a strategic perspective, several patent strategies may result involving the above cooperative, fight or wait strategy modes depending on the level of demand (high, medium or low) and the size of cost advantage (no, small, large), as summarized in Figure 3. In the base case analysis we assume the two rivals have equal a priori market power. In our subsequent robustness analysis we also consider the situation that incumbent firm B has larger market power to start with.

The combination of three states of demand for each of three relative cost advantage sizes results in 9 subgames, each potentially involving a different equilibrium and optimal patent-leveraging strategy. These subgames are numbered from 1 to 9 in the figures. In brief, if there is no significant cost advantage resulting from firm Aôs patented innovation and the firms are otherwise symmetric in market power, they are more likely to cooperate, cross-licensing their patents to each other.[16] At the other end, if firm Aôs innovation brings about a large relative cost advantage, a fight mode (keeping the innovation in-house) is more likely to result.[17] The precise patent fight strategy may depend on the level of demand, with high demand potentially involving more offensive strategies (e.g., bracketing), intermediate demand involving raising a defensive patent wall by the firm with the stronger patent to reinforce its advantage and potentially drive the rival out of the market, while in case of low demand letting the patent sleep.[18]

[INSERT FIGURE 3 ABOUT HERE]

We subsequently put more structure on the 9 subgames to determine the value payoffs and resulting strategy equilibria depending on the three levels of demand (H, M or L) and the size of the firmôs patent advantage (no, small, large). We suppose the two patent holders, firm A and firm B, compete in the same industry as a duopoly and behave rationally. Each pursues a set of patent-leveraging strategies at time 2 resulting in a given value payoff. Patent leveraging choices during stage II take the generic form wait or ñ*sleep*ò versus ñ*invest*.ò Investing under a cooperative mode (e.g., in the left region) may involve licensing-out oneôs patent to the rival (who does not invest letting its own patent sleep) or cross-licensing each otherôs patents (both firms invest). It may happen that one or both firms let their respective patents sleep (which characterizes the sleep-sleep scenario). Keeping oneôs patent sleeping amounts to deferring the strategic decision (e.g., cooperating via patent cross-licensing with the opponent or deciding to fight) to the next period ($t$ = 3). Holding a sleeping patent essentially means keeping a wait-and-see option. This option is more valuable when demand is more volatile. The effect of continuing to let the patent sleep for one more

[16] In many situations involving cross-licensing, firms may be in an asymmetric position in terms of the relative value of the IP contributed. The mechanism of balancing royalty payments views the net-taking firm paying a fee to the other (see Grindley and Teece, 1997). An asymmetric distribution of patent value a priori may change the results. In the asymmetric case that incumbent firm B has more market power, a fight mode involving a bracketing war (rather than cooperation) may result in lower demand states. See later robustness analysis and discussion surrounding Figure 11A.

[17] In the in-between case of a small cost advantage, hybrid patent leveraging strategies may result, e.g., involving fighting via offensive bracketing strategies at high levels of demand while switching to cooperation via licensing out the patented technology at low or intermediate demand levels.

[18] At medium demand the two firms may collaborate via a joint patent wall to fight new entrants.

period (during stage II) is captured by the continuation (or call option) value ($C$) of the associated deferral option. In such wait-and-see strategy, if both firms let their patents sleep we assume that the potentially stronger patent position of firm A enables it to appropriate a larger share (s %) of total continuation value (i.e., s$C$). Firm B captures the remaining, smaller portion, (1 ï s)$C$.[19] In general, the driving force of the sharing terms of end-of-period collaboration value between the two firms in the base case (assuming symmetric prior market power) is the relative market power based on the cost advantage or size of the innovation of firm A´s patent relative to firm B´s. If the size of resulting cost advantage from firm Aꞌs patent innovation is large, we assume firm A appropriates most (s = 75%) of NPV or $C$ (and firm B gets 25%); if small, firm A receives 60% (and firm B 40%). If there is no cost advantage from the patent, market value sharing is assumed 50-50 in the base case of (a priori) symmetric firms. The continuation value represents an option on stage II-total market value ($V$), which evolves according to the binomial tree of Figure 2.[20]

Under a fight mode, investing involves carrying out a defensive patent clustering strategy via construction of a patent wall around oneꞌs *core* patent (keeping the opponent out), or each firm pursuing an offensive patent bracketing strategy attempting to block its opponent from exploiting its patent (both firms invest). The patent leveraging strategy cost is assumed to be the base commercialization cost ($I$ = \$80 m), though it may be delayed, increased or reduced depending on the strategy choice (sleeping, fighting or collaboration). We assume that cooperation among the firms results in an enlarged market value pie (by 20%). This is operationalized by a strategy (cooperate or fight) mode multiplier ($m$), which in case of cooperative mode is $c$ = 1.2, amplifying the underlying market value to $mV$ (=1.2$V$). By contrast, a fighting mode results in a reduced total market value pie (by 30%) due to ensuing costly patent wars. That is, in case of fighting $mV = f\ V$ = 0.7$V$. In Figures 8 and 9A later we provide sensitivity of Expanded-NPV to the fighting and cooperation multiplier parameter ($m$) choices. Again, one or both firms may choose to let their respective patents sleep instead of investing, which characterizes the sleep mode. If both firms end up postponing a fight over their patents, the continuation value refers to the next-period ($t$ = 3) equilibrium situation in which firms A and B receive a declining market value because of intensified rivalry. Each firm´s payoff corresponds to the present value of expected future cash

[19] In a next-period collaboration with firm A, firm B will be in an inferior position relative to A.
[20] In the extension section, we present robustness results when incumbent firm B has asymmetric prior market power. In this case we make the following alternative assumptions. If the size of firm Aꞌs patent advantage is large, it fully offsets incumbent firm Bꞌs initial market power advantage so the symmetric case of 50-50 market sharing results. If there is no cost advantage from firm Aꞌs patent, we assume incumbent firm B appropriates most (s = 75%) of NPV or $C$ (and firm A 25%); if small advantage, firm B receive 60% (and firm A 40%). This is summarized in the right column in Figure 5.

inflows that will be generated by implementing a specific patent-leveraging strategy.[21] An options game valuation of firm A ô s patent strategy depends on the equilibrium solution found for each of the investment subgames composing the overall options game. The resulting equilibrium outcome values in the High, Medium and Low states of demand ($E_H$, $E_M$ and $E_L$) constitute the payoffs in the end-of-period nodes of the binomial option tree. These are multiplied by the respective (risk-adjusted) probabilities and discounted back at the riskless rate ($r$). We assume both firms as players in this options game choose their patent leveraging strategy simultaneously (independently).

[INSERT FIGURE 4 ABOUT HERE]

The resulting value payoffs (for firm A, firm B) in each of the 9 subgames are summarized in normal form via the 2 x 2 matrices of Figure 4, depending on demand (High, Medium, Low) and the size of competitive advantage (no, small, large). These subgame payoffs are described in more detail in the Appendix. Three benchmark *subgames (1, 3 and 5)* are highlighted (in circle) and explained at length. The other subgames are essentially variations on these. *Subgame 1* illustrates a typical value payoff structure of a game in which firm A leverages its patent in a cooperative mode (e.g., licensing out to or cross-licensing with the rival). This type of game is more likely to occur when firm A has no significant cost advantage. *Subgame 3* represents a payoff structure when firm A leverages its patent under a fight mode (e.g., defensive via a patent wall or offensive via bracketing). The latter fight modes are typically more prevalent in situations where firm A´s innovation cost advantage is large. For example, under medium level of demand (M) where there is room for only one of the firms to operate profitably in the market, firm A may solidify its advantage by building a defensive patent wall around its core patent that enables it to drive the rival out of the market and earn monopoly profits.[22] If demand is high (whether firm A´s advantage is large or small), the rival may believe it has a fighting chance and may go on the offensive to identify gaps around firm A´s core patent to limit its advantage and enhance its own position; firm A may pursue a similar offensive strategy in this case, resulting in a patent bracketing war. *Subgame 5* represents a more complex situation where a hybrid strategy may be preferable, described in the Appendix.

[21] Information is common knowledge, from the set of strategic actions available to both firms to the resulting value payoffs. Although both firms A and B have a *core* patent to leverage, for convenience we take the perspective of patent-advantaged firm A and assess the *expanded* net present value of its patent strategy.

[22] If the cost advantage is small, it may not be able to drive out the rival and a cooperating strategy via licensing may instead be preferable at intermediate demand levels.

**NUMERICAL RESULTS AND SUBGAME EQUILIBRIA**

We next discuss the *equilibrium outcomes* in the different states of demand under a cooperative, fight or wait mode for a given size of cost advantage. First, it is convenient to review the underlying assumptions and inputs behind these. Figure 5 summarizes the main inputs used in our calculations of the 2 x 2 matrix outcomes in the three states of demand (High, Medium, Low) at period 2 (end of stage I) under the assumption of no, small or large relative cost advantage resulting from firm A´s patented innovation. If the firms are in a cooperation mode, underlying market value ($V$) is enlarged by a cooperation mode multiple ($m$ = $c$ = 1.2) to 1.2$V$; if they enter into a fight mode, the fight multiple (or erosion factor) $m$ here is $f$ = 0.7, resulting in reduced value of 0.7$V$. Relative market power shares (s for firm A, 1 ï s for firm B) in sharing the total market value (adjusted NPV) or the continuation option value ($C$), depending on the size of cost advantage (no, small, large), are: 0.5, 0.5 (no), 0.6, 0.4 (small), 0.75, 0.25 (large advantage).[23] Investment or commercialization cost is $I$ = \$80 million (m), cost of capital ($k$) is 20% and the risk-free interest rate ($r$) is 8%. Building a defensive patent wall by firm A raises costs by 20% to $w_A I$ ($w_A$ = 1.2) and strengthens its market position increasing its market value to $w$**ô**$_A(mV)$ ($w$**ô**$_A$ = 1.2).[24] If firms engage in an offensive patent bracketing war, costs are increased to $bI$ ($b$ = 1.3). In certain situations a firm (e.g., firm A) may pay a fee as % of market value ($F$ % of $V$) to the other firm to license in its technology provided that the former agrees not to operate in the market (with the licensing fee schedule $F$ as shown in Figure 6). Demand moves up or down randomly in each period, with total market value ($V$), starting at $V_0$ = \$100 m, moving up or down by multiplicative factors $u$ = 1.8 and $d$ = 0.6, with a risk-adjusted probability of up move $p$ = 0.4 (and down move 1 ï $p$ = 0.6). The implied base-case volatility ů (= ln u) is 60%. At $t$ = 2, if demand is high (moves up twice) $V^{++}$ = 324, if demand is medium (after one up and one down move) $V^{+-}$ = 108, and if demand is low (following two down moves) $V^{--}$ = 36.

[INSERT FIGURE 5 ABOUT HERE]

Given the above assumptions, inputs and the payoff value expressions derived in the different subgames discussed around Figure 4 (see Appendix), we obtain the numerical results for the various subgames under high ($V^{++}$ = 324), medium ($V^{+-}$ = 108) and low ($V^{--}$ = 36) demand values, each under no, small or large cost advantage, resulting in the 9 matrix outcomes shown in

---

[23] The assumed relative market shares if incumbent firm B has prior market share power (under no, small or large patent advantage by firm A) are: 0.25, 0.75 (no), 0.4, 0.6 (small), 0.5, 0.5 (large advantage).

[24] Building a patent wall by weaker firm B raises its costs by 30% to $w_B I$ ($w_B$ = 1.3) and increases its market value share to 2.2($mV$), where $w$**ô**$_B$ = 2.2.

Figure 5. Each of the four ñstrategicò patent-leveraging scenarios within each subgame is associated with a pair of payoff-values for (firm A, firm B) as derived from the above analysis (Appendix). Each subgame involves two main choices by firm A or B: invest now or wait (sleep). The patent-leveraging ñinvestò choices by firm A or B are primarily of a cooperative nature in case of no patent advantage (symmetric players) or small advantage under low demand (involving licensing or cross-licensing); are of a fighting nature in case of large cost advantage (building a patent wall or bracketing), and may be hybrid for small advantage under intermediate demand (e.g., licensing vs. bracketing). The Nash equilibrium outcome in each subgame is shown as a shaded box, with the prevailing patent-leveraging investment strategy listed below it. These equilibrium outcomes and patent-leveraging strategies are consistent with the theoretical predictions shown in Figure 3.

[INSERT FIGURE 6 ABOUT HERE]

To illustrate, consider first the simple symmetric case of no patent advantage involving a cooperative mode under the high demand scenario at the end of stage I ($V^{++}$ = 324) shown in the leftmost top matrix (***subgame 1***). If both firms decide to keep their patents sleeping (upper-left box), each firm appropriates the deferral (or wait-and-see) option value according to their (assumed equal) market power, resulting in respective payoffs (157, 157). If both firms choose to invest cross-licensing their respective patents (lower-right box), they equally share the expanded NPV ($mV^{++}$ ï $I$ = 1.2*324 ï 80 = 308.8) at $t$ = 2 resulting in a (154, 154) payoff. If firm A decides to license its patent to firm B for a fee F (= 50% of $V^{++}$) and leave the market to its rival, firm A receives F = 162 and firm B the remaining 147 (308.8 ï 162). The symmetric diagonal case results in payoffs (147, 162). Given these payoff outcomes, summarized in *subgame 1* of Figure 6, the resulting Nash equilibrium is ***cross-licensing*** as shown in the lower-right shaded box. The game is dominance solvable as each firm has a dominant strategy to invest (license), regardless of its competitorôs decision (for firm A, 162 > 157 if firm B sleeps and 154 > 147 if it invests; for firm B, 162 > 157 if firm A sleeps and 154 > 147 if it invests).[25] The Nash equilibrium is the invest-invest outcome (154, 154) with each firm agreeing to license to the other (cross-licensing). Under no cost advantage involving symmetric firms, both firms prefer to collaborate via cross-licensing and there is no incentive for them to deviate from this collaborative ñstrategicò stance. ***Subgames 4 and 7*** under Medium and Low demand, also involving no cost advantage, result in similar invest-invest *cross-*

[25] A dominant strategy for a player is indicated by an arrow or a black dot (indicating the tip of an implied arrow) over the higher payoff choice; a Nash equilibrium is reached when a pair of black dots is obtained in a cell or when the arrows point the flow to a position (box) that once reached there is no incentive or pressure to deviate from it. The resulting equilibrium is indicated by a shaded box.

*licensing* Nash equilibria -- only with lower values for the collaborating firms, namely (25, 25) and (2, 2), respectively. The above can be summarized in the following.

