Journal of Management
Vol. 40 No. 6, September 2014 1535–1557
DOI: 10.1177/0149206311429861

Market Entry in the Presence of Network Effects: A Real Options Perspective

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This research holds that extant theory on real options has several limitations with regard to strategic initiatives in markets influenced by network effects. In addressing these limitations, the authors argue that markets with strong network effects tend to enhance both growth and deferral options. Furthermore, the extent to which growth and deferral options affect market entry in these settings is conditioned by both the strength of network effects (i.e., network intensity) and the presence of a dominant design in the market. Implications for real options theory in the context of network effects and for firms considering entry into markets influenced by network effects are offered and discussed.

Keywords: *real options; network effects; market entry; uncertainty*

Real options, rooted in financial theory (Myers, 1977; Myers & Turnbull, 1977), have attracted considerable attention in the field of management (Bowman & Moskowitz, 2001; Folta & O'Brien, 2004; Kogut, 1991; K. D. Miller, 2002; Reuer & Leiblein, 2000). However, real options logic in a managerial context has been hindered by mixed support for

Acknowledgments: We thank associate editor Michael Leiblein for his guidance throughout the review process as well as the anonymous reviewers for their constructive comments and help in improving this article. We also thank Todd Alessandri, Ilya Cuypers, and Eugene Kang for their comments on earlier drafts of the article. All errors remain our own. The authors contributed equally to this article.

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hypothesized relationships, and inconsistencies in the application of the theory (Adner & Levinthal, 2004; Bowman & Moskowitz, 2001; Peavy, 1984). For example, although a central proposition of real options is that firms face tension between early market entry and deferred market entry (Fisch, 2008; Folta & O'Brien, 2004; Miller & Folta, 2002), empirical support for this tension has been ambiguous (Leiblein & Ziedonis, 2007; Ziedonis, 2007). This lack of robust support for the dueling nature of real options—growth versus deferral—may be the result of the failure to incorporate contextual factors and market-specific dynamics to the theory (Adner & Levinthal, 2004; Folta, Johnson, & O'Brien, 2006; Leiblein & Ziedonis, 2007).

This ambiguity in real options logic is exacerbated in markets influenced by network effects, where effective timing of strategic initiatives such as market entry may drive one firm to a dominant position whereas others are competed out of the market (David, 1985; Schilling, 2002). Network effects occur when some of the value of a product to a consumer is dependent on the number of other people already using it, such as telephones, computer operating systems, and online auctions (Farrell & Saloner, 1985, 1986; Katz & Shapiro, 1994). With a large existing base of users of its product, or *installed base*, a focal firm not only benefits from increased customer adoption (Lieberman & Montgomery, 1988; Suárez & Utterback, 1995) but will also attract producers of complementary goods and services, thus facilitating "winner-take-all" dynamics (Gupta, Jain, & Sawhney, 1999; Schilling, 1998; Stremersch, Tellis, Franses, & Binken, 2007).

Though some attempts have been made to link real options to network effects, particularly in the context of growth options (e.g., Lin & Kulatilaka, 2007), a comprehensive real options framework for markets influenced by network effects remains lacking. Specifically, current real options perspectives on network effects do not account for (a) the specific impact of network effects on the value of both growth options *and* deferral options, (b) the differences in the strength of network effects, or network intensity, across markets, and (c) the differences in the structural dynamics of the market before and after a dominant design has emerged in a given industry.

We address these limitations by drawing on theories of real options and network effects to disentangle the effects of growth options and network intensity on the value of real options. We then contextualize these findings to a specific strategic initiative, market entry. Market entry as a strategic variable has been a focus of a significant body of theoretical and empirical literature in both real options (Folta et al., 2006; Lévesque, Minniti, & Shepherd, 2009; Miller & Folta, 2002; O'Brien, Folta, & Johnson, 2003; Schilling, 2002) and network effects (Agarwal & Bayus, 2002; Schilling, 2002) and thus represents a logical strategic phenomenon that allows us to explore the intersection of both perspectives and gain insights that each theory alone cannot provide.

This research contributes to the literatures on both real options and network effects by offering novel implications of real options theory to firm strategy in markets influenced by network effects. More specifically, we offer propositions that offer insights into three questions at the nexus of real options and network effects. First, how does network intensity condition the relationship between market uncertainty and real options? Second, how does the interplay of real options, market uncertainty, and network intensity affect patterns of market entry? Finally, based on these confluence of forces, how does the market entry

threshold differ prior to and after the emergence of a "dominant design" from a real options perspective? In building these propositions, this research takes a first step toward a comprehensive application of real options to the unique market dynamics of network effects, thereby addressing the relative lack of contextual and market-specific dynamics that currently characterizes real options theory (Adner & Levinthal, 2004; Folta et al., 2006; Leiblein & Ziedonis, 2007).

We begin by providing a brief review of the relevant literatures on growth options, deferral options, and network intensity. We then offer propositions regarding the impact of network intensity and uncertainty on growth and deferral options. Next, we contextualize these propositions to market entry and propose a more specific model in which the threshold for entering a market is critically dependent on the interplay among uncertainty, network intensity, and the emergence of a dominant design in a given market. The article concludes with a discussion of the implications of this work for theory and practice in strategic management.

Theoretical Background

Real options are characterized by sequential, irreversible actions made under conditions of uncertainty that, when applied to investment or market entry decisions, may result in different decision outcomes than from when the traditional neoclassical investment approach is applied (Dixit & Pindyck, 1994; Kester, 1984). Under the traditional models of investment, the threshold for entering a market is when the net present value of entering a market is equal to or more than zero. However, this model fails to account for the potential of firms to acquire growth opportunities that may not be evident at the time of entry consideration, nor does it consider the flexibility of firms to defer making the required irreversible investments when entering a market under uncertain market conditions. These two main tenets of real options, the potential to acquire growth opportunities and the ability to defer investment, have opposite effects on the threshold for entering a market, and both of these tenets increase with uncertainty (Dixit & Pindyck, 1994).

