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# Strategy in Network Industries: A Review and Research Agenda

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**Abstract**

This article reviews extant theoretical perspectives and empirical literature at the nexus of network effects and strategy. Building on these insights, it offers a research framework that focuses on three primary avenues: the strategic drivers of network intensity, approaches to assess variations in network intensity, and effective strategies for leveraging network intensity. In doing so, the study widens the perspective of the role of strategy in network industries and offers directions for future research.

**Keywords**

network effects, competitive strategy, technology management

## Introduction

Network effects occur when the value of a product or service to a consumer is contingent on the number of other people using it (Farrell & Saloner, 1985, 1986; Katz & Shapiro, 1986, 1994). For instance, the value of an online auction site such as eBay to its users, critically hinges on the number of buyers and sellers using it. Network effects shape competition in a wide spectrum of markets in our economy, from technology sectors such as video games and software to more traditional businesses such as HMOs, credit cards, and real estate (Eisenmann, Parker, & van Alstyne, 2006; Gupta, Jain, & Sawhney, 1999). In *network industries*, or industries where network effects exist, performance outcomes can exhibit positive feedback. A few firms that establish an early customer base can reinforce their position and gain from their momentum, whereas others may find it hard to get a foothold and face increasing pressures to exit from the marketplace. More broadly, network effects can induce market imperfections in an industry, making it structurally attractive with high barriers to entry, power over buyers, and low intensities of rivalry (Porter, 1980). As a result, such industries can allow us to closely observe and understand how such market imperfections can be purposefully harnessed to gain advantage in the market place (Venkatraman & Subramaniam, 2002). In essence, strategy can play an

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essential role in these settings by further unleashing the propensity of these industries to create competitive advantage.

Though the basic dynamics of network effects have received a fair amount of research attention in the context of technology adoption and diffusion (e.g., Arthur, 1989; David, 1985; Farrell & Saloner, 1985), a robust understanding of the role that firm strategy plays in network industries remains limited. A key reason for this lapse is that exogenous market-characteristic driven explanations for performance outcomes currently dominate our thinking. Relatively less is understood about endogenous or firm-initiated efforts that shape or control the firm's competitive destinies in these industries (Cowan, 1990; David, 1985). More recently, however, a burgeoning body of work has begun to address strategic issues in network industries (e.g., Casadeseus-Masanell & Ghemawat, 2006; Eisenmann, 2006; Hill, 1997; Schilling, 2002; Tanriverdi & Lee, 2008). These studies provide some useful insights on a few specific strategic initiatives such as entry timing, expectations management, or firm diversification. However, each of these studies focus on precise, yet discrete and narrow attributes of these select initiatives in network industries. As a result a wider and more unified perspective of how these and other possible strategic initiatives play out in network industries remains underdeveloped.

In this article, we aim to broaden the discourse and widen our perspective of the role of strategy in network industries. We do so by first reviewing the major theoretical and empirical literature at the nexus of network effects and strategy and synthesizing their insights. We then build on these insights to develop a research framework that is organized broadly around three questions. First, what underlying factors influence the strength of network effects, or *network intensity*, in a given industry? This question allows us to identify and expand on the various strategic drivers that influence the strength of network effects in an industry. Second, how can we identify and assess the network intensity of a given industry? This question allows us to focus on the outcomes of the drivers of network effects, on how to categorize and systematically assess them in a research setting. Third, what are the optimal strategies for leveraging network intensity? This question enables us to classify different approaches by which firms can both influence the strategic drivers of network effects and understand how to achieve positive outcomes to gain competitive advantage.

By elaborating on the themes around these questions we aim to develop an appreciation of the wider implications of strategy in network effects. Also, in building on previous theoretical and empirical work on strategy and network effects, our research framework offers several potential avenues for future work on effective firm strategies in network-based competition. As network effects play an increasingly salient role in modern industries (Arthur, 1996), understanding the critical elements underlying the high-stakes battles in network industries represents a critical next step for scholars and practitioners of strategic management.

## Theoretical Basis for Strategy in Network Industries

In certain industries the value of a given product or service to a consumer is contingent on the number of other consumers of the same product[1] (Farrell & Saloner, 1985; Katz & Shapiro, 1986). Examples include telephones, fax machines, electronic mail, and online auctions. In these "pure" network industries, there is virtually no value for the product in the absence of other consumers, and the value of the product increases exponentially with the number of fellow users of the product. The cumulative number of users at any given time in the product's life (i.e., the network size) is its *installed base*. Because consumers desire compatibility with

others, a product with a large installed base should be favored over one with little or no existing installed base.