> *Proposition 1: When there is* no *relative patent advantage and rivals are symmetric,* collaboration *(via cross-licensing) is a natural equilibrium outcome across demand states.*

Consider next the situation at the other extreme involving a *large cost advantage* under a *fight* mode instead, again under High demand (***subgame 3***). When choosing to keep their patents sleep (upper-left box), each firm appropriates the continuation value of the wait-and-see option (*C*) according to their (asymmetric) market power (s = ¾ for firm A and 1 ï s = ¼ for firm B), resulting in payoffs (98, 33).[26] When both firms invest fighting via bracketing, they share the reduced (from fighting) total market value according to their market power, with each incurring a relatively larger cost of bracketing (by $b$ = 1.3) the otherôs patent (e.g., $NPV_A$ = ¾(0.7*324 ï 1.3*80) = ¾(122.8) = 92). This results in a (92, 31) payoff in the lower-right *bracketing* box. In the case where one firm (e.g., firm A) engages in patent clustering (building a patent wall) while the rival keeps its patent sleeping (off-diagonal boxes), the former captures an enhanced share (e.g., firm A receives s $w_A$ = ¾(1.2) or 90%) of net market value ($V^{++}$ ï $I$ = 324 ï 80 = 244) or 220, with the rival receiving the remainder (8).[27] This results in payoffs of (220, 8) or (68, 152) along the diagonal, depending on whether it is firm A or firm B that decides to preempt the opponent via raising a patent wall. The Nash equilibrium is derived similarly (as in *subgame 1* above), as each firm again has a dominant strategy to invest regardless of the opponentôs decision (for firm A, 220 > 98 and 92 > 68; for firm B, 152 > 33 and 31 > 8). The resulting equilibrium is the bottom-right, invest-invest ***bracketing*** strategy (92, 31). Under asymmetric reciprocating competition with high demand, both firms feel induced to fight via reciprocal patent bracketing -- even though they would be better off to let their patents sleep. The fear of the rival investing in a patent wall and strengthening its position if it lets its own patent sleep puts pressure on both firms to invest aggressively bracketing each otherôs patent, a situation analogous to the prisonerôs dilemma.

The other two cases also involving *large* cost advantage but at intermediate (M) or low (L) demand levels (***subgames 6 and 9***) are interesting in themselves. Although they essentially involve

---

[26] The end-of-period payoff (considering the upper-node value $V^{+++}$ in next period 3) on which continuation values are calculated is max(0.70$V^{+++}$ - 1.3$I$, 0). Here the fighting, delayed to next period, causes market value erosion (by 30%) and investment costs are larger by a factor $b$ = 1.3 because of intense patenting around the competitorôs product (bracketing). The time-2 value of 98 is obtained as the average (using risk-neutral probabilities) of the subsequent period upper and lower payoffs given a fight strategy.

[27] Firm B receives (1 - s $w_A$)$V$ ï (1 - s) $w_A$ $I$ or 10% of 324 ï 30% of 80 = 8.

a similar derivation of payoff values they result in qualitatively different types of equilibria, with *subgame 6* at intermediate demand resulting in an invest-sleep *patent wall* strategy outcome of (34, 0) along the lower-left diagonal box, and *subgame 9* at low demand in a *sleeping* strategy by both firms with payoff (9, 0) in the top-left box. In ***subgame 6*** involving intermediate demand there is room for only one of the players to profitably operate so firm A can further strengthen its large patent advantage by investing in a protective patent wall earning monopoly profits (valued at 34) and driving its rival out of the market (0). In this case, firm A has a dominant strategy to invest, regardless of its rivalôs decision (34 > 9 and 3 > -29). Knowing that firm A is better off to invest and fight regardless, firm B prefers to wait (sleep) rather than engage in a costly bracketing fight (0 > -17), resulting in the ***patent wall*** equilibrium outcome (34, 0).

In ***subgame 9*** involving low demand, it is not profitable for either firm to operate at present, with firm B (being at a large cost disadvantage) abandoning the market (truncating its value to 0). Firm A lets its superior patent sleep, maintaining its option to become a monopolist should the market recover in the future (with continuation value 9). In the matrix, each firm has a dominant strategy to let its patent sleep (or abandon) independently of its competitorôs move (for firm A, 9 > -5 and -14 > -20; for firm B, 0 > -1 and 0 > -7). Given the low level of demand ($V^{--}$ = 36), both firms would actually lose value fighting against each other via engaging either in patent clustering (wall) or a bracketing war. There is just one strictly dominant ***sleeping*** strategy equilibrium in the upper-left box (9, 0), which amounts to the disadvantaged firm abandoning the market with the advantaged firm maintaining an option to become a monopolist in the future.

> *Proposition 2: When a firm has a* large *patent advantage, a* fight *mode is likely. The precise strategy may differ across demand regimes. It may range from offensive fighting (bracketing) in high demand, to defensive patent wall by the advantaged firm to drive out its rival in medium demand, to a wait-and-see strategy (patent sleep) with an option on future monopoly position in low demand regime.*

The case involving *small* patent advantage under high demand in ***subgame 2*** is similar to *subgame 3*, with the share of firm A being lower (s = 60% rather than ¾) assuming bracketing war neutralizes or eliminates firm Aôs small patent advantage, rendering the bracketing outcome symmetric (61, 61). Each firm again has a dominant strategy to invest, resulting in a symmetric ***bracketing*** equilibrium under a *fight* mode. However, under low or medium demand the firm switches to a *cooperative* mode, yielding different equilibrium outcomes, namely an invest-sleep ***licensing*** equilibrium in the lower-left box. The *hybrid* case of ***subgame 5*** at intermediate demand is particularly interesting as investing may take the form either of a cooperative licensing strategy or of a costly bracketing fight. Firm B is better off to wait and avoid investing in a costly fight, with firm A agreeing to cooperatively license its marginally superior patented technology to firm B for a fee $F$ while still operating (and capturing half the market value).

*Proposition 3: In case of* small *patent advantage, the firm may be better off to pursue a* flexible hybrid strategy*, switching from a fight mode (e.g., bracketing) at higher demand to collaboration (licensing) as demand declines.*

## THE VALUE OF THE PATENT STRATEGY

A strategic patent investment thus involves a portfolio of patent leveraging options (to abandon, sleep, license in or out, cross-license, fight through raising a patent wall, a bracketing war etc.). Each of these options has the base economic value of the commercialized patent as underlying asset. The resulting time-$t$ = 2 equilibrium payoffs associated with the patent leveraging outcomes among the two patent-holding rivals in each state of demand ($E_H$, $E_M$ and $E_L$), for a given cost advantage (C = No, Small or Large), are then weighted by their respective (risk-adjusted) probabilities and discounted back to the present ($t$ = 0) for 2 periods at the riskless interest rate $r$ within a backward binomial option valuation process. Using risk-neutral probabilities for each up and down move of $p$ = 0.4 and 1 - $p$ = 0.6 and a risk-free rate $r$ = 0.08, yields an *expanded* net present value (E-NPV) for the patent strategy for firm A of \$32 m in case of *no* competitive advantage involving a cooperative mode (cross-licensing); \$31 m in case of *small* advantage involving a hybrid strategy (fighting via bracketing under high demand and cooperating via licensing under medium or low demand); and \$29 m in case of a *large* cost advantage involving a fight stance (bracketing under H demand, raising patent wall to preempt and gain monopoly rents under M demand while sleeping under L demand), respectively:

**No** Cost Advantage/ Cooperative Mode:

$$\textit{Expanded}\ \mathrm{NPV}_0 = \frac{p^2 E_H + 2p(1-p)E_M + (1-p)^2 E_L}{(1+r)^2} = \frac{0.16x154 + 0.48x25 + 0.36x2}{(1+0.08)^2} = 32;$$

**Small** Cost Advantage/ Hybrid Strategy:

$$\textit{Expanded}\ \mathrm{NPV}_0 = \frac{0.16x61 + 0.48x46 + 0.36x12}{(1+0.08)^2} = 31;$$

**Large** Cost Advantage/ Fight Mode:

$$\textit{Expanded}\ \mathrm{NPV}_0 = \frac{0.16x92 + 0.48x34 + 0.36x9}{(1+0.08)^2} = 29.$$

[INSERT FIGURE 7 ABOUT HERE]

These results are summarized in Figure 7. Compared to the passive NPV of \$20 m (that assumes investing now while ignoring competitive interaction), firm A ̓s patent leveraging options portfolio (estimated from above Expanded NPV ï passive NPV) is worth about \$12 m under the cooperative strategy (involving cross-licensing) when there is *no* patent advantage (symmetry); \$11 m under the hybrid strategy when there is *small* advantage; and \$9 m under a fight mode in case of *large* advantage. The fight mode in this case, despite firm A ̓s cost advantage, results in lower value due to value destruction from ensuing patent war.

In case of large patent advantage, firm A might recognize that in high demand (H) it might actually be better off to cooperate (via cross-licensing), obtaining a smaller (½) share of a (20%) larger market pie (resulting in a 154 value as in *subgame 1*), rather than fight shouldering higher bracketing costs to obtain a higher share (¾) of a (30%) smaller pie (resulting in value of 92). Such a hybrid patent strategy, switching from a fight mode via raising a patent wall to strengthen its patent advantage in medium demand (with room for just one firm) to a cooperative relationship via cross-licensing in high demand (effectively replacing 92 by 154 in the last equation for Expanded NPV above), results in a higher E-NPV of \$38 m (up from \$29 m), doubling the value of the patent options portfolio to \$18 m. This hybrid patent strategy under large cost advantage is more valuable (\$38 m) than the cooperative strategy under no patent advantage involving symmetric firms (\$32 m) or the hybrid strategy under small patent advantage (\$31 m).

## ROBUSTNESS AND EXTENSION

We next consider robustness of our results to alternative specifications and extension to the case of asymmetric prior market power by the rival. We first examine the tradeoff between fight and cooperate modes for high demand and extrapolate our investigation considering a broader menu of patent leveraging strategies at more extreme levels of demand or involving higher volatility, highlighting the value of hybrid strategies with flexibility to switch among various fight, collaborate or sleep modes. Figures 8A and B highlight the tradeoff between the cooperate vs. fight strategy arising in high demand states in case of large patent advantage examining the sensitivity of Expanded-NPV to the fight erosion or cooperation multiple ($m$ = $f$ or $c$). In Figure 8A, at the assumed fight erosion multiple of $f$ = 0.7 in the base case (with cooperation multiple of $c$ = 1.2), the fight strategy results in a lower E-NPV than the cooperate (cross-licensing) strategy (\$29 m vs. \$38 m). However, as the fight multiple rises above a certain cutoff level $f^*$ = 0.96 (i.e., as the degree of damage from an ensuing patent war diminishes), the fight strategy results in a higher value. If there is no value erosion from bracketing war ($f$ = 1), E-NPV = \$40 m. For $f > f^*$ a pure fight strategy is preferable when firm A ̓s patent is superior, while for $f < f^*$ a hybrid strategy involving a switch from fighting to cooperation via cross-licensing when demand gets very high is optimal instead. A hybrid strategy is also optimal when patent advantage is small.

Figure 8B illustrates the sensitivity of E-NPV to the *cooperation* multiple ($c$) assuming *large* competitive advantage under a cooperate/hybrid strategy. Again, when c = 1.2 (as in the base case) cooperation results in higher value (38) than fight (29) when $f$ = 0.7. In fact, cooperation always dominates fighting for $f$ = 0.7. At the cutoff fight multiple $f$ * = 0.96 (upper horizontal dotted line) fighting and cooperation result in the same value (38) when $c$ equals $c$* = 1.2. For $f$ * = 0.96 cooperation is beneficial when the cooperation multiple exceeds $c$* = 1.2, while fighting dominates when $c$ < 1.2. Figure 9A extends the sensitivity analysis of E-NPV to the cooperation multiple ($c$) under different patent advantage scenarios. The case where c = 1.2 corresponds to the base case of Figure 7. Even under a large advantage, a rigid fight strategy results in a lower value (independent of the collaboration multiple) of 29 m. Above a cutoff level of 1.1, having a small advantage under a hybrid strategy is preferable to a rigid fight strategy, as collaboration via (cross) licensing in the low and medium states enhances value. Below a cutoff level of c = 1.17, having a small advantage results in a higher value than having no advantage, but at a higher cooperation multiple no advantage might lead to higher value as it induces collaboration via cross-licensing in all demand scenarios whereas under small advantage a fight bracketing strategy may ensue in the high demand regime (as in Figure 2). A conscious hybrid cooperative strategy under large advantage seems best.

[INSERT FIGURES 8A & B AND 9A & BABOUT HERE]

Figure 9B presents sensitivity of Expanded NPV to volatility (ů) under no, small and large competitive advantage. The base level of ů = 60% confirms the E-NPV values found in the middle column of Figure 7: E-NPV = 29 m for large advantage under a fight (rigid) strategy; 31 m for small advantage under a hybrid strategy; 32 m for no advantage under a cooperate strategy; and 38 m for large advantage under a hybrid/dynamic strategy involving cooperation in High (H) demand. The tradeoff between fight and collaboration in high demand states leads to the value discontinuity or gap between the rigid fight strategy and the dynamic switch (cooperative) strategy E-NPVs under large advantage. E-NPV values decline at lower volatility levels as expected. At ů = 15%, values coincide with those shown in the left E-NPV column in Figure 7. An interesting discontinuity in the E-NPV values of the various strategies is observed around a critical volatility level of about ů* = 38%. This discontinuity arises due to a shift in certain equilibrium subgames as volatility declines below a critical threshold level. For example, for large patent advantage, in low demand the equilibrium strategy is to sleep (wait) under high volatility; but as ů declines below ů*, the value of the wait-and-see option declines while the attractiveness for the stronger firm to fight and drive the weaker rival out of the market given its disadvantage, low demand and low recovery prospects rises. But at very high demand, cooperation is attractive under high volatility, partly deriving from the option to jointly appropriate the value of open innovation and optimizing future decisions under demand uncertainty, avoiding the prisoner´s dilemma of both firms investing prematurely under the pressure of competitive rivalry; as volatility declines below a certain level, however, there is again a shift from cooperative to fighting equilibrium. As volatility declines there is a shift from the wait (sleep) and cooperation modes to fighting, resulting in a rigid fight only mode.[28] Figure 10A confirms, in case of large patent advantage, that at low ů a rigid, fight only strategy (e.g., raising a defensive patent wall to strengthen the patent´s large advantage) may be optimal. However, as the cone of uncertainty rises a wider menu of strategic choices opens up, including sleep/abandon at the low end and cooperation at the high (as well as middle) end of demand. At high volatility (ů = 90%), optimal competitive strategies span the whole range from abandon, sleep, defensive fighting (raising patent wall), offensive fighting (bracketing), and cooperation (cross-licensing).