Uncertainty refers to the inability to predict the likelihood of future events or outcomes (Duncan, 1972). Although there are many sources of uncertainty, our focus is on demand uncertainty—uncertainty that arises from the inability to predict consumers' demand or adoption of a certain type of product. Firms entering markets that exhibit network effects face uncertainty because there is little information to determine whether a critical mass of consumers will be willing to adopt or continue to adopt a certain product or not, which is an essential requirement for a successful entry (Hill, 1997; Schilling, 2002; Suárez & Utterback, 1995). The presence of uncertainty may disrupt a firm's abilities to develop production and marketing plans as well as assess the appropriate amount of investments required to successfully enter a market (Dess & Beard, 1984). Two types of real options arise from the presence of uncertainty: growth options and deferral options.

Growth options. The growth option perspective has its roots in financial theory in which a firm's value is composed of assets in place and future growth opportunities (M. H. Miller & Modigliani, 1961; Zingales, 2000). A firm's future growth opportunities are viewed as

growth options because of the potential for firms to use their resources and capabilities to claim preferential access to future opportunities through the flexibility of staged investments over time and avoidance of risk by reacting to the changing environment (Bowman & Hurry, 1993; Kester, 1984; Trigeorgis, 1991). In other words, the value of growth options comes from actions or investments that provide a platform for subsequential investments that provide further profitable growth (Kulatilaka & Perotti, 1998; Pindyck, 1988). When growth options can be obtained, even if the net present value of entering a market is less than zero, it may be worthwhile to enter the market because of the potential growth opportunities that a firm stands to gain. Thus, the ability to acquire growth options will lower the threshold for entering a market.

The level of growth options depends on the level of uncertainty in the market (Folta & O'Brien, 2004). An increase in uncertainty will lead to a larger width of stochastic distribution of expected outcomes and can bring about higher levels of valuable growth opportunities to a firm (Pindyck, 1988). Appropriation of growth options is achieved when firms pursue opportunities that have significant upside potential in a manner that permits downside risk to be contained (McGrath, Ferrier, & Mendelow, 2004). Thus, the high levels of uncertainty bring about high levels of growth options and, as a result, lower the thresholds for entering a market (Strebel, 1983).

There has been a significant body of research that describes how firms develop and appropriate growth options in a strategic manner (Alessandri, Lander, & Bettis, 2007; Folta & Miller, 2002; Kogut, 1991; Kogut & Kulatilaka, 2001; Kulatilaka & Perotti, 1998). Specific contexts of work in this area include technology and R&D investments (Fisch, 2008; Hurry, Miller, & Bowman, 1992; McGrath, 1997; McGrath & Nerkar, 2004; Vassolo, Anand, & Folta, 2004), market entry (Chang, 1995; Miller & Folta, 2002), joint ventures (Cuypers & Martin, 2009; Reuer & Tong, 2005; Tong & Reuer, 2006; Tong, Reuer, & Peng, 2008), technology acquisition (Warner, Fairbank, & Steensma, 2006), licensing (Ziedonis, 2007), and international competition (Tong, Alessandri, Reuer, & Chintakananda, 2008).

Deferral options. According to real options theory, a firm can defer its market entry while maintaining the right to enter at a later date (Dixit & Pindyck, 1994; McDonald & Siegel, 1986). The ability to defer market entry allows for firms to pursue high-variance outcomes by entering a market when the market conditions are more predictable or favorable (McGrath, 1999). When a high level of uncertainty exists, it becomes difficult for firms to assess the market environment and the resultant outcome. Entering a market under highly uncertain market conditions eliminates the possibility for a firm to choose a different decision path should new information arrive that could have influenced the initial market entry decision. This may result in large opportunity costs because of the high levels of irreversible investments involved in entering a market (Folta & O'Brien, 2004; Kulatilaka & Perotti, 1998). In other words, by making irreversible investments under uncertain market conditions, firms give up their flexibility to time their market entry to when market conditions may turn more favorable. This foregone opportunity cost, which elevates the threshold for entering a market, is equal to the value of the deferral options. Therefore, even if the net present value of entering a market may be greater than zero, with a higher threshold for entering a market because of the opportunity cost in entering a market or a higher value of

deferral options, it may be worthwhile for a firm to defer its market entry until uncertainty subsides.

By deferring entry to a time when uncertainty in the market subsides or when better information becomes available, firms can protect themselves against any downside losses or costly mistakes (Majd & Pindyck, 1987; McDonald & Siegel, 1986). In addition, deferring entry may provide firms with the opportunity to free ride on the market development for which early movers had endured the costs and risks of developing and promoting (Kauffman & Li, 2005; Liu, 2005; Wernerfelt & Karnani, 1987). Thus, high levels of uncertainty bring about high levels of deferral options and, as a result, high thresholds for entering a market. And as deferral options increase with uncertainty, the threshold for entering a market also increases with uncertainty.

There has been a significant body of research that describes how firms utilize deferral options in a strategic manner. Specific contexts of work in this area include market entry (Brouthers, Brouthers, & Werner, 2008; Campa, 1993; Folta et al., 2006; O'Brien et al., 2003), licensing (Jiang, Aulakh, & Pan, 2009), and investments (Campa, 1994; Guiso & Parigi, 1999; Rivoli & Salorio, 1996).

The Tension Between Growth Options and Deferral Options

The presence of uncertainty creates tensions between growth options and deferral options, or "dueling options" (Folta & O'Brien, 2004). With dueling options, how a firm responds to uncertainty will depend on whether the growth options or deferral options dominate. Kulatilaka and Perotti's (1998) theoretical work suggested that growth options or deferral options may dominate one another at different levels of uncertainty, resulting in a nonmonotonic effect of uncertainty on the threshold for entering a market. Folta and O'Brien (2004) extended Kulatilaka and Perotti's (1998) work and found that at low levels of uncertainty, deferral options largely dominate growth options, but such relationship reverses at higher levels of uncertainty. They suggested that this U-shaped relationship between uncertainty and market entry is the result of the different dynamics of growth options and deferral options: The upside potential of growth options is unbounded because of the potential economic value of gaining competitive advantages, whereas the downside value of deferral options is bounded because of the fact that the value of the deferral option cannot exceed the initial level of investments required to gain a foothold for future expansion or development.

