How High-Technology Start-Up Firms May Overcome Direct and Indirect Network Externalities

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ABSTRACT

This paper presents a conceptual model of strategic choice for high-technology start-up firms in the face of network externalities—the strength of the market's preference for standardized technology. Our model suggests that the commercialization strategies followed by such a firm will depend on the type of network externalitites—direct versus indirect— as well as the degree of appropriability—the firm's ability to retain the value of innovation. We offer a number of propositions generated by the model and discuss their implications.

Keywords: network externalities, appropriability, high-technology start-ups

INTRODUCTION

A particularly vexing barrier for some start-up firms is how to overcome network externalities that may exist in their markets. Similarly, another hurdle for many start-up firms is how to appropriate value from an innovation. The model in this paper suggests that the distinction between direct and indirect network externalities, and the degree of appropriability, will determine whether the firm's commercialization strategy focuses on internal resources and decision variables or on interactions with its competitive environment.

High technology start-up firms may be particularly sensitive to network externalities and appropriability since many such firms are introducing products based on technologies for which there are yet no market standards for compatibility (Hill, 1998) and facing particularly uncertain appropriability conditions that affect their ability to grow and survive (Shane, 2001). Not all new technologies, and not all start-up firms, face network externalities or appropriability issues. For those that do, however, overcoming these barriers to commercialization is crucial as these barriers may influence the firm's strategy for commercialization, growth and survival.

This paper models strategic choice for start-up high technology firms in the face of network externalities—the strength

of the market's preference for standardized or compatible technology (Farrell & Saloner, 1985; Katz & Shapiro, 1985). It suggests that commercialization strategies will depend on appropriability—the firm's ability to retain the value of an innovation (Arrow, 1962; Teece, 1986)—and the type of network externality—direct versus indirect. Following prior researchers (Katz & Shapiro, 1985; Kotabe, Sahay & Aulakh, 1996), direct network externalities refers to a direct relationship between the number of users of a product and the product's quality or utility, while indirect network externalities refers to the indirect effects from the price and availability of goods and services that complement a product. The paper is rooted in streams of research from technology and innovation literature on how technologies become commercialized (Lee, O'Neal, Pruett & Thomas, 1992; Tushman & Rosenkopf, 1992), organization research on technological discontinuities (e.g., Anderson & Tushman, 1990; Tushman & Anderson, 1986; Tushman & Rosenkopf, 1992), and literature from strategy and economics focused on the impact of technological standards (e.g., Farrell & Saloner, 1987; Garud & Kumaraswamy, 1993; Hill, 1992, 1997; Katz & Shapiro, 1987; Majumdar & Venkataraman, 1998; McGrath & McGrath, 2000).

These streams have posed longstanding questions for researchers and for firms. How can standards be established? How can a new entrant compete? What roles do switching costs, first or second mover advantage, regulation, and intra-industry cooperation play? In competitive strategy, how can a firm profitably commercialize its own technology if the technology poses a network externality for customers and there is the potential for competition from other firms, either through imitation or through alternative technologies? In particular, our model suggests that direct network externalities will lead firms to pursue strategic choices centered on internally-controllable decision variables. Indirect network externalities, on the other hand, will lead firms toward efforts to manage their competitive environment by cooperating with outside actors. In addition to theory-building, these questions also pose the need for additional work to empirically quantify the relationship between strategic choice, appropriability, and the two distinct forms of network externalities. The model developed in this paper offers a basis for subsequent empirical study.

SIGNIFICANCE TO HIGH TECHNOLOGY INDUSTRIES

This topic is particularly significant in a global economy that is evolving rapidly in the area of so-called "high" technology, a term encompassing a variety of industries focused on newer technologies. The most prominent may be telecommunications and information technology (IT) hardware, software, and services. There are other significant areas as well that often are placed under the high technology umbrella, including biotechnology, advanced manufacturing technologies, and advanced product technologies. These industries have moved to the forefront of business activity and change in the last decade, in part because of their impact

on traditional economic sectors, but also in part because of their own growing economic significance.