[INSERT FIGURES 10A & B ABOUT HERE]

Figure 10B provides a summary and an extension (including the case of small and no advantage) of the various cooperate vs. fight patent strategies that may be optimal when a broader range of demand states is possible under highly volatile markets in the base/symmetry case. The case of large advantage (rightmost column) corresponds to the high volatility case (rightmost column) of Figure 10A above. Here, higher demand volatility allows adding Very High (VH) and Very Low (VL) demand states at the two extremes, besides High (H), Medium (M) and Low (L) demand after time period $t = 4$. As previously, in determining the equilibria for each of the various cooperate or fight subgames, the firm should select the type of patent leveraging *strategy S* (e.g., sleep or abandon, licensing out, cross-licensing, raising patent wall, or bracketing) and associated options to optimally exercise depending on different market demand (or volatility) conditions and the size of its relative cost advantage. The optimal patent strategy is a function of the size of competitive cost advantage C (No, Small, Large), the cooperative or competitive strategy mode *m* (*c*ooperate, *c, or f*ight, *f),* and demand level regime *D* (e.g., VH, H, M, L or VL).[29] Under large cost

[28] In moderate or high demand if the patent advantage is small and volatility is high, the possibility of future high rewards may induce a somewhat weaker rival to fight aggressively and enter a bracketing war; as volatility declines, however, the possibility of high rewards declines and the weaker rival may face a patent wall by the stronger patent holder or shift to cooperation via licensing or cross-licensing.

[29] For a given competitive advantage C (C = N, S or L), patent strategy *S* is a function of the strategy mode *m* and demand regime *D*, namely $\mathit{PatentStrategy}_m^D(S \circ C)$. Generally, for no or small relative cost advantage where a

advantage (L) the strategic patent leveraging by firm A may span the entire menu of available options depending on prevailing market demand conditions: ***abandon*** when demand is very low (VL);[30] ***sleep*** or ñwait and seeò when demand is low (L); expand/strengthen the patent through a patent wall to preempt the rival and gain monopoly position at medium demand (M), while at times cooperate with the rival in a duopoly to preempt third entrants; engage in offensive fighting via ***bracketing*** in high demand (H); and potentially switch to a cooperative mode (***cross-licensing***) at very high levels of demand (VH) allowing room for both rivals to profit. In general, under large patent advantage, the optimal patent leveraging strategy of firm A may vary or switch among defer/abandon, fight, or cooperate, depending on the level of demand and other conditions (e.g., volatility). Under volatile conditions, patent strategy should thus be dynamic, able to adapt and switch among various fight, cooperate or sleep modes. Patent leveraging strategy is generally hybrid when the competitive advantage is small, with small variations in demand, e.g., from High to Medium, necessitating a strategy switch from a fight mode (e.g., bracketing) to a cooperate mode (licensing). This may also be the case when patent advantage is large, with cooperation possibly prevailing unless the market is limited. These dynamic switches among the cooperate, fight or sleep modes bring about value discontinuities and non-trivial tradeoffs not fully recognized in traditional analyses.  The above insights can be summarized via the following propositions.

> *Proposition 4A: A larger patent advantage raises the benefit and lowers the demand threshold at which it pays to fight. Cooperation can prevail in more volatile situations when demand is very high. Cooperation prevails when the (smaller) share of joint benefits exceeds the dominant share of a reduced market pie from winning a bloody fight (or engaging in a costly patent war). The case of high demand is most peculiar as initially give-up strategies may switch to fighting and then, at even higher demand levels, to cooperation. Volatility exacerbates these peculiar switching patterns between fighting and collaboration.*

---

cooperative mode typically prevails, firm A can leverage its patent via exercising one of the following strategic options depending upon demand conditions: option to extend the patent through $PatentStrategy_c^D$ (*cross-licensing* ˚ C = No), D = VH, H, M or L; option to extend the patent through $PatentStrategy_c^D$ (*licensing-out* ˚ C = Small), for D = M or L; or option to defer the exploitation of the patent or abandon it through $PatentStrategy_c^D$ (*sleep* or *abandon*) for D = VL (regardless of the size of cost advantage).

[30] In Figure 10B it is assumed that a fight mode extends to the very low demand scenario forcing abandonment by a disadvantaged rival. If firms are roughly ex post symmetric, a collaborative strategy may result instead (e.g., patent pool) particularly if incumbent firms A and B jointly face external party entrants.

*Proposition 4B: Even with a superior patent, the firm should consider the full menu of fight as well as cooperate strategies potentially switching among various sleep, collaborate and fight modes as demand changes in pursuit of a dynamic competitive strategy.*

**Asymmetric Prior Market Power**

Figure 11A considers the asymmetric situation when incumbent firm B has larger *prior* market share power to examine how an asymmetric distribution may change the results concerning cooperate vs. fight strategies.[31] Suppose that before the new patent is introduced by firm A, incumbent firm B has a 75% market share dominance. If firm Aôs new patented technology has only a small cost advantage, the initial asymmetry in favor of incumbent firm B will be partly reduced (shares will adjust to s = 40% for firm A and 1 ï s = 60% for B). The incumbentôs initial market power advantage will be completely eliminated, however, if firm Aôs patented innovation involves a large cost advantage, reverting back to an ex post symmetric situation (50-50). The assumed relative market shares for firms A and B in this case (under no, small or large patent advantage by firm A) are: 0.25, 0.75 (no), 0.4, 0.6 (small), 0.5, 0.5 (large advantage). The circles in Figures 11A and 11B indicate subgames that shift between fight and cooperation modes and vice versa in this asymmetry case, compared to the base case of symmetry discussed earlier. Previous symmetry games 4 and 7 that under no patent advantage were previously characterized by cooperation (cross-licensing) under moderate and low demand, now change into fight games involving bracketing due to the asymmetry resulting from incumbent firm B´s prior market power; similarly, subgame 8 involving small patent advantage under low demand previously characterized by cooperation (licensing out) also turns into a bracketing fight. By contrast, the previous asymmetry due to firm A´s large patent advantage in subgame 6 that led to a fight (patent wall) is now offset by the incumbent´s prior advantage so the resulting symmetry now supports cooperation (cross-licensing). In other words, cases that were previously symmetric, characterized by cooperation, now become asymmetric characterized by fighting, and vice versa. What really matters is the *relative* competitive advantage or asymmetry, not just the absolute patent cost advantage. Figure 11B shows the revised outcomes and resulting equilibria in the changed subgames.

[INSERT FIGURES 11A & B ABOUT HERE]

[31] As noted, it is unlikely to find cases of cross-licensing where the firms are in a purely symmetric position. Sometimes the weaker firm will pay a fee to the other. A legitimate question is what would compel the old technology owner to cross-license if it has a dominant market share? If the new technology has no advantage over the old, buyers of the old patented product will likely require some inducement to switch to the new (but not superior) technology. The old technology owner may be induced to agree to cross-license for a number of reasons, such as freedom to invent, a fee payment, or collaborate to prevent entry by new entrants (third parties).

## DISCUSSION AND MANAGERIAL IMPLICATIONS

We identified a research gap at the very core of the strategy literature (Figure 1A) that over the years has struggled with two classic dilemmas: commitment vs. flexibility (e.g., Wernerfelt and Karnani, 1987; Spencer and Brander, 1992; Sadanand and Sadanand, 1996; Boyer, 1997; Ghemawat and del Sol, 1998; Smit and Trigeorgis, 2004), and competition vs. cooperation (Teece, 1986; Kogut, 1991; Parkhe, 1993; Lado, Boyd and Hanlon, 1997; Chi, 2000; Arend and Seale, 2005; Reuer and Tong, 2005; Somaya and Vonotras, 2010). The main aim of this article and our main contribution is to help address this long-standing and persisting gap. Utilizing a relatively new context in strategic management involving the strategic use of patents in ñproactiveò business strategy (e.g., see Grindley and Teece, 1997; Cohen *et al*., 2000; Reitzig, 2004; Somaya, 2012), we analyze the dilemma of when firms should compete and when they should cooperate (licensing or cross licensing their patents), while concurrently capturing the tradeoff between commitment (fight/preempt) and flexibility (wait/stage/ally) via the use of a novel strategic tool, option games, recently developed by Smit and Trigeorgis (2004). As Somaya (2012) concludes, ñit would be valuable to incorporate the strategies and actions of rival and partner firms within this calculusé actions initiated by rival firms may lead to competitive dynamics that have yet to be systematically investigatedé it would be worthwhile to further explore when firms are and are not better off pursuing ñweak,ò nonproprietary [collaborative] patent strategies to enhance the value creation potential of their innovation.ò This timely call underscores how little we have advanced since Wernerfelt and Karnaniôs (1987) early warning. Our related findings and managerial implications are reviewed below and compared with those in the licensing and related literatures.

In line with recent contributions using real options logic in the technology strategy space (e.g., McGrath and Nerkar, 2004: Oriani and Sobrero, 2008) enhanced with a game theoretic perspective (Camerer, 1991; Ferreira, Karr and Trigeorgis, 2009) we illustrated how a patent strategy can be valued and examined the optimality of different competitive or cooperative patent strategies. The optimal patent strategy is moderated not only by the strength of patent advantage (in line with licensing literature e.g., Somaya, 2012) but also by the level and volatility of demand. Extending literature on alliances (e.g., Teece, 1986; Kogut, 1991; Gulati, 1998; Chi, 2000; Arend and Seale, 2005; Somaya and Vonortas, 2010) and on licensing (Anand and Khanna, 2000; Fosfuri, 2006; Davis, 2008), we analyzed the circumstances under which rivals should collaborate rather than compete in using their IP assets strategically under uncertain conditions. This complements recent results by Kumar (2011) confirming that cooperative forces eclipse competition in JVs when both firms possess valuable resources. Interesting managerial implications for the formulation of an adaptive patent strategy result. In line with Rumelt (1984) and Wernerfelt and Karnani (1987), we propose a dynamic notion of strategy that involves the use of a menu of patent leveraging strategies enabling the firm to switch among compete (fight), cooperate or wait (patent sleep) modes that may prevail under different future demand or volatility scenarios. The above dynamic strategy is conditioned on the strength of the patent advantage and on prior (potentially asymmetric) market power, consistent with prior related literature (e.g., Arrow, 1962; Fosfuri, 2006; Ceccagnoli, 2009). A number of managerial implications are noteworthy.

First, we confirm that a larger patent advantage generally increases the benefit and lowers the critical demand threshold at which it pays to *fight*. The greater the advantage of the newly patented over the existing technology, the greater are the incentives to fight (e.g., bracketing each otherǒs patents or erecting a defensive patent wall). This is analogous to the classic result in the licensing literature (e.g., Arrow, 1962; Hill, 1992; Wang, 1998) that large innovation advantage should be kept proprietary while patented technologies with small advantage might be shared via licensing out to capture royalty fees or as a defense against imitation. Beyond the above opportunistic factors and competitive forces or strength of patent advantage, we also emphasize strategic elements such as interactions among industry players and the role of market uncertainty. Moreover, the above result is moderated by the level and volatility of demand. Patent leveraging strategies seem to be well-ordered for small patent advantage at increasing levels of demand, with fighting becoming more attractive when demand gets higher. Collaboration via licensing may result in low or moderate demand states, in line with Hill (1992). However, contrary to the traditional result, even when the patent advantage is large, *cooperation* can prevail in more volatile situations when demand is *very* high. This is a novel result that merits deeper reflection by managers. An option games analysis of such a dynamic patent strategy reveals that if the firm follows a cooperating strategy (e.g., via cross-licensing of patents with rivals) it might significantly enlarge its patent value share by enlarging the market pie. The joint benefits from cooperation that enlarge the market pie may exceed the reduced pie from winning the fight net of higher fight costs. Under high demand one can anticipate scenarios where there is fierce fighting to take advantage of monopoly rents (e.g., typical Microsoft stance), as well as other scenarios where some collaboration occurs (e.g., via cross licensing) to jointly appropriate the value of open innovation and exploit larger joint rents, consistent with Teece (2000). More collaboration may also prevail at moderate demand if the incumbent firms fear competition from new entrants. Cross-licensing here may essentially develop a wall around incumbent oligopolists, especially when complementary assets are important (e.g., Intel and AMD). The above reveals a severe limitation of standard or passive NPV analysis that treats the size of the market pie (and sometimes firm market shares) as given (for the expected market scenario). In our option games analysis, optimal strategic decision-making is contingent on both market demand uncertainty as well as the endogenous incorporation of rival reactions to oneĝs strategic patent moves. Indeed the size (and sharing) of the market pie is a function of the (competing, cooperating or hybrid) strategy pursued by firm management and its rivals, moderated by the demand level and volatility (or implied future prospects).

A related implication managers should note is that when the firm pursues a fighting strategy it may potentially lead to lower overall value due to ensuing patent wars even when it has considerable cost advantage via a superior patent. In such a case the *expanded* net present value of the patent strategy may be lower. It is important for managers to realize that value may be enhanced by a combination of favorable market conditions as well as via a cooperating stance (e.g., via cross-licensing of patents) among rivals under high demand. Even in low demand with a small patent advantage, value may be enhanced via licensing in anticipation of future collaboration. Such collaboration strategies can enhance value significantly in many cases. The dilemma between competition and collaboration in high demand states merits special attention by managers and strategists as it may lead to interesting value discontinuities and tradeoffs. A large patent advantage under moderate or high demand often induces a compete mode (e.g., not license to a rival or fight via the use of patent wall or bracketing strategies), in line with classic first-mover advantage arguments (Lieberman and Montgomery, 1988). But our rationale here is distinct and complementary to Hillĝs (1992) preference for licensing out to prevent imitation. Moreover, under other circumstances collaboration among the firms (e.g., against an external third-party threat) may be a preferable strategy. A strong patent advantage may induce patent sleeping or rival exit under very low demand. The above reveals a more rich set of circumstances under which rivals should fight or cooperate in using their IP assets under uncertainty, enriching our understanding of patent strategy and management (Somaya, 2012).