## Sources of Value in Network Industries

In network industries, consumers derive value from two aspects of a given product. First, these products have some degree of network value or the value stemming from other consumers already using the product. For example, for certain computer applications, consumers gain value from the ability to interact and exchange files with a compatible network. Second, such products also have a stand-alone or network-independent value that is retained in the absence of a network, such as a graphical interface computer application that offers intrinsic simplicity and intuitive features in its use (Brynjolfsson & Kemerer, 1996). More generally, network value is a reflection of the benefits associated with a large cohort of fellow adopters (installed base) for the product, whereas network-independent value represents benefits conferred by inherent, "physical attributes embodied in each unit of the good" (Bental & Spiegel, 1995).

At a basic level, network value is influenced by interdependence in consumer demand (Rohlfs, 1974) or when product adoption decisions are dependent on the decisions of other consumers. The network value of a given product is driven by two primary components—direct and indirect network effects. Direct network effects are present when product value increases with the number of people directly using a given product, such as an online auction. Compatibility with other users becomes an important issue, and thus, adoption decisions are often heavily influenced by a product's installed base relative to competitors. Furthermore, a large installed base may act a signal that a given product exhibits some degree of long-term viability, thereby reducing uncertainty and assuring adopters that investments in learning will be beneficial (Brynjolfsson & Kemerer, 1996).

In addition to these direct network effects, network value is also influenced by indirect network effects. Indirect network effects occur when complementary products are critical to the use of a given product and its value stems indirectly from the volume and diversity of available complements (Venkatraman & Lee, 2004). For example, video game consoles have little value without corresponding software titles, and the value of a console increases with the number and variety of complementary titles (Schilling, 2003; Venkatraman & Lee, 2004). Concurrently, game developers must decide which consoles to target when developing new titles. The platform with the larger installed base offers a larger potential pool of adopters for the game, over which the developer may be able to exploit economies of scale in production. Thus, consumers enjoy indirect benefits from a large and diverse set of complements to the core product.

## Competitive Outcomes in Network Industries

Given that the network value of a product is directly and indirectly tied to the size of its installed base, network industries are thought to exhibit several unique characteristics. First, they are characterized by *path dependence*, whereby contemporary performance outcomes are strongly dependent on past events. For example, the QWERTY keyboard design in modern computers can be traced to seemingly minor marketing and layout decisions about typewriters in the late 19th century (David, 1985). With a growing installed base of consumers gaining familiarity with the QWERTY design, these seemingly minor decisions became amplified over time, as firms refrained from burdening consumers to learn or get used to new design attributes. Put

differently, its installed base inhibited firms from initiating any major discontinuities for their existing users, thus constraining them into a specific and predetermined trajectory of design options. As such, seemingly minor or idiosyncratic strategic actions by a firm may be magnified over time (Arthur, 1989).

Such path dependence often manifests in *positive feedback*, or a tendency for leading firms to further reinforce their lead, whereas those falling behind accelerate their decline (Arthur, 1996). The more consumers adopt a leading product, the more valuable it becomes to future adopters. In other words, in network industries there is a propensity for the "strong to grow stronger and the weak to grow weaker" (Shapiro, 1999). For example, with more and more people using Microsoft Word in the 1980s and 1990s, the value of this particular Microsoft Office application package to future users increased exponentially, reinforcing Microsoft's lead in the market place.

When positive feedback is strong enough, network industries may foster *winner-take-all* scenarios, whereby, a single product and its sponsoring firm can lock-in virtually the entire market for a given good or service. For instance, the strong network effects in the online auction industry has made eBay close to a enjoying a monopoly position in its market. Despite efforts from a variety of other online competitors such as Yahoo, eBay has long maintained its dominant position.

Path dependence, positive feedback, and winner-take-all attributes are generally assumed to be exogenous factors or preexisting conditions in an industry. Moreover, their influence is considered to be so strong that prior research has tended to downplay the importance of endogenous firm-related approaches to leverage network effects. This premise, as we have pointed out earlier in the Introduction section, has limited our understanding of the role of firm-level strategy in network industries.

Although these industry dynamics can offer lucrative returns for firms that can leverage the dynamics of positive feedback in their favor, they could have potentially adverse consequences for consumers. When the value of network membership is strong enough, a superior entrant to the market may be unable to attract marginal adopters, as consumers may value a large installed base more than intrinsic quality characteristics of the product. That is, there are conditions when network value trumps network-independent value. In these conditions, consumers incur high *switching costs* if they chose to migrate from a product with a large installed base to an ostensibly "better" one with little or no installed base. As such, network industries may result in, or even foster, situations where consumers are left with inferior products and technologies (Besen & Farell, 1994; Schilling, 1998; Shapiro & Varian, 1999).