As a result of the insights offered by Folta and O'Brien (2004), recent research has begun to explore the contextual factors that may drive the tension between growth options and deferral options, and when one may dominate another. For example, Leiblein and Ziedonis (2007) describe how the nature and expected advancement of technology condition the strength of the growth options and deferral options differently. Lin and Kulatilaka (2007) describe how the strategic advantages of shaping customer expectations early situate growth options to dominate deferral options. Although most efforts have focused on how uncertainty interacts with factors specific to the investment in the option (e.g., technology, license-holding period), much less has been focused on the differences between the structural characteristics of the market. Previous research has suggested that structural characteristics

such as different levels of network effects and the number of firms within the same market may affect how firms appropriate growth opportunities (Kulatilaka & Perotti, 1998; Tong et al., 2008) and the degree to which firms' up-front investments are irreversible (Capron, Mitchell, & Swaminathan, 2001; O'Brien et al., 2003). This burgeoning literature suggests that the influence of market structural characteristics, such as network effects or the emergence of dominant designs, on the relative value of growth or deferral options merits further theoretical consideration.

Network Intensity

The tension between growth options and deferral options is particularly evident in competitive settings that are influenced by network effects, as these markets tend to offer substantial growth opportunities yet also involve substantial uncertainty about the long-term viability of products and require significant irreversible up-front investments to enter a market (Eisenmann, 2006). Network effects are present when the value of a given product to a potential consumer is at least partly dependent on the product's installed base, or the number of people who have already adopted it (Farrell & Saloner, 1985; 1986; Katz & Shapiro, 1994). Network effects stem from a confluence of factors. First, direct network effects are present when consumers of a given product interact frequently and thus value the presence of a large number of other users of the product. Second, if product adoption requires some degree of learning investments, consumers may be unwilling to make such an investment when there is significant uncertainty over which of two or more competing technologies may emerge as a "dominant design" (Arthur, 1989; Schilling, 1998; Utterback & Abernathy, 1975).[1] The presence of a large installed base of users acts as a signal that a given product exhibits some degree of long-term viability, thereby reducing consumer concerns and assuring adopters that investments in learning will be beneficial (Brynjolffson & Kemerer, 1996; Chacko & Mitchell, 1998; Suárez & Utterback, 1995). Finally, indirect network effects are present when a large installed base is thought to attract producers of complementary goods and services to the focal product, resulting in increased value to users of the focal product (Gupta et al., 1999; Schilling, 1998, 2002; Stremersch et al., 2007; Venkatraman & Lee, 2004).

Previous research on network effects and strategy has largely focused on certain high-technology or "network" markets, where consumers place a premium on adopting products with the largest existing installed base (Brynjolffson & Kemerer, 1996; Lee, Venkatraman, Tanriverdi, & Iyer, 2010; Tanriverdi & Lee, 2008). In such cases, one product and its sponsoring firm may emerge as a dominant design and lock in the market as a de facto standard (Arthur, 1989; Schilling, 1998). For example, Microsoft Windows (operating systems), Facebook (social networking), and eBay (online auctions) have emerged as dominant designs in their respective markets in part as the result of the dynamics of strong network effects. These markets can be contrasted with manufacturing-based markets, where network effects have little or no influence on competition and multiple firms compete for a given share of the market (Arthur, 1996).

This dichotomy between "network" markets and more traditional manufacturing markets has been relaxed in recent years. More recent views have focused not on a strict dichotomy between markets that are influenced by network effects and those that are not but rather the notion of the relative influence of network effects as a continuum (Lin & Kulatilaka, 2007; McIntyre & Subramaniam, 2009; Suárez, 2005), along which network effects may have varying degrees of influence on product diffusion and competitive dynamics in a given setting.

We conceptualize this notion of heterogeneity in the influence of network effects across markets as a reflection of variation in *network intensity* in these settings. We define network intensity as the extent to which the value of a product to a consumer is dependent on the total size of its installed base. In high network intensity markets such as telephones, e-mail exchanges, and online auctions, the focal product has virtually no value in the absence of a large network of other consumers with whom to interact. In these cases, a given consumer will value a large installed base of fellow adopters, as this network is essential for deriving value from the product. Yet in other cases, consumers may value a network of other product users, but the total size of a product's installed base is not the primary driver of technology adoption and diffusion. Thus, an industry exhibits lower network intensity as (a) consumers place significant value on stand-alone aspects of the underlying product(s) independent of installed base size or (b) consumers place greater value on a small cohort of users with whom they can interact, rather than the total size of the product's installed base. For example, video game consoles offer network benefits such as online gaming and the availability of game titles (Schilling, 2003) but can also be used by an individual consumer in the absence of a large network of interactive users.

In summary, although much of the previous research on network effects and real options has focused on "winner-take-all" markets, variation in the intensity of network effects has been largely overlooked, particularly in the context of the option value of strategic actions in these markets. The following sections describe how the interplay among network intensity, uncertainty, and real options will have a significant impact on market entry strategies.

Disentangling Option Value and Network Value

Although both real options and network effects have made significant contributions to our understanding of various strategic initiatives, there are several limitations at the nexus of these two perspectives. First, existing theoretical and empirical perspectives at the intersection of growth options and network effects do not account for the strategic value of deferral options, or delaying irreversible investments, which are often described in tandem with growth options (Folta & O'Brien, 2004; Kulatilaka & Perotti, 1998; Lin & Kulatilaka, 2007). The rationale for this gap is fairly straightforward—given that markets influenced by network effects are prone to "tip" in favor of one product and its sponsoring firm, optimal strategies in these settings have focused on the value of establishing growth options via an early installed base of users (Eisenmann, 2006; Hill, 1997) rather than the value of deferring action and risk being "locked out" of the market. Yet again, this perspective tends to focus on situations where one firm will dominate the entire market for a given good and does not account for situations where network effects may have a lesser (yet nontrivial) role in determining competitive outcomes.

Second, an emerging body of evidence suggests that network effects do not manifest uniformly across competitive settings (McIntyre & Subramaniam, 2009; Shankar & Bayus, 2003; Suárez, 2005). As such, it is critical to distinguish between real option value in the presence of strong network effects, or high network intensity, and in those markets where network effects may play a lesser role in technology diffusion. Markets where network effects are present, but not strong enough to drive winner-take-all dynamics, may have unique impacts on real option value that have not been fully explored via existing theoretical and empirical perspectives.