Contrary to conventional thinking, higher market uncertainty may be value-enhancing not only because it increases growth option value (Dixit and Pindyck, 1994; Trigeorgis, 1996; McGrath, 1997) but also because it induces firms to switch to collaboration strategies. This hidden upside potential resulting from higher market uncertainty can be exploited through a richer menu of strategic choices by cooperating firms (e.g., via cross-licensing). This is generally the case when firms are roughly symmetric with equivalent technologies. This is broadly in line with Fosfuri (2006), though for somewhat different reasons. If the innovator instead holds a small patent advantage, Fosfuri would argue that the incentive to license is low as there is low profit dissipation effect. We find licensing out may be justified even under low or medium demand.[32] Additionally,

[32] Fosfuri (2006) notes that firms with larger prior market share have a weaker incentive to license as they would suffer higher profit dissipation. Our finding that in the asymmetric situation (when incumbent firm B has larger prior market

we find that upside potential from collaboration also holds under very high demand or volatility conditions even when firms are asymmetric, with one firm holding a superior patent (or having a larger prior market share). Our perspective also complements that of the property rights theory (Anand and Khanna, 2000) that argues a firm should avoid licensing a superior technology or should cross-license mainly to reduce the risk of imitation. Instead we emphasize the benefits of collaboration such as enhancing the value of the relevant market by fostering exchange of technologies and more innovation at industry level. Managers should be cautioned that such potential collaboration benefits may be lost when fighting reciprocating rivals via taking an aggressive stance that may erode total market value at moderate levels of demand. Aggressive fighting may be justified in some cases, however, if the firm has a large advantage via a superior patent, in line with Arrow (1962) and Hill (1992). But our analysis indicates that this holds if the market value erosion from patent fighting is limited or if market conditions are constrained such as when overall demand is just sufficient for only one producer enabling the firm with the superior technology to drive its rival out of the market and gain a current or future monopoly position. Our justification of preemptive patenting strategies (under moderate demand) and the moderating role of market power asymmetry are consistent with recent evidence by Fosfuri (2006) and Ceccagnoli (2009). Managers, however, should be aware that a different strategy may be appropriate if demand is so high or the rewards of winning a fight are so appealing that the rival may not be driven out by any means and is in a position to cause substantial damage when fighting back. A careful scanning of the competitive environment is thus warranted. The case of high demand is most peculiar and deserves careful managerial attention as initially give-up strategies may switch to fighting strategies and then, at even higher demand levels, to cooperation. Hybrid strategies may thus result, involving switching from one type of fight mode to another or from competition to cooperation as demand rises or as the cost advantage gets smaller. Higher demand volatility exacerbates and brings out more explicitly these peculiar switching patterns between fighting and collaboration modes.

In conclusion, in assessing the *expanded* net present value of a core patent today, managers must clearly identify which set of contingent patent-leveraging strategies they might pursue. This decision will depend on some well-known factors such as the strength of the patented new technology (Arrow 1962; Hill, 1992), relative prior market power position (Fosfuri, 2006; Ceccagnoli, 2009) and anticipated rival reactions (Smit and Trigeorgis, 2004). What really matters of course is the relative competitive advantage arising out of firm heterogeneity or asymmetry (Peteraf, 1993), not just the absolute patent cost advantage. However, it has been less obvious how the optimal strategy also depends on the demand and volatility regimes. Our analysis enriches and

share power whereas innovator firm A has a small patent advantage) under medium demand licensing is preferable for firm A, is in the same direction.

extends the work of Davis (2008) in providing a more dynamic analysis of an IP vendorôs licensing strategies, accounting for market uncertainty, patent advantage as well as relative market power and strategic interaction among industry players. It may enable IP vendors and licensees negotiate more appropriate contracts. Contract provisions may be adjusted in a contingent manner going forward. When one goes the extra mile to combine real options and games under uncertainty, the tradeoffs between competition and collaboration (or flexibility and commitment) are not as trivial as it might appear from early analysis of corporate licensing behavior. In contrast with the view that cross-licensing may settle litigation disputes (Anand and Khanna, 2000) or may dissipate rents (Hill, 1992), we believe that patent portfolio management should be made in light of enhancing a flexible overall IP strategy and attracting the right collaborations (Grindley and Teece, 1997). Creating and managing cooperative relationships, leveraging (ñborrowingò) resources outside firm boundaries (Capron and Mitchell, 2012), within a broader alliance portfolio that is ñevolving from adapting to shaping and exploiting, according to the state of strategic uncertaintyò (Hoffman, 2007), is a critical dynamic capability requiring requisite complementary capabilities and absorptive capacity (Anand, Oriani and Vassolo, 2010). Management should be more flexible to dynamically switch among various fight, wait or cooperate strategy modes as market circumstances warrant. This is, after all, the very essence of competitive strategy, being in ñconstant search for ways in which the firmôs unique resources can be redeployed in changing circumstancesò (Rumelt, 1984: 569). The increasing cone of market and competitive uncertainty thus makes the value of a dynamic patent strategy that enables managerial switching among a broader menu of competing or cooperative strategic alternatives key to survival and success in a fast-changing world.

## REFERENCES


Adner R, Levinthal D. 2004. What is *not* a real option. *Academy of Management Review* **29**: 74-85.

Anand J, Oriani E, Vassolo R. 2010. Alliance activity as a dynamic capability in the face of a discontinuous technological change. *Organization Science* **21**(6), 1213-1232.

Ananda BN, Khanna T. 2000. The structure of licensing contracts. *The Journal of Industrial Economics* **48**(1): 103-135.

Appelbaum E, Lim C. 1985. Contestable markets under uncertainty. *Rand Journal* **16:** 28-40.

Arend RJ, Seale DA. 2005. Modeling alliance activity. *Strategic Management Journal* **26**: 1057-1074.

Arend RJ. 2009. Reputation for cooperation. *Strategic Management Journal* **30**(4): 371-385.

Arrow K. 1962. Economic welfare and the allocation of resources for invention, in *The Rate and Direction of Incentive Activity*, Nelson RR (ed). Princeton University Press: Princeton, NJ.

Arora A, Fosfuri A, Gambardella A. 2001. Markets for technology and their implications for corporate strategy. *Industrial and Corporate Change* **10**(2): 419-451.

Arora A, Fosfuri A. 2003. Licensing the market for technology. *Journal of Economic Behavior and Organization* **52**: 277-295.

Arora A, Ceccagnoli M. 2006. Patent protection, complementary assets and firmôs incentives for technology licensing. *Management Science* 52: 293-308.

Arundel A, Patel P. 2003. Strategic patenting. *New Trends in IPR Policy*.

Barney, JB. 1986. Strategic factor markets. *Management Science* **32**(10): 1231-1241.

Bettis R, Hitt M. 1995. The new competitive landscape. *Strategic Management Journal* **16**(S1): 7-19.

Bowman EH, Hurry D. 1993. Strategy through the option lens: An integrated view of resource investments and the incremental-choice process. *Academy of Management Review* **18**: 760-782.

Bowman EH, Moskowitz GT. 2001. Real options analysis and strategic decision making. *Organization Science* **12**: 772-777.

Boyer M. 1997. Capacity commitment versus flexibility. *Journal of Economics and Management Strategy* **6**(2): 347-376.

Brandenburger AM, Nalebuff BJ. 1995. The right game: use game theory to shape strategy. *Harvard Business Review* July-August: 57-71.

Brandenburger AM, Nalebuff BJ. 1996. *Co-opetition*. Doubleday: New York.

Camerer CF. 1991. Does strategy research need game theory? *Strategic Management Journal* **12**: 137-152.

Capron L, Mitchell W. 2012. *Build, Borrow, or Buy*. Harvard Business Review Press: Boston, MA.

Ceccagnoli M. 2009. Appropriability, preemption, and firm performance. *Strategic Management Journal* **30**: 81-98.

Chevalier-Roignant B, Trigeorgis L. 2011. *Competitive Strategy: Options and Games*. The MIT Press: Cambridge, MA.

Chi TI. 2000. Option to acquire or divest a JV. *Strategic Management Journal* **21**(6): 665-687.

Cohen WM, Nelson RR, Walsh JP. 2000. Protecting their intellectual assets: appropriability conditions and why U.S. manufacturing firms patent or not. NBER Working Paper no. 7552.

Dasgupta P, Stiglitz J. 1980. Uncertainty, industrial structure and the speed of R&D. *Bell Journal of Economics* **11**: 1-28.

Davis L. 2008. Licensing strategies of the new ñintellectual property vendorsò. *California Management Review* 50(2): 6-30.

Dierickx I, Cool K. 1989. Asset stock accumulation and sustainability of competitive advantage. *Management Science* **35**(12): 1504-1511.

Dixit A, Pindyck R. 1994. *Investment under Uncertainty*. Princeton University Press: Princeton, NJ.

Ferreira N, Karr J, Trigeorgis L. 2009. Option games. *Harvard Business Review* **87**(3): 101-107.

Folta TB. 1998. Governance and uncertainty: the tradeoff between administrative control and commitment. *Strategic Management Journal* **19**: 1007-1028.

Fosfuri A. 2006. The licensing dilemma. *Strategic Management Journal* **27**(12): 1141-1158.

Fudenberg D, Tirole J. 1985. Preemption and rent equalization in the adoption of new technology. *Review of Economic Studies* **10**: 383-401.

Gallini NT. 1984. Deterrence through market sharing: a strategic incentive for licensing. *American Economic Review* **74**: 931-941.

Gallini NT, Winter R. 1985. Licensing in the theory of innovation. *Rand Journal of Economics* **16**(2): 237-252.

Ghemawat P, del Sol P. 1998. Commitment versus flexibility? *California Management Review* **40**(4): 26-41.

Gilbert R, Newbery D. 1982. Preemptive patenting and the persistence of monopoly. *American Economic Review* **72**: 514-526.

Goyal M, Netessine S. 2007. Strategic technology choice and capacity investment under demand uncertainty. *Management Science* **53**(2): 192-207.

Grant RM. 1991. The resource-based theory of competitive advantage: implications for strategy formulation. *California Management Review* (Spring): 114-135.

Grant RM. 1996. Toward a knowledge-based theory of the firm. *Strategic Management Journal* **17**: 109-122.

Grindley PC, Teece DJ. 1997. Managing intellectual capital: licensing and cross-licensing in semiconductors and electronics. *California Management Review* **39**(2): 8-41.

Gulati R. 1998. Alliances and networks. *Strategic Management Journal* 1**9**: 293-317.

Hall BH, Ziedonis RH. 2001. The patent paradox revisited. *Rand Journal* **32**(1): 101-128.

Harrigan KR. 1988. JVs and competitive strategy. *Strategic Management Journal* **9**(2): 141-158.

Hill CWL. 1992. Strategies for exploiting technological innovation: when and when not to license. *Organization Science* **3**(3): 428-441.

Hoffmann, W. 2007. Strategies for managing a portfolio of alliances. *Strategic Management Journal* **28**: 827-856.

Kamien MI, Tauman Y. 1986. Fees versus royalties and the private value of a patent. *Quarterly Journal of Economics* **101**: 471-493.

Katz ML, Shapiro C. 1985. On the licensing of innovations. *Rand Journal* **16**: 504-520.

Kogut B. 1988. Joint ventures. *Strategic Management Journal* **9**(4): 319-332.

Kogut B. 1991. Joint ventures and the option to expand and acquire. *Management Science* **37**(1): 19-33.

Kumar S. 2005. Value from acquiring and divesting a joint venture. *Strategic Management Journal* **26**(4): 321-331.

Kumar S. 2011. Are JVs positive sum games? *Strategic Management Journal* **32**(1): 32-54.

Lado AA, Boyd N, Hanlon SC. 1997. Competition, cooperation, and the search for economic rents. *Academy of Management Review* **22**(1): 110-141.

Leiblein MJ, Miller DJ. 2003. An empirical investigation of transaction and firm-level influences on the vertical boundaries of the firm. *Strategic Management Journal*, **24**(9): 839-859.

Lieberman MB, Montgomery DB. 1988. First-mover advantages. *Strategic Management Journal*, **9**: 41-58.

McGahan AM. 1993. The incentive not to invest: capacity commitment in compact disk introduction. *Research and Technology Innovation, Management and Policy* **5**: 177-197.

McGrath, RG. 1997. A real options logic for initiating technology positioning investments. *Academy of Management Review* **22**: 974-996.

McGrath RG, Ferrier WJ, Mendelow A. 2004. Real options as engines of choice and heterogeneity. *Academy of Management Review* **29**: 86-101.

McGrath RG, Nerkar A. 2004. Real options reasoning and a new look at the R&D investment strategies of pharmaceutical firms. *Strategic Management Journal* **25**: 1-21.

Miller KD, Arikan A. 2004. Technology search investments: evolutionary, option reasoning, and option pricing approaches. *Strategic Management Journal* **25**: 473-485.

Miller KD, Folta TB. 2002. Option value and entry timing. *Strategic Management Journal* **23**(7): 655-665.

Oriani R, Sobrero M. 2008. Uncertainty and the market valuation of R&D within a real options logic. *Strategic Management Journal* **29**: 343-361.

Parkhe A. 1993. Strategic alliance structuring. *Academy of Management Journal* **36**(4): 794-829.

Penrose, ET. 1959. *The Theory of the Growth of the Firm*. John Wiley & Sons: New York.

Peteraf MA. 1993. The cornerstones of competitive advantage: a resource based view. *Strategic Management Journal* 14: 179-191.

Porter ME. 1980. *Competitive Advantage*. Macmillan: London.

Rahmandad H. 2012. Impact of growth opportunities and competition on firm-level capability development trade-offs. *Organization Science* **23**(1): 138-154.

Reitzig M. 2004. Strategic management of IP. *Sloan Management Review* (Spring): 35-40.

Reitzig M, Puranam P. 2009. Value appropriation as an organizational capability: the case of IP protection through patents. *Strategic Management Journal* **30**(7): 765-789.

Reuer JJ, Tong TW. 2005. Real options in international joint ventures. *Journal of Management* **31**: 403-423.

Reuer JJ, Tong TW. 2010. Discovering valuable growth opportunities: an analysis of equity alliances with IPO firms. *Organization Science* **21**(1): 202-215.

Reuer JJ, Ragozzino R. 2012. The choice between joint ventures and acquisitions. *Organization Science* **23**(4): 1175-1190.

Rivette, K.G., Kline, D. 2000. Discovering new value in Intellectual Property. *Harvard Business Review* (January-February), 54-66.

Rumelt RP. 1984. Towards a strategic theory of the firm. In *Competitive Strategic Management*. Lamb R (ed). Prentice-Hall, Eaglewood Cliffs, NJ.

Sadanand A, Sadanand V. 1996. Firm scale and the timing of entry: a choice between commitment and flexibility. *Journal of Economic Theory* **70**: 516-530.

Schelling TC. 1980. *The Strategy of Conflict*. Harvard University Press: Boston, MA.

Shapiro C. 1985. Patent licensing and R&D rivalry. *American Economic Review* 75, 2: 25-30.

Smit HTJ, Trigeorgis L. 2004. *Strategic Investment*. Princeton University Press: Princeton, NJ.

Smit HTJ, Trigeorgis L. 2009. Valuing infrastructure investment: an option games approach, *California Management Review* **51**(2): 79-100.