The growth and evolution of these industries has not been entirely pain-free, however. We have witnessed in the past several years a dramatic weeding-out process in the IT sector. The "dot-com" collapse in the United States may be the central example in this process. Hundreds of IT-related firms have, in a remarkably brief span of time, declared bankruptcy, been sold off, experienced sales declines, laid off large numbers of employees, redefined their missions and strategies, or simply closed their doors. It is worth noting, however, that many continue to survive, even prosper.

Although some firms in IT are well-established (such as the traditional telecom and mainframe computer companies), many IT-related firms are remarkable for their youth and their independent emergence. Many of these firms, whether failures or survivors, are relatively young companies, having come into being in the 1990s, particularly in the second half of the decade. Financed by a healthy venture capital sector and strong responses to public stock offerings, many of these companies were independent start-ups rather than the progeny of large, established firms.

These firms also have faced a highly competitive environment characterized by rapid technological advancement and entry by new firms. In this environment, strong network externalities and widely varying appropriability pose a particularly fascinating mix of competitive issues.

First, network externalities are common in IT hardware, software, and services. That is, the value of many IT products to a user depends on the number of other users. New firms have strong incentives to build a critical mass of customers for their product quickly. At the same time, many high technology products may be unfamiliar to existing markets, so new firms also must educate customers about new product technologies and their uses.

Second, firms have faced varying degrees of appropriability. Appropriability is the ability of a firm to capture the economic rents generated by its activity. It may depend on financing or other resources, on technological barriers to imitation, and/or on legal barriers to imitation. The degree of appropriability is a major factor in a firm's ability to sustain a competitive advantage.

The perception that these new areas could offer substantial economic rents has created strong incentives for competitors to arise. Certainly, venture capital for new IT firms is now harder to obtain than in the last decade, but we have seen a variety of new would-be competitors arriving in fairly short order in many segments of information technology. In some segments these new entrants compete with incumbents, yet other segments are new areas of business populated by *de novo* firms or by incumbents entering from other arenas.

Entry has been facilitated by the intangible nature of intellectual property. The high job mobility of workers with technical knowledge and other intellectual capital has facilitated start-ups. Further, since innovation and competition have moved rapidly, it has been risky for firms to rely

heavily on legal protection for their intellectual property. Legal protection may be definitive, but it is not necessarily swift. In a highly competitive environment, relying primarily on the law for protection may lead a firm to "win the battle but lose the war."

STRATEGIC CHOICES BASED ON APPROPRIABILITY AND THE TYPE OF NETWORK EXTERNALITIES

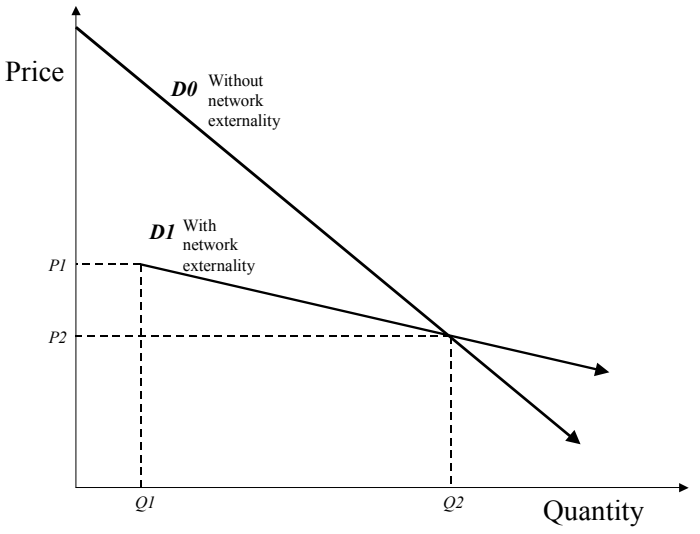
A start-up firm with an innovative product facing network externalities has a difficult situation. It needs a substantial customer base in the short term to gain a first mover advantage.