Third, research on deferral options have assumed that the flexibility inherent in sequential investments, where a firm can commit new resources only if and when positive outcomes emerge, allows for the opportunity cost of entering a market to be bounded by the initial amount of investment required to enter (Folta & O'Brien, 2004). As such, when both growth options and deferral options are present, growth options tend to dominate deferral options at very high levels of uncertainty. However, this neglects the market dynamics of network effects, in which market entry requires substantial investments to ensure the tipping of the market (Arthur, 1989; Schilling, 1998). Such level of investments may be large enough to create exit barriers for the entrant, forcing the entrant to make continued investments for a prolonged period (Caves & Porter, 1976). As such, the opportunity cost of entering a market, or the value of deferral options, may be unbounded.

Finally, the existence of network effects in a market is often associated with the emergence of a dominant design, whereby a single firm may effectively dominate the market for a given product. As a dominant design is a specific path along a market's structural design hierarchy (Suárez & Utterback, 1995), how a firm appropriates growth opportunities or responds to market uncertainty will be affected by the emergence of such design. However, the differences in real option value before and after this emergence have gone largely unexplored, perhaps because of the assumption that markets where a dominant design exists offer little in the way of either growth or deferral, as the markets are essentially locked in to a single firm.

This section incorporates the concepts of network intensity, market uncertainty, and real options to conceptualize option value and market entry decisions at various levels of network intensity. We disentangle several underlying assumptions about network effects from real options value and argue that the network intensity acts as a multiplier that enhances *both* the growth option value and deferral option value in network industries. We then illustrate that with the influence of the multiplier effect, the threshold for entering a market can take on many different relationships contingent on market uncertainty. Finally, we contextualize these findings to situations both before and after a dominant design emerges in an industry influenced by network effects.

Growth Options and Network Intensity

Firms competing in markets that exhibit strong network effects tend to have higher values of growth options than those in other markets (Kester, 1984; Lin & Kulatilaka, 2007). In these high network intensity settings, network effects act as a multiplier that shifts the

growth option value to a higher level. Three characteristics drive this shift in growth option value. First, the ability to operate across multiple product lines using the same installed base allows firms to create a portfolio of individual growth opportunities across different product lines that the firm releases or plans to release (Raynor, 2008). It is important to highlight the difference between the ability of firms to operate within the same dominant design but across different product lines and the rise of complementary products or services. Firms are able to operate across product lines when one installed base can be leveraged across different product lines that may not be complementary. Complementary products or services reinforce the dominant design by attracting users to an ecology of products around the focal technology. For example, the launch of Microsoft Windows 7 not only gave rise to several complementary products and add-ons for the Windows 7 operating system itself but also allowed Microsoft to operate Windows 7 across multiple computing product lines such as the Microsoft Windows Phone Series 7.

Second, the preemptive characteristic of high network intensity markets sustains the growth options available to the firm that comes to own the dominant design. When little or no network intensity exists, many firms may try to bid to gain the growth options that are available in the market (Tong et al., 2008). These growth options may include licenses, concessions, patents, and R&D capabilities. As these growth options are not exclusive to any one firm, bidding by more than one firm will likely escalate the bidding or "exercise" price of acquiring these growth options. Such actions will shorten the "time to expiration" of these growth options and minimize, or even eliminate, the value to the firm that successfully acquires the growth option (Chi, 2000; Folta & O'Brien, 2004; Trigeorgis, 1996). However, when network intensity is high, such growth options generally have value to only the holder of the installed network base because without an installed base, a firm will have little use for these growth opportunities (Tong et al., 2008). As such, the holder of the largest installed base can acquire the entire growth options available in the market without eliminating the value through bidding.

Third, through preemption, firms not only lock in their consumers but also may lock in the development of future opportunities, such as locking in consumers for the release of future product lines (Schilling, 1998, 2002), creating barriers for new incompatible products by other firms (Kauffman & Kumar, 2008), preemptive learning about consumer markets (Kauffman & Kumar, 2008), and the ability to charge higher margins for their products (Katz & Shapiro, 1994; Matutes & Regibeau, 1988).

Given the exacerbated growth options for firms in markets with high network intensities, the threshold for entering a market is significantly lowered. As such, firms are likely to seek an early presence in the market to preempt rivals from developing or acquiring growth options (Kulatilaka & Perotti, 1998). By not immediately capturing these growth opportunities, firms risk losing the value of the growth options that they possess; if a competitor is able to tip the market in their favor, the firm's future growth prospects are significantly reduced, if not eliminated. Thus,

Proposition 1: All else being equal, the higher the network intensity of a market, the stronger the positive association between uncertainty and growth option value.

Deferral Options and Network Intensity

Although extant literature on network effects and real options logically suggests significant benefits from growth options, high network intensity also exacerbates the value of deferral options. In markets with high network intensity, firms must invest heavily in market development to attract customers and develop a large installed base to gain value from positive feedback (Agarwal & Bayus, 2002; Chacko & Mitchell, 1998). The winner-take-all assumptions in these markets provide incentives for firms to overinvest in the development of their installed base (Demirhan, Jacob, & Raghunathan, 2007). Such investments are very risky, as consumer acceptance of new network products is likely to take time (Agarwal & Bayus, 2002; Kauffman & Kumar, 2008; Rogers, 1995). In addition, the complementary products needed to instill consumer confidence in new network products are likely to be developed only after the product has already reached a critical mass (Min, Kalwani, & Robinson, 2006). Such situations can leave firms competing for dominance with no clear winner for a prolonged period, inducing very high irreversible sunk costs, which in turn heightens the value of deferral options.

The value of deferral options is also heightened by the potential for later mover advantages in markets influenced by network effects (Lieberman & Montgomery, 1988, 1998; McIntyre, 2011; Schilling, 2002). Such advantages are driven by the declining cost of network development over time—a distinguishing characteristic of network markets (Liebowitz & Margolis, 1999). As a result, firms that follow early movers may be able to threaten the competitive positioning of the early movers by competing at a cost advantage, in particular when the market has not tipped or has not shown any tendency to tip in favor of any other firm (Bohlmann, Golder, & Mitra, 2002; Demirhan et al., 2007). Besides cost advantages, later movers may also benefit from reduced switching costs. Although a first mover may create switching costs to lock in customers to their product base, this lock in effect can be diminished through development of a compatible system (Chen & Hitt, 2002) or advances in technology (Demirhan et al., 2007). Furthermore, later movers may be able to refine their strategies to better meet consumer needs (Schilling, 1998, 2002).