Somaya, D. 2012. Patent strategy and management: An integrative review and research agenda. *Journal of Management* **3**8(4): 1084-1114.

Somaya D, Kim Y, Vonortas N. 2010. Exclusivity in licensing alliances. *Strategic Management Journal* **32**(2): 159ï 186.

Spence M. 1979. Investment strategy and growth in a new market. *Bell Journal of Economics* **10**(Spring): 1-19.

Spencer BJ, Brander JA. 1992. Pre-commitment and flexibility: applications to oligopoly theory. *European Economic Review* **36**: 1601-1626.

Teece DJ. 1986. Profiting from technological innovation: implications from integration, collaboration, licensing and public policy. *Research Policy* 15: 285-305.

Teece DJ, Pisano G, Shuen A. 1997. Dynamic capabilities and strategic management. *Strategic Management Journal* **18**(7): 509-534.

Teece DJ. 2000. Strategies for managing knowledge assets. *Long Range Planning* **33**: 35-54.

Tong TW, Reuer JJ, Peng MW. 2008. International joint ventures and the value of growth options. *Academy of Management Journal* **51**(5): 1014-1029.

Tong TW, Li Y. 2011. Real options and investment mode. *Organization Science* **22**(3): 659-674.

Trigeorgis L, Mason SP. 1987. Valuing managerial flexibility. *Midland Corporate Finance Journal* **5**(1): 14-21.

Trigeorgis L. 1996. *Real Options*. The MIT Press: Cambridge, MA.

Vanhaverbeke W, Duysters G, Noorderhaven. 2002. External technology sourcing through alliances or acquisitions. *Organization Science* **13**(6): 714-733.

Wang XH. 1998. Fee versus royalty licensing in Cournot duopoly. *Economic Letters* **60**(1): 55-62.

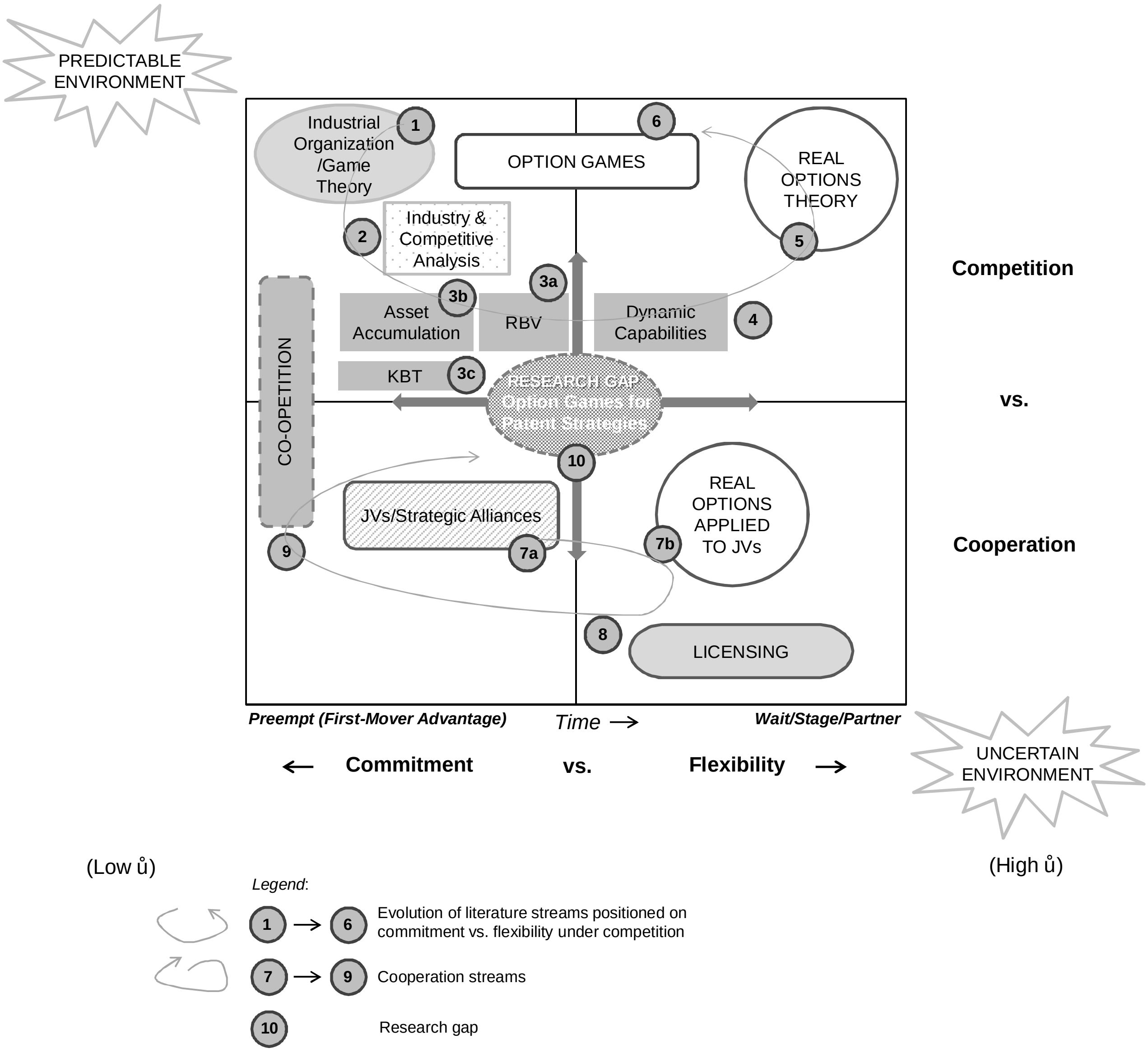
Wang H, Lim SS. 2008. Real options and real value: the role of employee incentives to make specific knowledge investments. *Strategic Management Journal* **29**(7): 701-721.

Wernerfelt B. 1984. A resource based view of the firm. *Strategic Management Journ*al **5**(2): 171-180.

Wernerfelt B, Karnani A. 1987. Competitive strategy under uncertainty. *Strategic Management Journ*al **8**: 187-194.

Figure 1. Literature categorization

A. Streams positioning on Commitment vs. Flexibility and Competition vs. Cooperation dilemmas




B. Ways to obtain (and use) a resource (e.g., patent)

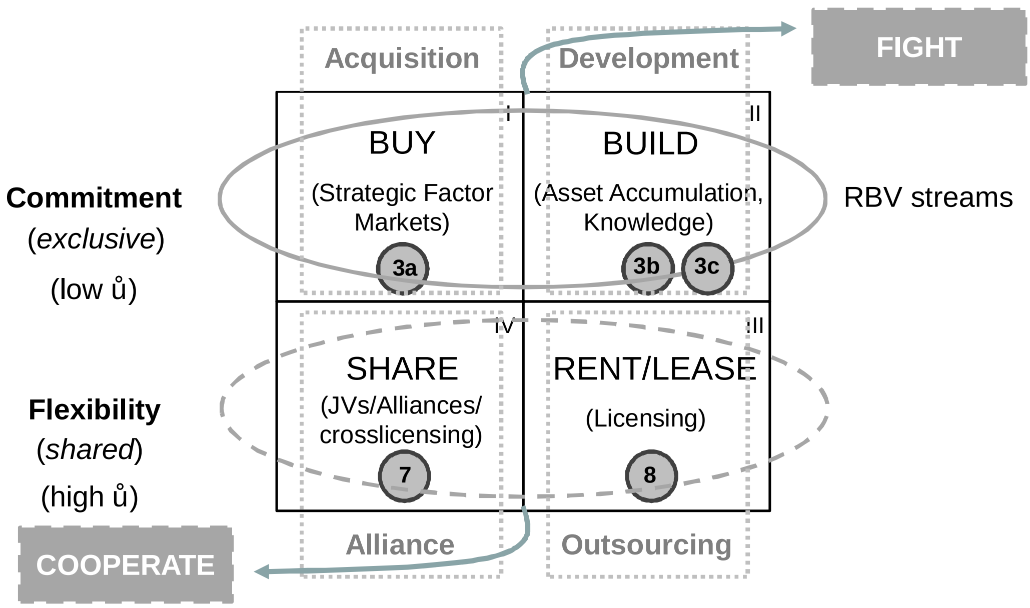


Figure 2. Basic two-stage strategic patent game and underlying market value evolution tree (under High, Medium and Low demand)

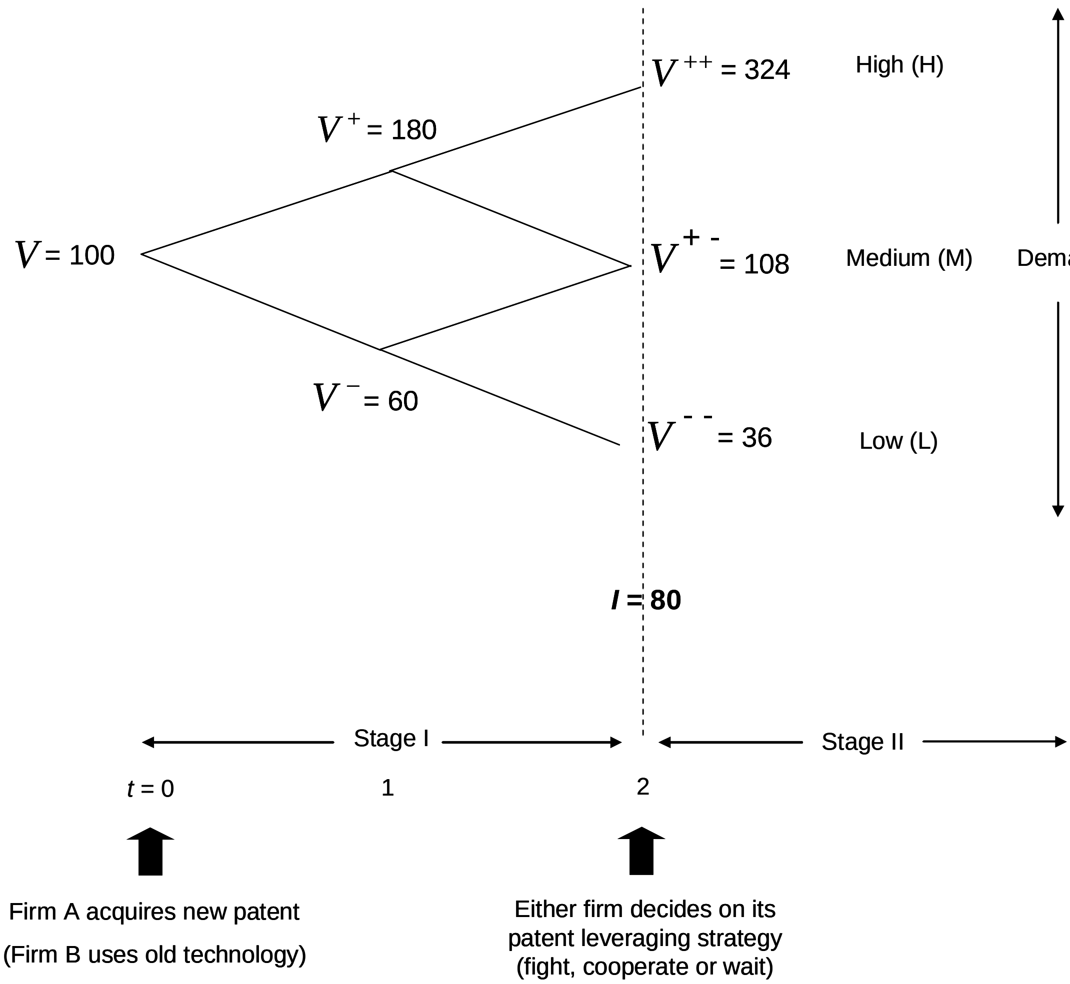


Figure 3. Patent leveraging strategies contingent on competitive advantage and state of demand

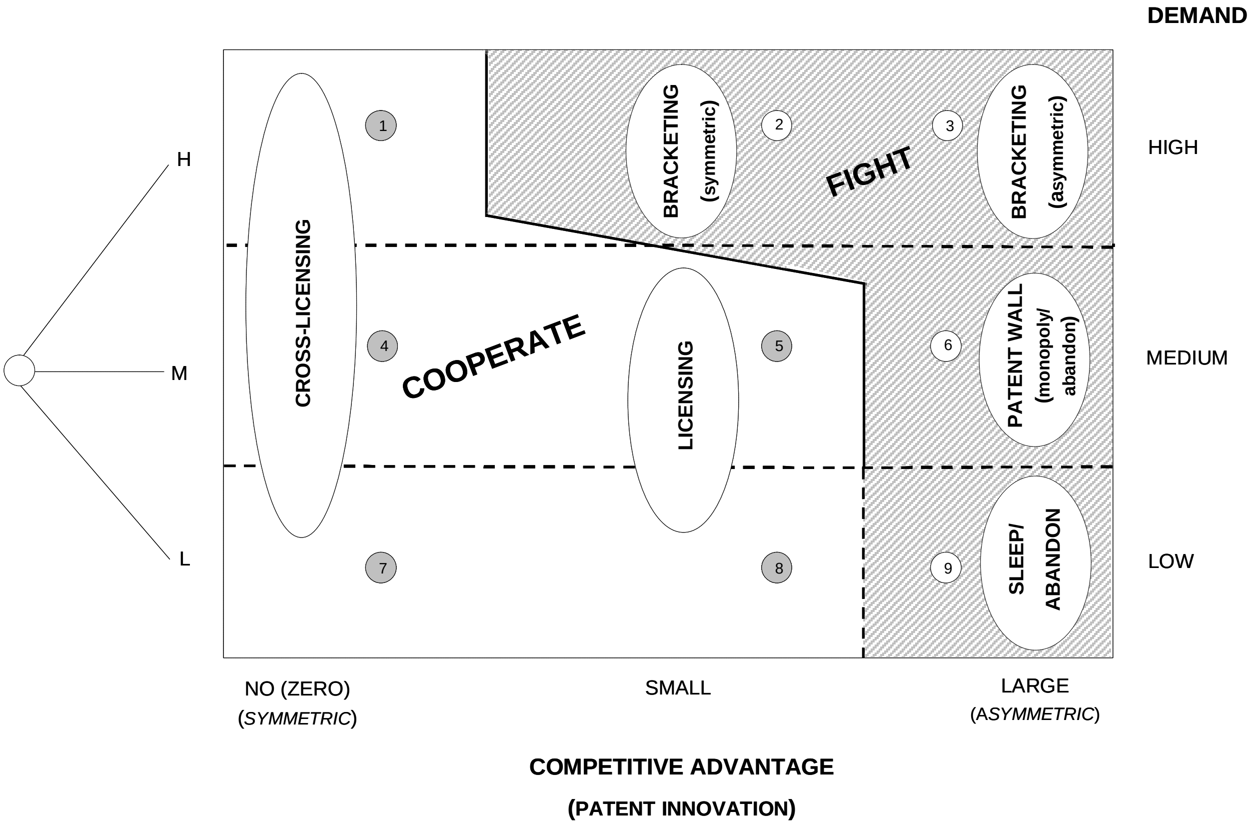


Figure 4. Value payoffs for various subgames depending on demand and competitive advantage