From a consumer's point of view, network externalities echo the supplier's minimum efficient scale. For the supplier, it may be uneconomical to produce below some given level. For the consumer, demand may be absent below some level, regardless of price. Figure 1 presents a stylized example of hypothetical demand curves for two products, one with a network externality and one without. This is a simplified model, not a depiction of a typical situation.

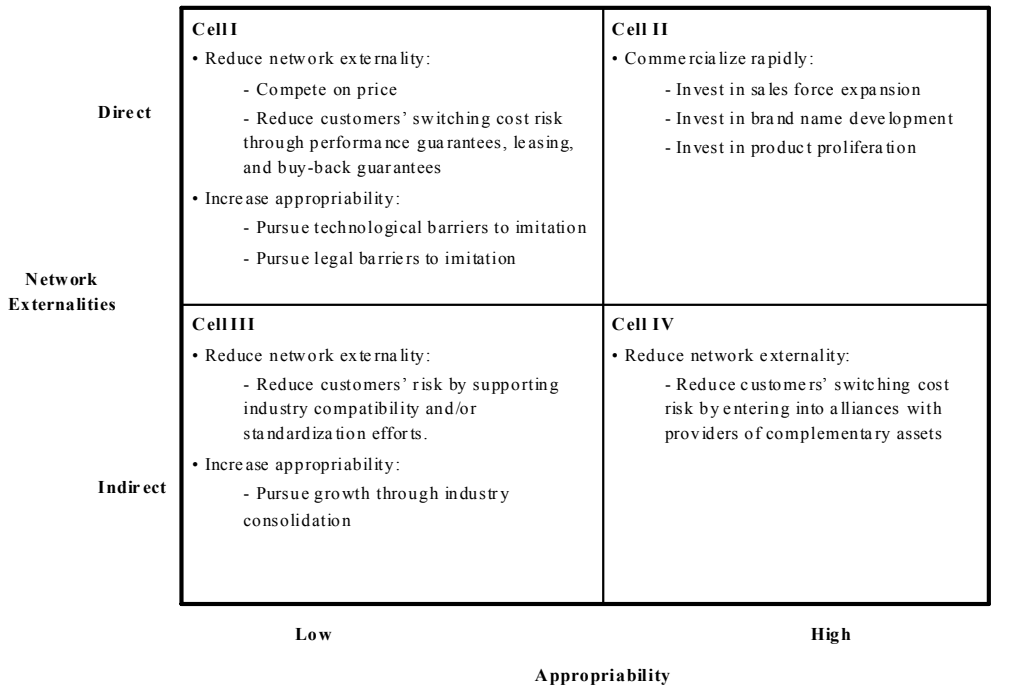
D_0 is a demand curve for a product without a network externality. It represents the traditional normal good—demand is an inverse function of price, and an individual consumer's product utility does not depend on aggregate demand. D_1 is a stylized demand curve for a product with a network externality. We have presented it in this form to highlight three network externality issues that are particularly interesting from a competitive standpoint for start-up firms

First, demand does not begin at zero—there is no demand below quantity *Q1*. This reflects the basic nature of a network externality. In a world with only one

Figure 1: Hypothetical product demand curves with and without network externality



FIigure 2: Strategic choices depending on appropriability and type of network externalities



telephone, there should be no demand for that phone, regardless of price. From a competitive perspective, this illustrates the start-up firm's initial sales issue—how to achieve sales of quantity *Q1*. Customer expectations about the product's likely popularity with other users will influence whether the firm can achieve any sales at all.

Second, by depicting demand beginning at price *P1*, it suggests that low levels of demand for a product with a network externality may be satisfied only at a price less than that for a similarly-priced product without a network externality. Stated another way, if two similarly-priced competing products are introduced, one with a network externality and one without, initial demand may be higher for the product without. Strategically, this also suggests that, *ceteris paribus,* resolving the network externality is the central competitive issue for the start-up.