Given the exacerbated deferral options for firms facing high network intensity, the threshold for entering a market is significantly elevated. As such, firms are likely to derive greater value from deferring their market entry until some of the uncertainty in the market is resolved. Thus,

> *Proposition 2:* All else being equal, the higher the network intensity of a market, the stronger positive association between uncertainty and deferral option value.

Real Options and Network Effects in Context: Market Entry Pre– and Post–Dominant Design

Although the previous two propositions explain how both growth options and deferral options are heightened by strong network effects, they do not address changes in the structural characteristics of the market that are often associated with network effects. As previously

described, network effects may alter the structural characteristics of the market through the emergence of a dominant design. The significance of the emergence of a dominant design in this context is twofold. First, although the emergence of a dominant design represents a significant structural change to the market (Suárez & Utterback, 1995), the impact of this structural change on both growth and deferral options has been largely overlooked by extant theory. Second, though dominant designs are often associated with the "winner-take-all" dynamics of high network intensity markets (Arthur, 1996; Eisenmann, 2006), dominant designs may also emerge in markets where network intensity is lower (Schilling, 2002).

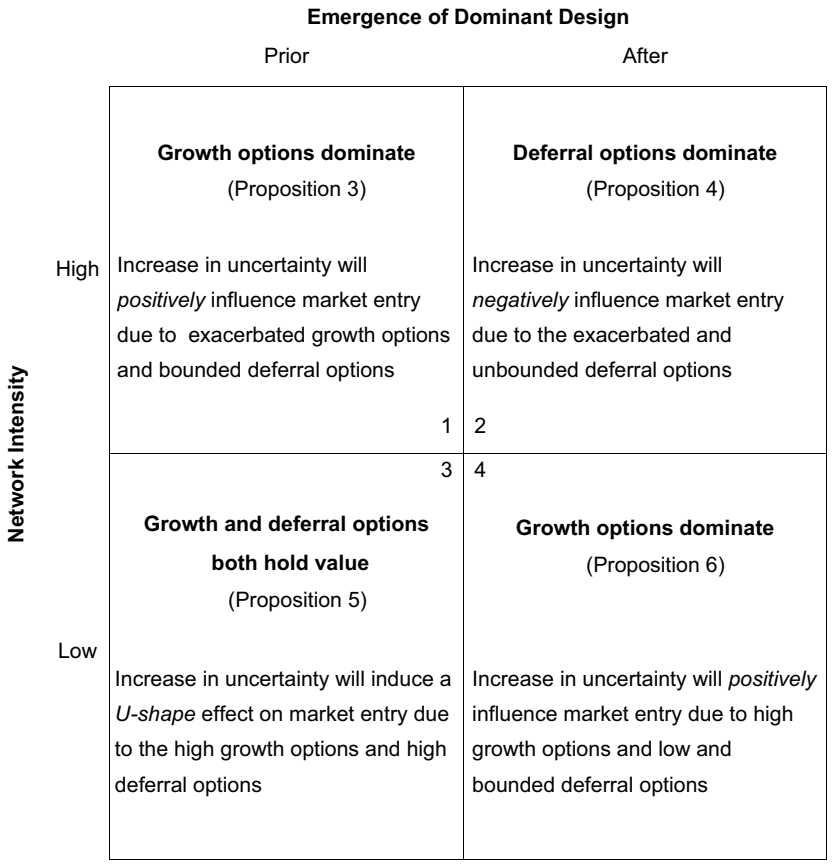
From a real options perspective, the emergence of a dominant design should have a significant but potentially asymmetric impact on growth and deferral options in both high and low network intensity markets. In turn, these changes in the relative strength of growth and deferral options should alter patterns of market entry. Given the relevance of dominant designs in the context of network effects, the following sections describe the influence of uncertainty on market entry in four contexts: before and after a dominant design has emerged and in markets where the network intensity is high and low. We illustrate this influence in each context by describing the comparative strength of growth options and deferral options in the scenario and the resulting effect on the threshold for entering each respective market. Figure 1 outlines the four basic scenarios.

High network intensity prior to dominant design. The first possible scenario involves entry into markets with high network intensity prior to the emergence of a dominant design (Figure 1, Quadrant 1). This scenario closely approximates the traditional winner-take-all dynamic, whereby a leading firm will tend to dominate after a critical mass of installed base is achieved (Lin & Kulatilaka, 2007). In these markets, consumers place strong value on the total size of a product's installed base and will tend to flock to the leading product as a result of the factors discussed previously—interaction, viability, and availability of complements. However, successful integration of these factors needed to develop a viable installed base requires an experimental process between the firm and the potential users of the product (Suárez & Utterback, 1995). Early entry into the market will provide the firm with the necessary time to probe the market and enhance the likelihood of success.

Once a successful dominant design has emerged, a leading firm will have a proper platform to accumulate more knowledge, efficient distribution channels, strong brand reputation, and the ability to exploit scale economies (Lieberman & Montgomery, 1988; Suárez & Utterback, 1995). This developed platform will further create entry barriers to later entrants, which will help the holder of the dominant design sustain their growth options. Consistent with the logic of growth options in high network intensity markets described in Proposition 1, firms will find greater value in entering such markets early, particularly when there is significant uncertainty regarding the eventual "winner" of the market. As previously noted, eBay's early entry into the online auction market is an example of a firm entering a high network intensity market early, thus increasing its chances of establishing a significant installed base and creating significant barriers for other potential followers because of consumers' desire to interact with an existing network of users.

Similarly, consistent with the logic of deferral option value in high network intensity markets described in Proposition 2, firms will find greater value in deferring market entry.

Figure 1
Market Entry with Regard to Network Intensity and Emergence of Dominant Design



However, the deferral option in a market where a dominant design has yet to emerge is bounded by the initial investments required to enter the market. Once a firm has been able to successfully develop a proper design and create entry barriers, the firm will be spared from competing for dominance with no clear winner for a prolonged period. This makes an early entrant's deferral options bounded as their initial level of investment that will allow further development is not heightened.