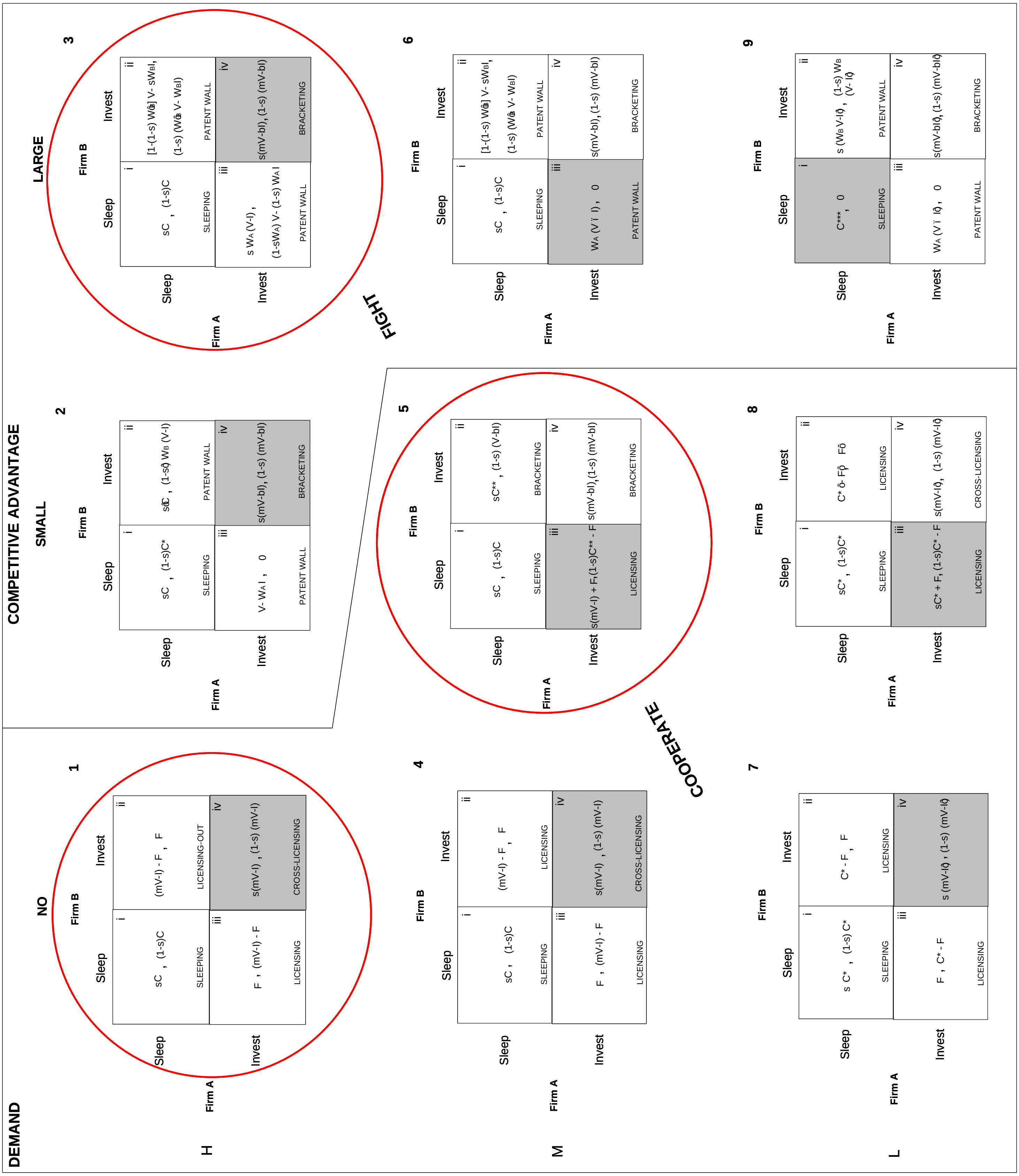


Figure 5. Summary of main assumptions and input parameters

**Cooperation/Fight mode multiple (*m*)**

| | |
|---|---|
| Cooperation ($c$) | 1.20 |
| Fight ($f$) | 0.70 |

**Market power share (s)**

| | FIRM | | | |
|---|---|---|---|---|
| | Symmetric | | Asymmetric | |
| PATENT ADVANTAGE | A | B | A | B |
| No | 50% | 50% | 25% | 75% |
| Small | 60% | 40% | 40% | 60% |
| Large | 75% | 25% | 50% | 50% |

**Patent Wall multiplier (*W*)**

| | FIRM | |
|---|---|---|
| | A | B |
| Cost Multiplier ($W$ $I$) | | |
| $W_A$ | 1.2 | |
| $W_B$ | | 1.3 |
| Value Multiplier ($W'$ $V$) | | |
| $W'_A$ | 1.2 | |
| $W'_B$ | | 2.2 |

**Bracketing Cost multiplier (*b*)**

| | FIRM | |
|---|---|---|
| | A | B |
| Cost Multiplier ($b$) | 1.3 | 1.3 |

**Licensing Fee (*F*)**

| | COMPETITIVE ADVANTAGE | | |
|---|---|---|---|
| | No | Small | Large |
| HIGH DEMAND (H) | 50% | | |
| MEDIUM/LOW DEMAND (M/L) | 40% | | |
| MEDIUM DEMAND (M) | | 20% | |
| LOW DEMAND (L) | | | 15% |

**Other valuation inputs**

Investment cost ( $I$ ): $ 80 million

Base volatility (ů): 60%

Cost of capital (k): 20%

Riskless interest rate (r): 8%

Figure 6. Subgame outcomes and resulting equilibria under No, Small or Large advantage

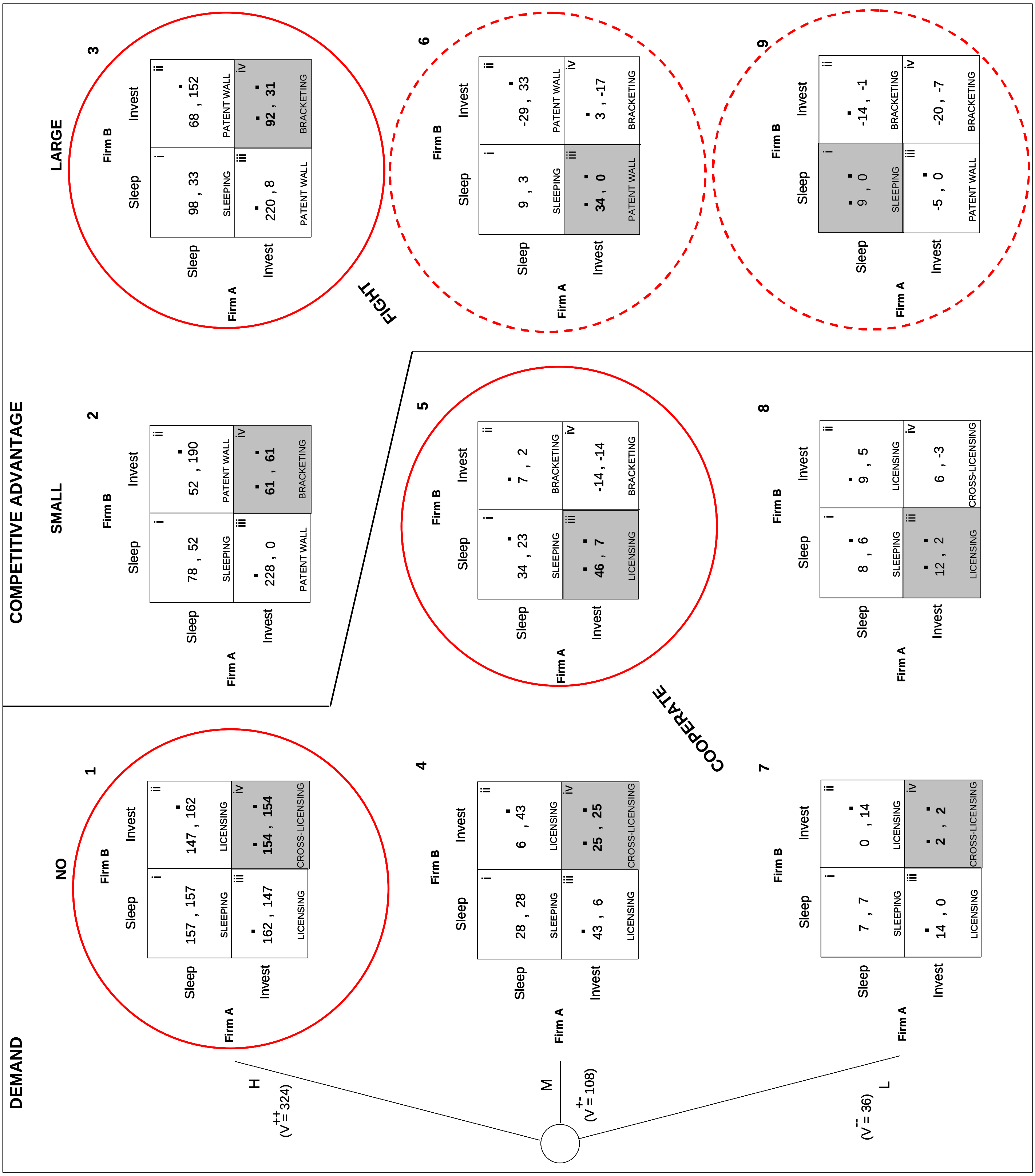


Figure 7. Value of patent strategy (Expanded-NPV) under No, Small or Large advantage

| COMPETITIVE ADVANTAGE | PATENT STRATEGY | | E-NPV | | |
|---|---|---|---|---|---|
| | | | Low ů (15%) | Base ů (60%) | High ů (90%) |
| No | COOPERATE (cross-license) | | 29 | 32 | 34 |
| Small | HYBRID | H Fight (bracket)<br>M/L Cooperate (license) | 24 | 31 | 32 |
| Large | FIGHT | H Fight (bracket)<br>M Fight (patent wall/preempt)<br>L Sleep | 19 | 29 | 32 |
| | HYBRID | H Cooperate (cross-license)<br>M Fight (patent wall/preempt)<br>L Sleep | 34 | 38 | 39 |
| Ignore competition; invest now | | | | 20 (=NPV) | |

*Note*: base fight multiple 0.7; cooperation multiple 1.2.

Figure 8A. The cooperate vs. fight tradeoff: Sensitivity of E-NPV to *fight erosion* multiple (under large competitive advantage)

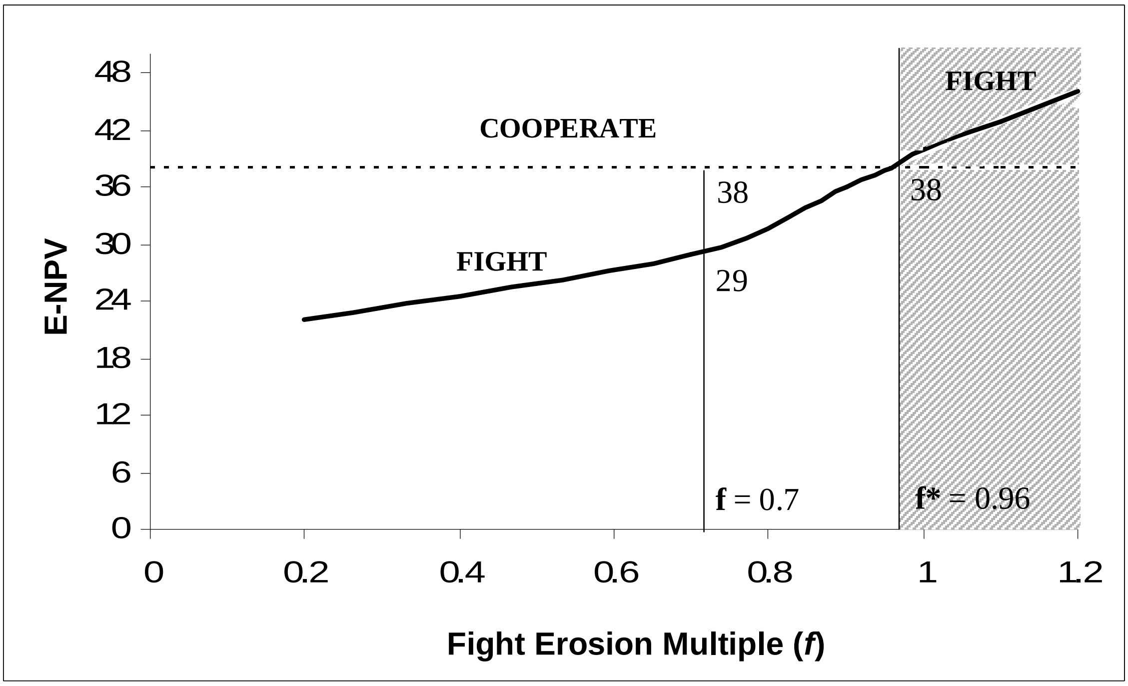



Figure 8B. Sensitivity of E-NPV to *cooperation* multiple (under large advantage/cooperate)