Third, the flatter slope of the demand curve for the product with a network externality suggests that the market may be more price-sensitive for this product. It highlights that at prices below some level, denoted here as *P2*, the product's rising marginal utility may actually induce the market to prefer the externality-driven product. Stated another way, it suggests that a firm facing a network externality for its product can gain market dominance and earn economic rents if it can stimulate demand to and beyond the point *Q2*.

Figure 2 introduces the subsequent discussion, in which we develop the logic of strategic choices that a firm is likely to pursue in the face of network externali-

ties. Although the model focuses on start-up firms (entrepreneurial or corporate), we recognize that an incumbent can influence the choice and success of these strategies. For example, an incumbent can block entry through their unique and inimitable resources and capabilities, and through market signals for a reputation of retaliation or by making nonreversible investments (Afuah, 1999). Alternatively, an incumbent can encourage entry to allow rivals to fill out product lines that it cannot provide themselves (Porter, 1980) to persuade buyers to adopt products and services provided by monoplists (Garud & Kumaraswamy, 1993), and to help win a standard/dominant design (Afuah, 1999). With this understanding, our model, however, focuses on start-up firms (entrepreneurial or corporate) and emphasizes the distinction between two types of network externalities—direct and indirect – and differing conditions of appropriability. The following discussion develops propositions for each of the four cells in Figure 2.

Cells 1 and 2: Direct Network Externalities

As noted earlier, *direct network externalities* are driven by a direct relationship between the number of users of a product and the product's quality or utility (Katz & Shapiro, 1985; Kotabe, Sahay & Aulakh, 1996). Direct network externalities often are found in products that facilitate human interaction. An obvious example, the telephone, has greater consumption utility as more users join the network (Katz & Shapiro, 1985). (As one reviewer noted, direct network externalities may be found in other areas as well, such as the issue of machine-machine interoperability in production or operations environments.)

Cell 1 illustrates the situation of direct network externalities in conditions of low appropriability. The firm faces customers whose marginal utility rises with the number of other users, yet the firm lacks the resources and barriers with which it could profit. Accordingly, the firm's strategy should be concerned with reducing the significance of the network externality to customers, and with increasing barriers to entry/imitation.

One way to reduce the significance of the network externality is to reduce a prospective customer's out-of-pocket investment. Although network externalities are known to increase a customer's willingness to pay, lowering prices can also increase demand (Kaufmann & Wang, 2001). If the innovation provides less utility for users at lower levels of demand, than it must be priced accordingly. Thus,

Proposition 1a. Direct network externalities and low appropriability will lead the firm to compete on price.

A significant factor underlying initial demand may be the expected switching costs for users should they stop using the innovation or change to an alternative design or supplier. As a result, network externalities typically create greater switching costs. Accordingly, the firm may seek to reduce these potential costs. One obvious way is to increase standardization and/or compatibility with competitors'

products. This may lower customers' incentives to switch, and it may help those who do switch to sell more easily their now-unneeded technology.

However, increasing standardization may not be a viable option in at least two instances. First, standardization may require technological changes that compromise the distinctive strengths of the firm's product. Second, the firm may be a first-mover without competitors. There are ways to reduce switching costs that do not affect the product development process or require coordination with competitors. Instead, the firm may simply shift switching costs from users to the firm by providing performance guarantees, offering leasing, and/or buy-back guarantees. Thus,

Proposition 1b. Direct network externalities and low appropriability will lead the firm to reduce customers' switching cost.

In addition to the above steps to make the innovation more attractive to the market by addressing the network externality, the firm may wish to raise barriers to entry to forestall competitors if it is to profit from its efforts. To a large degree in high technology industries, appropriability depends on both technological barriers and legal barriers to imitation (Teece, 1998). Barriers to entry in this instance center on preventing imitation of the innovation, for without this protection the firm has little prospect of profiting. Technological barriers to imitation include secrecy practices (not sharing the existence or details of a new technology or a firm's start-up plans) and technological complexity (offering sophisticated, multi-featured designs). Examples of legal barriers to imitation include patent enforcement, securing a multiplicity of patents, and the use of non-compete and nondisclosure agreements with employees. Thus,

Proposition 1c. Direct network externalities and low appropriability will lead the firm to pursue technological barriers to imitation.