In summary, the extent to which the threshold for entering a market is lowered by growth options is greater than the extent to which it is heightened by deferral options. In addition, the potential for a firm to become the dominant design and secure all the growth options lowers the threshold for entering a market even further. As the threshold for entering a market is largely dominated by the growth options, which increase with uncertainty, the entry threshold will also decrease with uncertainty. Thus,

Proposition 3: All else being equal, in high network intensity markets where a dominant design has yet to emerge, uncertainty will positively influence market entry.

High network intensity after dominant design. The second possible scenario involves entry into markets with high network intensity after the emergence of a dominant design (Figure 1, Quadrant 2). As noted previously, when network intensity is high, the strategic advantages of early entry and growth will dominate the value of deferral, leading to a positive relationship between uncertainty and market entry. However, once a dominant design has emerged, the positive relationship between uncertainty and market entry may not hold. In this scenario, the dominant design will have already tied up the platform for any profits or future growth opportunities, and the winner-take-all dynamics of the market will also provide little room for a new entrant to survive as a small niche player in the market. The exacerbated growth options, as described in Proposition 1, do exist—but only to the holder of the dominant design. As such, the threshold for entering a market is equal to the net present value of entering a market that can sustain only one player—a value that is below profit level (Schmalensee, 1978).

Although the growth options to a later entrant may be limited, the deferral option is exacerbated. For a new entrant, the cost of replacing the holder of the dominant design would require substantial investments in the development of a significantly higher quality alternative product (McIntyre, 2011) or other strategic initiatives to lure customers away from the existing dominant design (Agarwal & Bayus, 2002). Such investments are very risky, as consumer acceptance of a new entrant is likely to take time (Agarwal & Bayus, 2002; Kauffman & Kumar, 2008; Rogers, 1995), and complementary products needed to instill consumer confidence will also take time to be developed. Entering a market where a dominant design already exists can leave firms competing to displace the dominant design with no clear timeline on when (or whether) a new "winner" would emerge (Schilling, 2002). This makes the level of investments required to enter unbounded and increases the threshold for entering a market to very high levels—firms will have to invest beyond the initial amount required to enter, in which the total required level of investment could be unknown. This is in contrast to conventional understanding that the option to defer cannot exceed the total irreversible commitment required to enter the market (Folta & O'Brien, 2004).

Consistent with these dynamics, firms attempting early challenges to an established dominant design in high network intensity markets have met with little success. Even firms that have enjoyed substantial success in related products have struggled when entering such markets. For example, Google in social networking (Miller, 2010), Yahoo in online auctions (McIntyre & Subramaniam, 2009), and IBM in computer operating systems (Zuckerman, 1995) failed in their early attempts to achieve a critical mass of users to displace the dominant design in their respective markets, despite the significant financial investments that they had put into market development.

In summary, the threshold for entering the market is largely driven by the deferral options, as they are exacerbated and unbounded. And as the threshold for entering a market is largely dominated by the deferral options, which increases with uncertainty, the threshold for entering a market will also increase with uncertainty. In other words, there will be a negative relationship between uncertainty and market entry. Thus,

Proposition 4: All else being equal, in high network intensity markets where a dominant design has emerged, uncertainty will negatively influence market entry.

Low network intensity prior to dominant design. A third possible scenario involves entry into markets with low network intensity prior to the emergence of a dominant design (Figure 1, Quadrant 3). In this scenario, the relationship between uncertainty and market entry will be nonlinear; as uncertainty increases, firms will first defer their market entry, and then later hasten their market entry. At low levels of uncertainty, the market characteristics of low network intensity and the lack of a dominant design heighten the deferral options. Markets with low network intensity allow for firms to coexist without reducing profit to zero. This is because the dynamics of markets with low network intensity are based not solely on a product's total installed base size but also on the quality and the branding of the product (McIntyre, 2011; Schilling, 2003; Shankar & Bayus, 2003). Such market dynamics provide opportunities for multiple dominant designs in the market to coexist without the need to quickly enter the market to lock in consumers and secure growth options. In other words, the level of network intensity does not exacerbate the level of growth options to very high levels.

As firms in these markets must continuously compete on the product quality and features and cannot solely rely on strong network effects to lock in their customers, these firms may benefit from deferring their entry to a time when a more advanced technology becomes available, or when the technology becomes cheaper, to compete more effectively (Leiblein & Ziedonis, 2007). Also, by waiting for the cost of technology to decline, firms may be able to build on the technologies pioneered by the earlier entrants and threaten their competitive positioning by competing at a cost advantage, in particular when consumers have not shown any tendency to migrate toward any design (Bohlmann et al., 2002; Demirhan et al., 2007). Furthermore, with no emergent dominant design, firms may not have the proper information or knowledge on effective production and consumer acceptance, which may lead a firm to make costly mistakes. However, by waiting for other firms to emerge and pioneer the market, the new entrant can capitalize on other firms by fine-tuning their product as the customer needs become evident and avoid mistakes made by the early entrants (Lieberman & Montgomery, 1988; Pindyck, 1988). In support of this view, Kulatilaka and Perotti (1998) found that in the absence of very high levels of growth options, firms tend to benefit more from deferral. Thus, at low levels of uncertainty, the threshold for entering a market will be largely dominated by the deferral options, and as deferral options increase with uncertainty, the threshold for entering a market will also increase with uncertainty, leading to a deferred market entry.

However, at very high levels of uncertainty, the growth options will be more prominent whereas the deferral options will be bounded, resulting in a reverse in the relationship between uncertainty and the threshold for entering a market from positive to negative. Although markets with low network intensities may not engender "winner-take-all" dynamics, they still can offer lucrative opportunities for "winner-take-most," whereby a firm may still realize some of the benefits of positive feedback in the market (Eisenmann, 2006; Frank & Cook, 1995). At the same time, with low network intensity, firms do not require substantial investments to ensure the tipping of the market, as multiple competitors can coexist. Also, given the coexistence of viable firms in the market, in the event that a firm decides to

withdraw from the market, there is a possibility that a potential buyer for the focal firm's platform may exist. In support of this view, O'Brien et al. (2003) found that the higher the number of firms in the same market, the more active the secondary markets for the assets of the firm. Similarly, Capron et al. (2001) found a higher rate of resource redeployment among firms in the same market with similar strategic features that engage in acquisitions. This suggests that in markets with low network intensity, not only are the levels of investments required to enter lower, the level of irreversibility is also lower, which reduces the threshold for entering a market substantially. Thus, at very high levels of uncertainty, the threshold for entering a market will be largely dominated by growth options. And as growth options increase with uncertainty, the threshold for entering a market will also decrease with uncertainty.