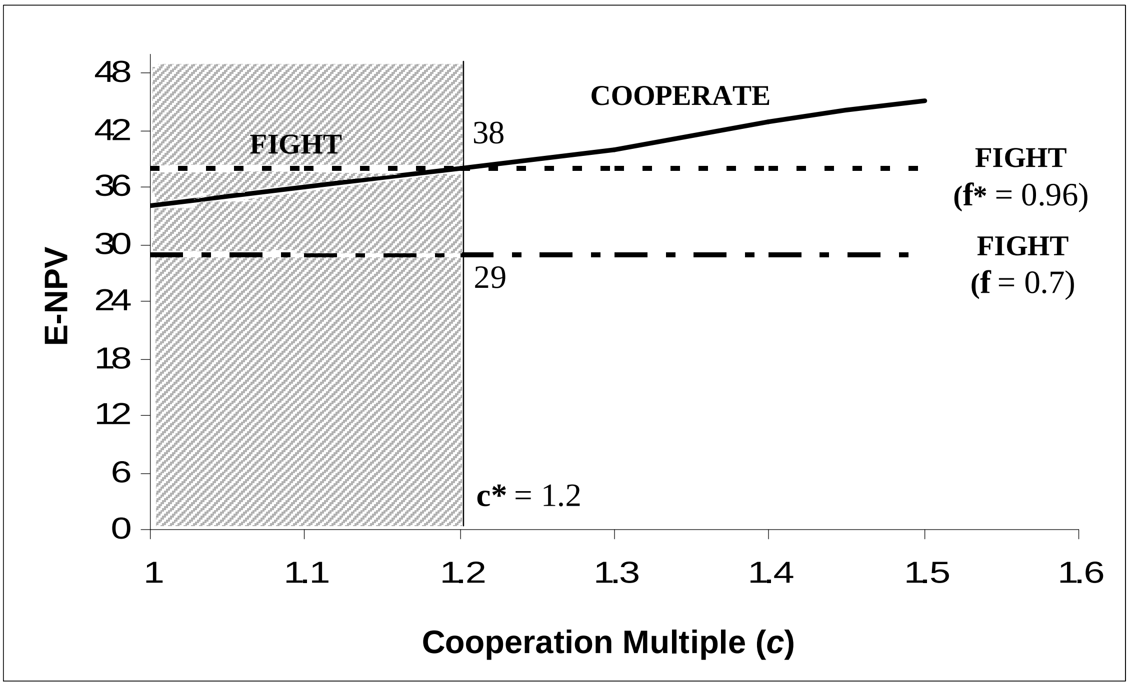


Figure 9A. Sensitivity of E-NPV to *cooperation multiple* for different competitive advantage cases

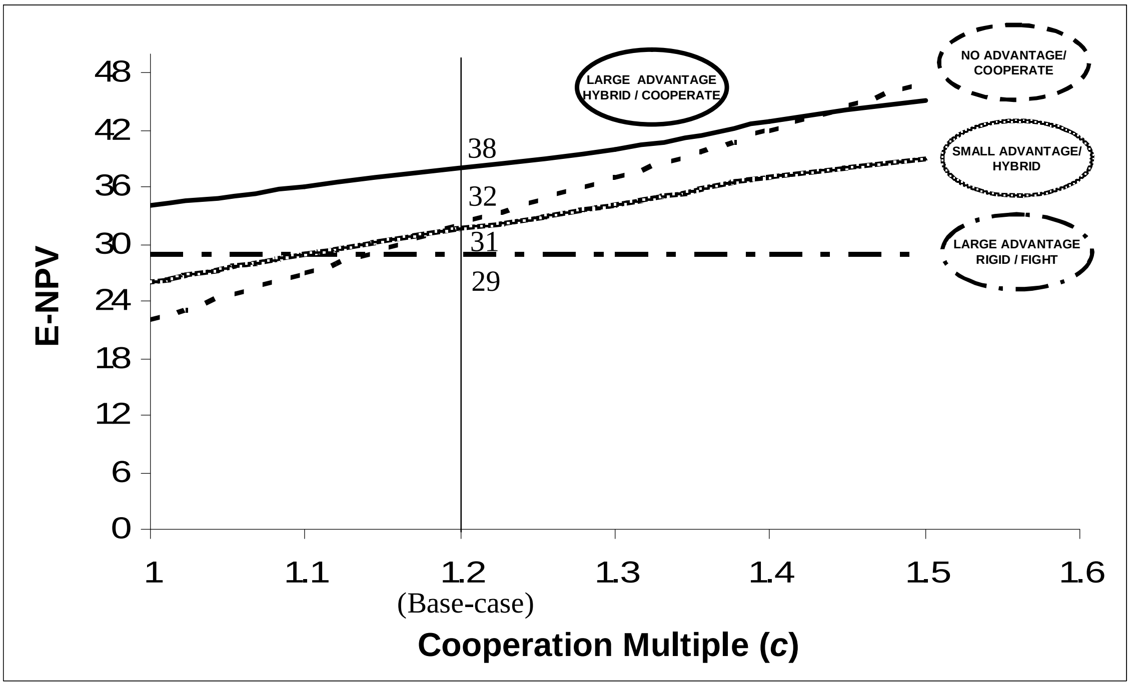



Figure 9B. Sensitivity of E-NPV to *volatility* under No, Small or Large advantage

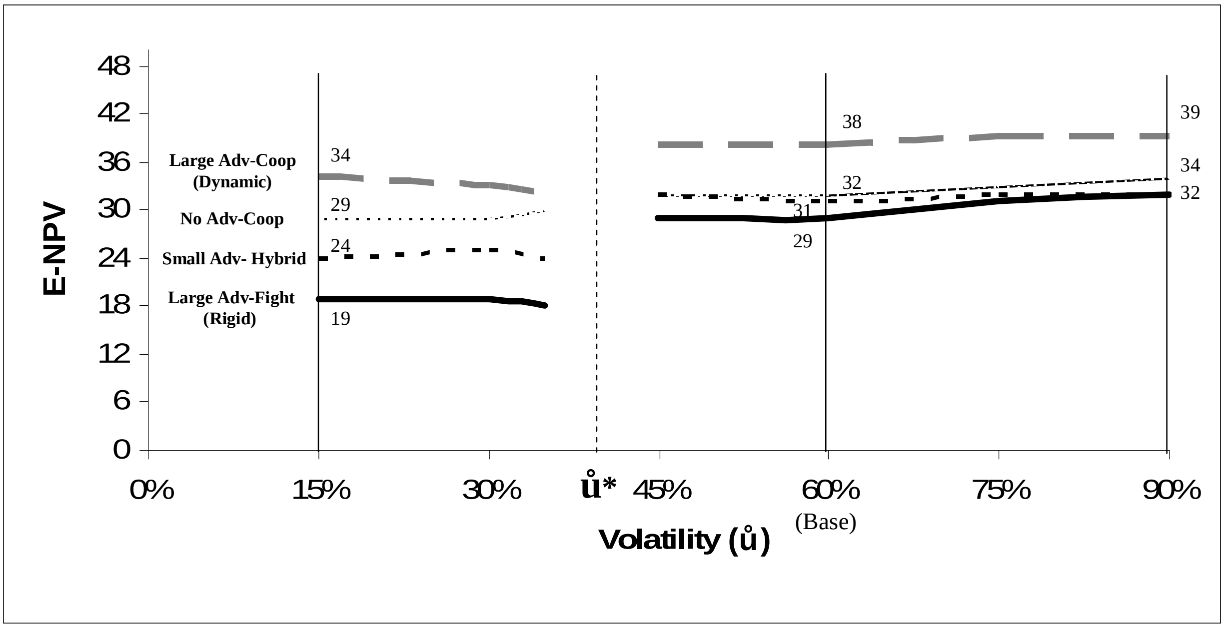
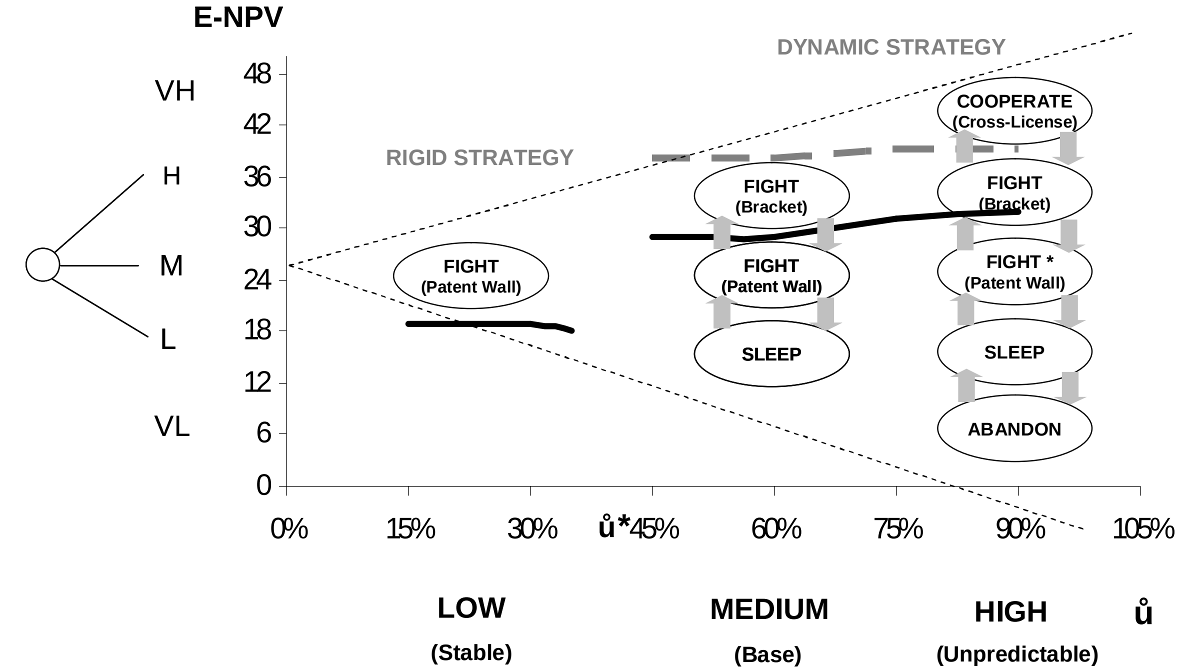


Figure 10A. Summary and extension of patent leveraging strategies for a broader range of demand/uncertainty (under large advantage) ï Symmetry case




* Sometimes cooperate (e.g., cross-licensing against third rivals)

Figure 10B. Summary and extension of *cooperate vs. fight* strategies (for a broader range of demand/uncertainty) under No, Small or Large advantage ï Symmetry case

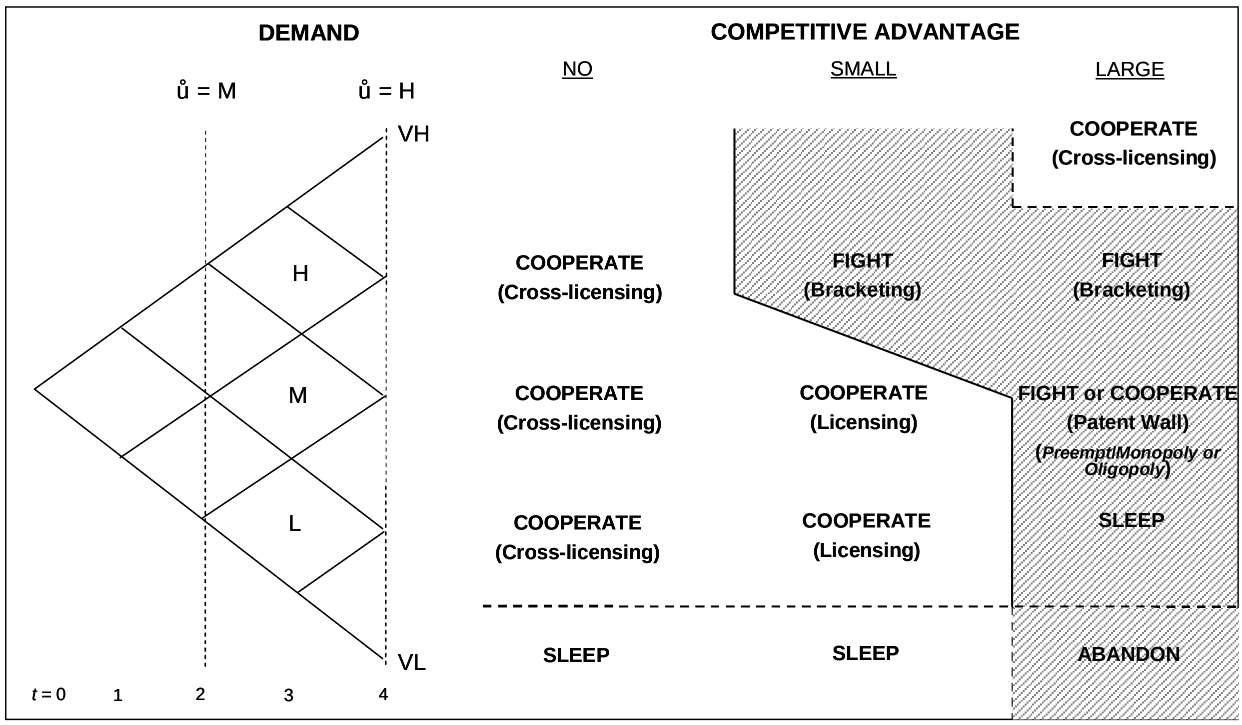
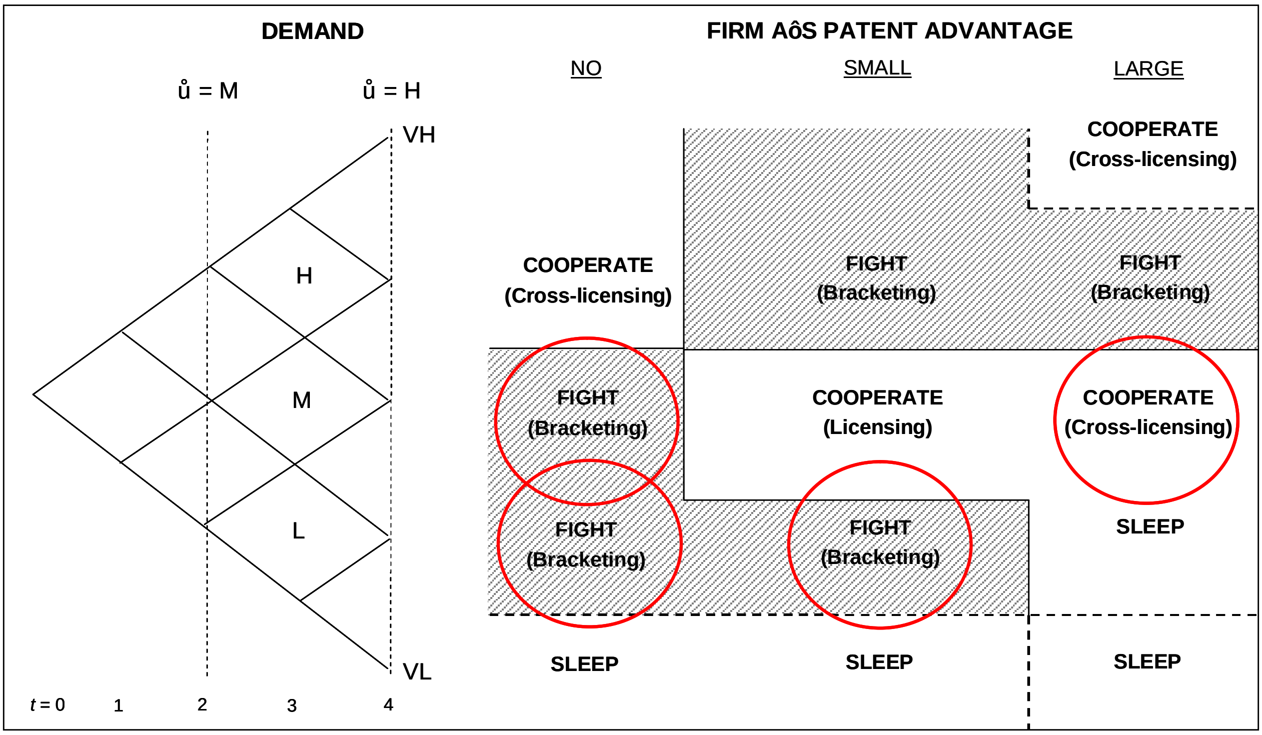
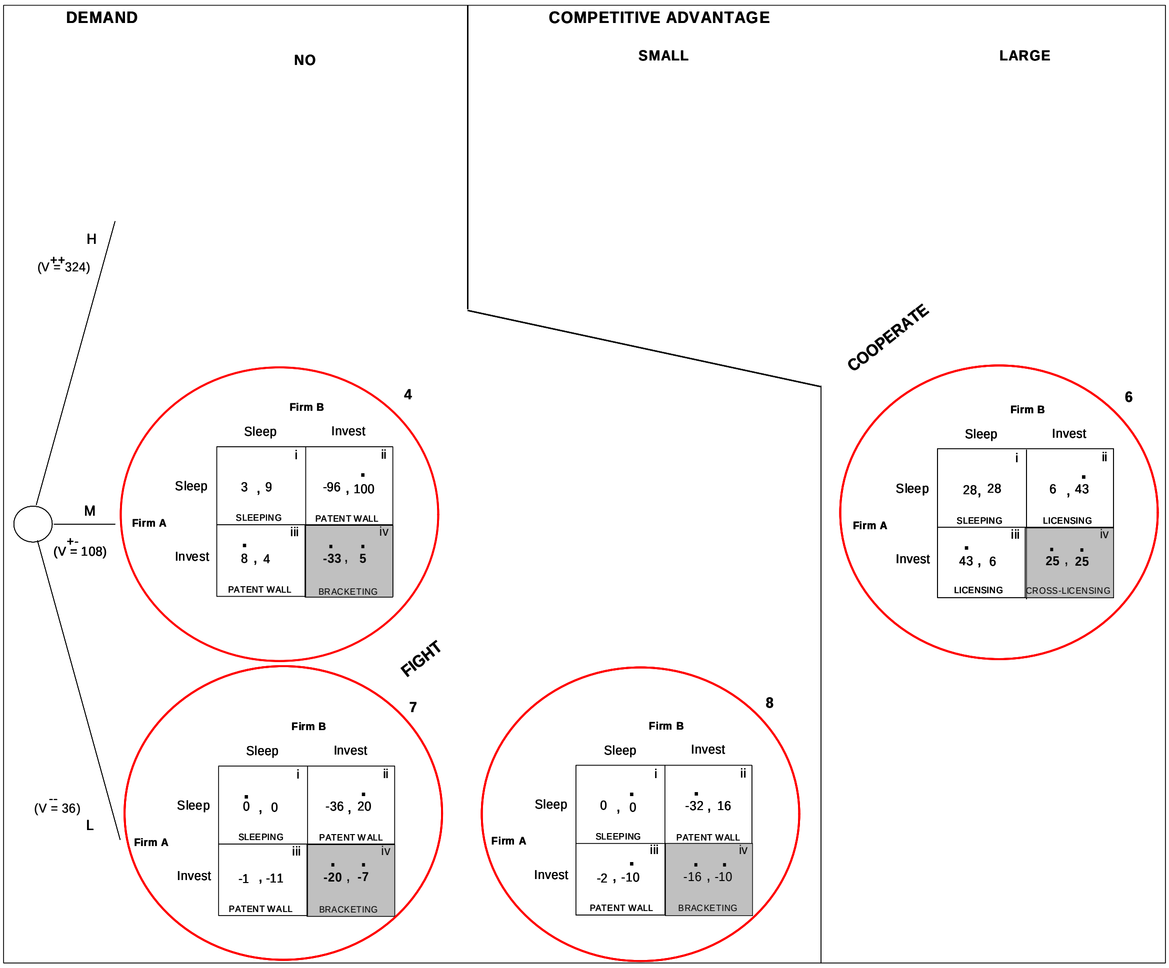