Proposition 1d. Direct network externalities and low appropriability will lead the firm to pursue legal barriers to imitation.

Cell 2 illustrates the situation of direct network externalities in conditions of high appropriability. The firm still faces customers whose marginal utility rises with the number of other users, but the firm possesses the resources necessary to secure a first-mover advantage. Accordingly, the firm's strategy should be concerned with putting those assets to their best use through rapid commercialization to lock out new entrants. By pursuing marketing barriers, firms can prolong first mover advantages that can lead to differentiation and sustainable competitive advantage (Porter, 1980). Consider, for example, the long-standing success of Intel's personal computer (PC) processors. The firm built on its early success with several interesting moves. First, it made its processors available to any firm wanting to build PCs. Second, it took the remarkable step of creating brandname recognition for its component among the buyers of finished computers through its "Intel Inside" advertising. Third, it reinvested its high returns in the rapid devel-

opment of new product offerings.

These traditional marketing barriers to entry—intensive selling efforts, developing brandname recognition, and product proliferation—are feasible solutions for a firm with high network externalities in conditions of high appropriability. For instance, several researchers have argued that marketing assets, such as promotional development, can enhance the appropriability of an innovation (Rao & Klein 1994; Vinod & Rao, 2000) and can preempt competitors by dominating a market (Hill, 1998). Similarly, Utterback and Suarez (1995) argued that product variety or proliferation can facilitate a dominant design and can provide a competitive advantage in a technologically uncertain environment. Thus,

Proposition 2. Direct network externalities and high appropriability will lead the firm to pursue marketing barriers to entry through intense early efforts to expand sales, develop its brandname, and proliferate products.

Cells 3 and 4: Indirect Network Externalities

Indirect network externalities are dependent on indirect effects of using a product. More specifically, they are found in products that require distinct scale-driven complementary assets (Katz & Shapiro, 1985; Kotabe, Sahay & Aulakh, 1996). For example, the utility of software support or of automobile repair service depends on the number of other users in the same user group or "network," since in these cases the unit costs and availability of these complementary products are highly related to the number of other users (Arthur, 1989; Chou & Shy, 1990; Teece, 1986). A car owner may have a piston-driven engine or a rotary one, and a videocassette recorder owner may have a VHS-format VCR or a Betamax one. The utility of the car does not directly depend on whether anyone else has the same design, but it does depend on the availability of repair services and parts for that particular engine technology. Similarly, the utility of the VCR depends on the availability of videotapes to fit that particular VCR design. In fact, an innovation can be rejected in instances where there exists a lack of complementary assets (Schilling, 1998). The faster rate of growth in the availability of VHS-format videotapes versus that of Betamax was one factor in the eventual demise of Sony's consumer-market Betamax VCRs.

In the case of direct network externalities, the firm's strategy highlights elements that are essentially internal to the firm, or firm-specific. In contrast, a firm facing indirect network externalities will turn its attention to the competitive environment. More specifically, the decisions that will drive the firm's success will center on interactions and relationships with other firms.

As Moner-Colonques and Sempere-Monerris (2000) observe, cooperation between firms is often considered in terms of its anti-competitive impact. However, research already argues that appropriability is one driver of such dynamics (Gemser, Leenders & Wijnberg, 1996; Gemser & Wijnberg, 1995) and of vertical integration (Krickx, 1995). Similarly, the importance of complementary

assets possessed by incumbent firms is one explanation for alliances between incumbents and new entrants to an industry (Rothaermel, 2001). If the network externality is indirect, the situation becomes more complex—the higher the indirect externality, the greater the need for some form of compatibility or standardization among competing designs, if customers are to be willing to invest. *Ceteris paribus*, we may see the emergence of product standards, whether formal or *de facto*.