The video game console market, which offers some network benefits such as online gaming but also provides consumers with stand-alone features in which the consoles can be utilized without the presence of a large network of interactive users, is an example of a market with modest network intensity where multiple dominant designs can coexist. In this market, Sony deferred its release of its PlayStation3 so that developers could finalize game development and its Blu-ray DVD technology could mature, despite the fact that such deferral allowed Microsoft to enter the video game market with its Xbox 360 game console one year earlier (Edwards, 2006).

In summary, for entry into markets with low network intensities prior to a dominant design, both growth options and deferral options exist and combine to make the relationship between uncertainty and the market entry a U-shaped curve—at low levels of uncertainty, deferral options will dominate, but at high levels of uncertainty, growth options will dominate. Thus,

> *Proposition 5:* All else being equal, in low network intensity markets where a dominant design has yet to emerge, uncertainty will initially negatively influence market entry and then later positively influence market entry (U-shaped effect).

Low network intensity after dominant design. The final scenario involves entry into markets with low network intensities after the emergence of a dominant design (Figure 1, Quadrant 4). In this scenario, the threshold for market entry will decrease with uncertainty because the presence of a dominant design or designs lowers the deferral option significantly, allowing for the threshold to be driven by the growth options in the market. Besides the characteristics of low irreversible investments that substantially bound the level of deferral options in these winner-take-most markets, the existence of a dominant design or designs in a market setting where firms can coexist will reduce the threshold for market entry even further. Existing studies have shown that early pioneers tend to pave the way for later entrants in the same market with better market information allowing for new entrants to have a higher entry success (Henisz & Delios, 2001; Lieberman & Montgomery, 1988; Martin, Swaminathan, & Mitchell, 1998) and avoid costly mistakes (Henisz & Delios, 2001; Shaver, Mitchell, & Yeung, 1997). Such information includes not only information on consumer demand but also knowledge related to production, distribution, stakeholders, marketing tactics, and organizational development. Thus, although market uncertainty may still exist, firms will have better knowledge and capabilities to navigating toward a successful

market entry. For example, "smart phone" operating systems exhibit only modest network effects, as consumers may desire compatibility with others for certain proprietary applications but may enjoy stand-alone features or interact with others across platforms, thus limiting the strength of direct network effects for a given product. Consistent with the growth options perspective, this burgeoning industry has seen an influx of major competitors such as Apple (iOS), Microsoft (Windows Phone), and Google (Android), despite the emergence of early dominant designs by Nokia (Symbian) and Research in Motion (Blackberry OS).

In summary, the knowledge and capabilities that can be inferred from the presence of a dominant design or designs will reduce the threshold for entering a market significantly. As a result, the threshold for entry will be driven mainly by the growth options. And as the level of growth options increases with uncertainty, there will be a negative relationship between uncertainty and the threshold for entering a market. Thus,

Proposition 6: All else being equal, in low network intensity markets where a dominant design has emerged, uncertainty will positively influence market entry.

Discussion

This work makes three contributions at the nexus of real options and network effects. First, we have proposed that the relative value of both growth and deferral options is influenced by differences in the strength of network effects, or network intensity, in a given setting. Although previous efforts in this domain have often implicitly linked network effects with growth options (Lin & Kulatilaka, 2007; Suárez & Utterback, 1995), we contend that network effects and growth options are two distinct but related phenomena. Specifically, network intensity acts as a multiplier that tends to enhance the value of growth options (Proposition 1). This "disentangling" of growth options and network effects allows for a more comprehensive understanding of the unique drivers of each. For example, growth options are mainly enhanced during periods of high market uncertainty, whereas network intensity is mainly enhanced through consumer interdependence (McIntyre & Subramaniam, 2009).

Second, we have clarified the impact of market uncertainty on the value of both growth options *and* deferral options in markets that exhibits network effects (Proposition 2). Previous research on network effects has emphasized the notion of positive feedback in markets influenced by network effects, which will incentivize firms to acquire high levels of growth options through early market entry. And previous research on real options, or specifically dueling options, has emphasized the notion of bounded deferral options that allow growth options to dominate at very high levels of market uncertainty. Our proposition indicates that these conceptualizations may not hold in all contexts. Although deferral options are present in most investments that have an irreversible component (Kogut, 1999), the amount of irreversible investments required to become a "winner" in a winner-take-all market acts as a multiplier that exacerbates the deferral option value to very high levels (and may remain unbounded). Separating these two constructs—deferral options and the multiplier effect of network intensity—allows us to understand the value of strategic actions in the presence of network effects. For example, deferral options are reduced during periods of low uncertainty

or reduced when arrangements that allow flexibility in the investment requirements are present, whereas the multiplier effect on deferral options can be altered through enhancement of the degree of a stand-alone or network-independent value that is retained in the absence of a strong network effect (Brynjolffson & Kemerer, 1996). Although real options and their dueling effects (i.e., the effects of growth options and deferral options) have been researched in other industry settings (e.g., Folta & O'Brien, 2004; Kogut, 1999), to our knowledge this article is the first to integrate the dueling effects of real options in markets influenced by network effects.

Finally, we contextualize these findings to a particular strategic action, market entry, in four particular contexts—high and low network intensity markets, before and after the emergence of a dominant design, to incorporate the structural characteristics of the market that have been altered by the presence of a dominant design or designs. The integration of both network intensity and dominant designs into this framework demonstrates that the value of market entry is not uniform across "network" markets. Specifically, the presence of a dominant design has different effects on deferral options in markets with different levels of network intensity; in markets with high network intensity, the presence of a dominant design heightens the deferral options (Proposition 4); on the contrary, in markets with low network intensity, the presence of a dominant design or designs lowers the deferral options (Proposition 6). The inclusion of dominant design allows a closer examination of how asymmetries between growth options and deferral options arise. Though previous research has largely assumed that growth options will tend to dominate markets influenced by network effects, our framework demonstrates that this scenario holds only in high network intensity markets prior to a dominant design (Proposition 3) or low network intensity markets after the emergence of a dominant design or designs (Proposition 6). Other situations may offer more complex option value scenarios, such as growth and deferral value in low network intensity markets prior to a dominant design (Proposition 5) or strong deferral value in high network intensity markets after a dominant design has emerged (Proposition 4).