Figure 11A. Changes in *cooperate vs. fight strategies* when incumbent firm B has more market power ï Asymmetry case




*Note*: Circles indicate subgames that shift between fight and cooperation modes in asymmetry case (compared to symmetry).

Figure 11B. Revised subgame outcomes and equilibria when incumbent firm B has more market power ï Asymmetry case



## APPENDIX: SUBGAMES VALUE PAYOFF DESCRIPTION

This Appendix describes in more detail the value payoffs (for firm A, firm B) in each of the 9 subgames in Figure 3 depending on demand (High, Medium, Low) and the size of patent cost advantage (no, small, large). If demand is low and firm A has a large patent advantage (*subgame 9*) it may ñwait and seeò until demand develops sufficiently (sleeping patent); the combined adversities of low demand and competitive disadvantage will likely force firm B to abandon the market. Lack of any relative cost advantage is likely to induce symmetric rivals to cooperate (almost regardless of demand level), while a large patent advantage by firm A over an otherwise symmetric rival will tend to favor a fight mode instead under certain circumstances.[33] The situation in the middle (small patent advantage), however, is not so clear-cut: a hybrid situation may arise where under high demand (*subgame 2*) the weaker rival, despite its small disadvantage, pursues an offensive fighting strategy (resulting in a roughly symmetric bracketing game), whereas under lower demand (*subgame 5*) the rivals may choose to cooperate (e.g., by licensing firm A´s technology to firm B).

Consider the simple option game to the top left under a cooperative mode involving little or no cost advantage assuming high demand (***subgame 1***). Although firm A has a patent on a newer innovation, the cost advantage over firm B´s alternative technology is negligible and the firms are basically symmetric. A cooperative stance prevailing in the second stage results in an enlarged total market value ($mV$, where the cooperation value multiple is $m = c = 1.2$). There are four ñstrategicò scenarios under this cooperative mode. When both firms sleep, postponing the decision to the end of the second stage, they share the continuation value $C$ based on their equal (symmetric) market power, where $C$ is computed based on the period-2 payoff $C$ = max($mV^{++}$ ï $I$, 0) with $m = 1.2$.[34] When both firms invest in a collaborative manner, e.g., via cross-licensing each otherôs patents, they share equally (½) the enlarged net market value, each obtaining ½($mV$ ï $I$).[35] When one firm (A or B) invests by licensing its patented technology to the other for a fee $F$ (as a % of value $V$ at $t$ = 2) agreeing to stay out of the market, the other keeps its own patent sleeping and uses the licensed technology to capture the market value net of the paid fee, ($mV$ ï $I$) ï $F$. *Subgames 4 and 7*, also involving no cost advantage, but at medium (M) and low (L) levels of demand, have similar

[33] It may also lead to potential cooperation in some other circumstances, such as in very high demand states or when two incumbents cooperate against outside threat.

[34] The continuation value of the wait-and-see option is calculated as the expectation (using risk-neutral probabilities, $p$) over the end-of-stage II (period 3) payoffs given a cooperative strategy (or alternatively, a fight strategy) discounted back one year at the risk-free rate ($r$): $C = \frac{p[\max(mV^{+++} - I, 0)] + (1-p)[\max(mV^{++-} - I, 0)]}{(1+r)}$ with $\frac{pV^{+++} + (1-p)V^{++-}}{(1+r)} = V^{++}$ (period 2-payoff).

[35] In the case of a priori asymmetric market power, firm A receives s($mV$ ï $I$) and firm B gets (1-s)($mV$ ï $I$), with the incumbent holding 1- s = 0.75 or 75%.

payoffs. The main difference is in *subgame 7* the adjusted NPV (= $mV - I$) in the diagonal boxes is replaced by continuation value $C^*$ as both firms will wait rather than operate due to low demand.[36]

Consider next the option games under fight mode (***subgames 3 or 6***) when firm A has a large cost advantage (under medium or high demand). Under medium demand firm A has an incentive to fortify and exploit its large cost advantage to drive its rival out. Despite being at a cost disadvantage, the rival is inclined to fight, even attack first, if demand (or volatility) is high. Entering a fight is costly and erodes profit margins for both firms, reducing the size of total market pie (to $mV = f\,V = 0.70V$), unless one of the firms ignores the rival and lets its patent sleep ($m = 1$). The four "strategic" scenarios under a fight mode in medium or high demand are: (i) when both firms sleep, they postpone their decision to next stage, with firm A capturing most of the continuation value ($C$) according to its market power ($s = ¾$), while firm B gets ¼$C$; (ii)/(iii) when one firm (A or B) invests (paying a cost premium of 20 or 30% to fortify its position via a patent wall) while the other waits ($m = 1$), the former may drive the latter out and capture monopoly NPV (effectively $s = 1$), i.e., $w_A(V - I)$, with $w_A = w'_A = 1.2$ reflecting both the higher cost and value enhancement due to wall patenting by firm A (or $w_B = 1.3$ for firm B) (***subgame 6***);[37] (iv) when both firms invest attacking each other via patent bracketing, they share a reduced market value due to fighting ($mV$ or $0.7V$) based on their market power ($s = ¾$ vs. $1 - s = ¼$) and incur higher costs due to bracketing ($bI = 1.3I$), i.e., firm A receives $s(mV - bI) = ¾(0.7V - 1.3I)$ and firm B gets $¼(0.7V - 1.3I)$. In case of a large advantage, bracketing does not eliminate the asymmetry (as assumed for small advantage). Large advantage under low demand (***subgame 9***) involves analogous payoffs (as in *subgame 6*), with difference that in the sleep-sleep outcome firm A receives exclusive option to be a future monopolist (receiving $C^{***}$) while the rival abandons (0) due to low demand and serious patent disadvantage.

The case of *small* advantage is more complex as it is a hybrid situation, partly behaving in a cooperative mode (as in *subgame 1*), e.g., under low or medium demand, and partly in a fight mode (bracketing) under high demand. Here bracketing or blocking each other´s patent effectively eliminates firm A´s small advantage resulting in symmetric ex-post market power position. The four strategic scenarios (low demand/cooperative mode vs. high demand/fight) can be quite different.

---

[36] In the low (L) demand subgames a lower investment cost is assumed, $I' = 40$; $C^*$ in subgame 7 above is thus based on $\max(mV - I', 0)$.

[37] In case of high demand (*subgame 3*), both firms stay in the game sharing total value based on their market power, with firm A receiving $s\,w_A\,(V - I)$ and B receiving the remainder, $(1 - s\,w_A)V - (1 - s)\,w_A\,I$. The corresponding payoff for *subgame 6* at intermediate demand allowing for only one player is a special case of the above with $s = 1$ (monopoly), namely firm A receives $w_A\,(V - I)$ and firm B gets 0. The reverse off-diagonal box (ii) in *subgames 3* and *6* involves a more general version, with firm B receiving $(1 - s)(w'_B V - w_B\,I)$ with $w_B$ being the patent wall cost amplifier and $w'_B$ the patent wall value enhancer, with firm A receiving the remainder, $[1 - (1 - s)w'_B]V - s\,w_B\,I$.

Under high demand and a small cost advantage, a fight mode may result (***subgame 2***). Here the payoffs are special case of the high-demand fight subgame under large cost advantage (*subgame 3*). Investing by firm A alone involves building a patent wall (at a larger cost $w_A I$) that allows it to capture the full market value ($V$) while the rival lets its patent sleep. The small patent advantage of firm A gets amplified by raising a defensive wall around it enabling it to drive out the sleeping rival and capture monopoly value, receiving $V$ - $w_A I$ (while firm B gets 0).[38] When both firms invest via bracketing each other´s patents the small cost advantage of firm A gets eliminated with each firm sharing equally (s = ½) the revised market value (reduced by the fighting discount factor and the higher bracketing cost), i.e., each firm receiving ½($mV$- $bI$) or ½(0.7$V$ - 1.3$I$).

In the cooperative mode under low demand (***subgame 8***), investing by one of the firms means licensing out its patent (with the other letting its patent sleep), while both investing here takes the form of cross-licensing. Again, when both firms sleep or both invest they share the continuation value ($C$*, based on max($mV$ ï $I$ô, 0)) or NPV ($mV$ ï $I$ô). When firm A licenses its superior patent to firm B (while B lets its own patent sleep), firm A´s small cost asymmetry is eliminated in exchange for a licensing fee ($F$), with firm A receiving half (s = ½) the continuation value (due to low demand) plus the fee (½$C$* + $F$) and firm B paying the fee in for half (1 ï s = ½) the continuation value (½$C$* - $F$). In the reverse (diagonally symmetric) case firm A pays a different fee ($F$´) to license firm B´s technology and get $C$*ô (provided firm B stays out of the market so firm A has an option on the whole market value as a potential future monopolist).

The intermediate demand case under small advantage (***subgame 5***) is *hybrid*, as it sits at the borderline between the cooperate and fight modes (see Figures 3 and 4). In this region the firm can choose among a cooperative invest mode (licensing) or a fight mode (attacking via bracketing). Here, firm A may again agree to license out its superior technology to B and still operate, receiving half (s = ½) the enlarged NPV (= $mV$ - $I$) plus the fee, i.e., ½($mV$ - $I$) + $F$, while firm B pays the fee with the right to operate later receiving half (1 ï s = ½) the continuation value (½$C^{**}$- $F$). In the diametrically symmetric case, firm B attacks by bracketing while firm A lets its patent sleep. If firm B operates now and firm A later, they share the adjusted NPV (given higher bracketing costs, $bI$) and the continuation value $C^{**}$ (on max($V$ ï $bI$, 0)) according to their power (s = 0.4 and 1 ï s = 0.6). The case where both firms invest bracketing each otherôs patents is the same as in above (high) demand region (*subgame 3*), each firm receiving s($mV$ ï $bI$) = (1 ï s)($mV$ ï $bI$) = ½(0.7$V$ ï 1.3$I$).

---

[38] The reverse (diagonal) situation is analogous, except firm A receives a share (s´) of continuation value while it sleeps (s´$C$) and firm B a share (1 - s´) of enhanced NPV value, $w_B$ ($V$- $I$), when it invests in a patent wall. Actual market shares of firms A and B are reversed with that of the latter (1- s´) being amplified due to the raising of a defensive wall. This is a special case of the corresponding more general case found under large advantage (in *subgame 3*) with wô$_B$ = $w_B$ = 1.3.