Cell 3 illustrates the situation of indirect network externalities in conditions of low appropriability. The firm lacks resource, technological, and/or legal barriers to imitation. Further, the firm's product requires complementary assets that are distinctive from those required by its competitors, but economies of scale mean the producers, distributors, and/or consumers of those assets prefer to use only one version of the complementary asset. Complementary asset producers will invest and exploit economies of scale, thus lowering their customers' fully loaded cost of use.

Certainly, firms may find it convenient to conduct product development/R&D processes within a variety of existing standards, many of which may simply be taken for granted as constraints in the development process. Software products may depend on standardized programming languages and may be developed for existing hardware, electronic products may conform to existing technological standards and may use some degree of standardized components, and production processes may be designed to use already-available machinery.

In this case, the firm may be less likely to invest heavily in unique technology and may be more likely to pursue standardization in its industry, whether before initiating research and development, during the R&D process, or during the initial phases of competition. Consider for example the myriad computer manufacturers that arose in the late 1980s and early 1990s. Few created highly novel designs—the majority followed the IBM PC format. They did so partly because of scale economies achievable in standardized, off-the-shelf components, and partly so that the crucial complementary asset—software—would work seamlessly across computer brands. Thus,

Proposition 3a. Indirect network externalities and low appropriability will lead the firm to pursue industry standardization and compatibility.

Certainly, an alternative solution in this case would be for the firm is to pursue industry consolidation by merging with competitors and then to standardize within the merged firm's market area and customer base. Thus,

Proposition 3b. Indirect network externalities and low appropriability will lead the firm to pursue industry consolidation.

Cell 4 illustrates the situation of indirect network externalities in conditions of high appropriability. The firm possesses the financial or other resources, technological expertise, and/or legal barriers needed to capitalize on its product, but the complementary asset question remains unresolved. Customers remain sensitive to

the switching costs associated with incompatible forms of complementary assets. Such conditions may lead to stronger relations between firms (Boschetti & Marzocchi, 1998). This case offers another form of capitalizing on a first-mover advantage. Although cooperative efforts with other firms may create appropriability hazards (Oxley, 1997), and although the asset specificity of those complementary assets is likely to mold the form of alliances between firms (Brousseau & Quelin, 1996), it has been argued that the lack of needed complementary assets is clearly tied to the extent of a firm's alliances with other industry actors (Arora & Gambardella, 1994). The firm is likely to encourage development, availability, and links to providers of the needed complementary assets, since those assets comprise the only significant remaining barrier to a successful start-up. To build on an earlier example, a dramatic scenario is the successful commercialization of the VHS-format VCR by Matsushita, a relatively small firm. Matsushita's major competitor in VCRs was the far-larger Sony, which possessed greater experience, the resources needed for commercialization, and a superior VCR technology (BetaMax). Matsushita's decision to license its design to multiple firms stimulated market growth, fostered entry by firms, encouraged product innovation, and spurred the widespread availability of prerecorded VHS videotapes. The combination of these factors drove Sony and its technology out of the consumer VCR market. Thus,

Proposition 4. Indirect network externalities and high appropriability will lead the firm to pursue alliances with providers of complementary assets.

CONCLUSION

This paper provides an overview of a model and propositions regarding a firm's choices when commercializing a new technology. The model is developed in the context of start-up firms, as the success of these firms is particularly sensitive to the issues of network externalities and appropriability. By distinguishing between direct and indirect network externalities, and by examining their relationship to appropriability, the model advances theory-building in the technology and innovation literature and offers specific insights into how start-up firms may overcome network externalities. In particular, the model suggests that direct network externalities will lead firms to pursue strategic choices centered on internally-controllable decision variables. Indirect network externalities, on the other hand, will lead firms toward efforts to manage their competitive environment by cooperating with outside actors.

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