In addition to the implications offered to extant theory on real options and network effects, this research also provides several implications for managers through a better understanding of the strategic advantages and disadvantages that firms may face in entering a market influenced by network effects. Although managers may face pressure for early entry into markets to capture and lock in growth options, under some circumstances there may be several strategic advantages to deferring entry. When entering high network intensity markets with a dominant design under conditions of high uncertainty, the amount of investments needed to develop a presence may be extremely high to the point that it may render any value from growth options that may be gained—even if the firm is able to "tip" the market to their favor. On the contrary, firms entering low network intensity markets with a dominant design or designs present may want to take advantage in developing a small niche market and focus on customer loyalty and branding as well as initiate cooperative efforts in their coexistence with other dominant players and complementary product developers. Or firms entering low network intensity markets without the presence of a dominant design or designs may need to consider the trade-offs between the growth opportunities that are appropriable and the opportunity costs of market development, not only for themselves but also for other potential later entrants.

Implications for Future Research

Our article suggests several avenues for future research. First, although network intensity has been characterized as a largely exogenous, market-level variable, recent work suggests that network intensity may also vary at the firm or product-line level as well (McIntyre & Subramaniam, 2009; Shankar & Bayus, 2003). If so, firms may benefit by attempting to strategically increase or otherwise manipulate the network intensity of their products. For example, cell phone service traditionally has had modest proprietary network value to a given firm, in that consumers could call virtually any other consumer on any other land-line, cell, or Web-based voice system. Yet the emergence of "friends and family" and related plans, which provide incentives for multiple users to use the same service, can be seen as increasing the network value of a product to a specific firm. Although these products certainly had some degree of network value—calling other consumers assumes an underlying infrastructure of phone service—these plans strategically increase the product's proprietary network value. Thus, future research should explore the underlying factors that influence the level of network intensity in a given industry and how it can be altered or enhanced in a manner that enables a firm to capitalize on growth or deferral opportunities.

Second, in addition to understanding how the level of network intensity can influence option value with regard to market entry, it is important to understand the impact of this intensity on more specific strategic actions related to entry. For example, Proposition 3 suggests that firms competing in high network intensity, predominant design markets will accelerate their market entry efforts. Empirical evidence of accelerated market entry, along with commensurate increases in advertising, marketing, or other customer acquisition efforts, would offer compelling evidence that the real options reasoning applied to this setting does indeed hold. Similarly, Proposition 5 suggests that firms competing in low network intensity, predominant design markets will defer their market entry efforts at low levels of uncertainty and accelerate their market entry efforts at high levels of uncertainty. Empirical confirmation of such market entry behavior would offer compelling evidence that the real options reasoning applied to this setting does indeed hold.

Third, we have presented a basic model of the interplay among real options, network effects, and market uncertainty. Future research in this domain should examine the implications of this interplay in more specific contexts. For example, Leiblein and Ziedonis (2007) contend that when option value is thought to be U-shaped (as in Proposition 5), certain contextual factors will determine whether growth options or deferral options will dominate. Such factors may include technological opportunity, the mechanisms used to secure a claim on the opportunity to act flexibly in the future, and the expected arrival time of the future opportunity. Similarly, other contextual or contingent factors may be present in each of the four quadrants of Figure 1 that have been outlined in our propositions. For example, the degree of network intensity that can be altered, the level of expected retaliation or cooperation from the dominant design, the level of compatibility among network platforms, and the technical uncertainty of the network product are factors that characterize network industries. The extent to which our broad propositions are influenced or modified by such factors certainly merits further investigation.

Third, although we followed previous research on real options and market entry in holding the net present value of the entry opportunity (NPV) and the cash flows foregone if the entry

is deferred (CF) constant (Folta & O'Brien, 2004; Leiblein & Ziedonis, 2007; Schilling, 2002) to focus on the relative strengths of the growth options and the deferral options, the level of NPV and CF does play a role in a firm's decision to enter a market. Future empirical research should incorporate the NPV and CF of firms in different markets to determine how endogenous factors such as customer acquisition efforts or technological investments that may alter the NPV and CF will affect a firm's decision to enter a market.

Last, we propose that future work should include empirical tests of our propositions across a broad spectrum of industries. Although previous researchers have developed approaches to testing antecedents of market entry under uncertain conditions (e.g., Folta et al., 2006; Folta & O'Brien, 2004) as well as measurements for the presence of a dominant design (Suárez & Utterback, 1995), direct measures of network intensity are largely lacking, with few exceptions (e.g., Suárez, 2005). Future empirical research in this domain should focus on the development of robust measures of network intensity that incorporate both direct network value from the product as well as indirect network value from the availability of complements. The development of such measures, which may incorporate both product or industry characteristics as well as ratings of network intensity by industry experts, would allow further empirical examination of the interplay among network intensity, uncertainty, and real options logic that we have proposed.

Conclusion

This research has attempted to resolve the ambiguity in real options theory with regard to the strategic value of market entry in the presence of network effects. We contend that this ambiguity can be partly explained by the lack of attention to the specific impact of network intensity on the value both of growth options *and* deferral options, variation in network intensity across markets, and the differences in structural characteristics of markets before and after a dominant design has emerged. By disentangling real options and network effects, and identifying the unique dimensions of the two theories, we provide insights into market entry that the perspectives of real options and network effects alone cannot provide.

In addressing these ambiguities, we developed propositions that demonstrate the influence of network intensity on the relationship between market uncertainty and real option value, in which high network intensity generally acts as a multiplier for both growth and deferral option value. In addition, we described the specific interplay of real option value, market uncertainty, and network intensity on patterns of market entry. Finally, we proposed that the relative influence of growth and deferral options on market entry will vary depending on the emergence of a dominant design in the market.

Note

1. We use *dominant design* here to refer to the emergence of a dominant product, design, or technology within a given market. Although other terms such as *technology standard* or *technology lock in* may connote similar dynamics, we use *dominant design* for its breadth (i.e., it may apply to industries with strong, weak, or no network effects) and consistency throughout.

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