## Empirical Approaches to Strategy in Network Industries

The above attributes of direct and indirect network effects have been well established in prior literature. As we have indicated above, their effects are believed to be so strong that competitive outcomes are thought to be strongly dependent on exogenous dynamics and idiosyncratic events rather than firm-specific capabilities or strategic initiatives. More recently, however, a burgeoning literature has begun to address the role of strategy in maximizing firms' potential for success in network industries in spite of the unpredictable nature of these settings. This section reviews recent empirical work on of strategy in network industries. Note that although a substantial body of literature has described economic models of network effects and product diffusion, we have attempted to limit our discussion to those empirical studies that examine the

specific role of network effects on optimal firm strategies and/or competitive outcomes. Please see Table 1 for a representative sample of recent empirical research at the nexus of strategy and network effects.

## Strategic Initiatives in Network Competition

As a result of the unique dynamics underlying network industries, strategy research in these settings has focused on a few select strategic initiatives that capture the benefits of positive feedback. We broadly classify such initiatives by their focus on (a) developing an installed base and (b) managing the influence of complementary products. Whereas the former focuses on maximizing direct network value to consumers, the latter centers on the benefits of indirect network value. We briefly review representative empirical studies of these initiatives and conclude the section with a summary of the contributions and limitations of these studies.

*Installed base development.* Firms in network industries often focus on building an installed base as quickly as possible, with the ostensible goal of offering future consumers greater network benefits, and consequently allow the firm to be optimally positioned to leverage the dynamics of positive feedback (Besen & Farrell, 1994; Hill, 1997; Schilling, 2002). Thus, several studies have examined strategic initiatives that are thought to influence the development of an early installed base of users, such as entry timing (Eisenmann, 2006; Schilling, 2002; Shapiro & Varian, 1999; Suarez & Utterback, 1995), product pricing (Bonardi & Durand, 2003; Clements & Ohashi, 2005), managing consumer expectations (Katz & Shapiro, 1994; Shapiro & Varian, 1999; Eisenmann, 2006), and enhanced product quality (Liebowitz & Margolis, 1994, 1995).

Perspectives on *entry timing* argue that early movers have significant advantages in network industries, as they are more likely to achieve a critical mass of early adopters. Indeed, empirical evidence suggests that firms that enter network industries before the emergence of a dominant design or a technology standard certainly have a better chance to build a significant installed base and thus ensure their future viability (Suarez & Utterback, 1995). However, Schilling (2002) notes that early entry may be detrimental to a firm, as very early entrants (and very late entrants) to the market run a higher risk of losing network battles. Eisenmann (2006) makes a similar and surprising finding that early movers in "winner-take-all" markets do not invest significantly more in customer acquisition efforts than firms in nonnetwork industries. Thus, effective strategies around entry timing in network industries appear to be more complex than a simple rush to achieve first-mover status.

Strategies related to *product price* in network industries have received a fair amount of attention in the empirical literature. Although price can be seen as a reflection of the value of attractive product characteristics such as a large installed base or adherence to existing technological standards (Brynjolfsson & Kemerer, 1996; Gallaugher & Wang, 2002; Gandal, 1995), it can also be seen as a strategic variable, which can be used by the firm to gain or reinforce an installed base as a network industry evolves (Bonardi & Durand, 2003; Clements & Ohashi, 2005; Ohashi, 2003). In such cases, firms may use steep discounts or even product giveaways early in the life of a product, in the hope of establishing a critical network of users.

Pricing strategies can also be seen as a type of *expectations management*. When markets tend to tip toward one dominant product or standard, consumer expectations about which product will win become increasingly important for making adoption decisions. Because it is costly to switch to a competing product once a dominant standard has emerged, early signals to consumers about the viability of a product become important aspects of network competition.

**Table 1.** Selected Findings on Network Effects and Strategy, 1985-2008

| Author | Industry | Methodological Approach (Level of Analysis) | Strategic Issue | Main Findings |
|---|---|---|---|---|
| David (1985) | Typewriters | Case study (technological standard) | Lock-in by inferior product design resulting from network effects | QWERTY keyboard design locked-in consumers, even when "better" designs emerged, as a result of network benefits |
| Cowan (1990) | Nuclear power | Case study (technological standard) | Lock-in by inferior product design resulting from network effects | Light-water nuclear reactors became entrenched, and later superior technologies were unable to replace it |
| Gandal (1995) | PC software | Hedonic price/ regression models (product line) | Does the PC software market exhibit network effects? | LOTUS file compatibility significantly explains price variations, suggesting compatibility effects in both the spreadsheet and database markets |
| Suarez and Utterback (1995) | Multiple | Survival analysis among pre- and postdominant design entrants (firm) | Effects of entry timing on survival in technology-intensive industries | Survival rates are higher for firms that enter such industries before a dominant design has emerged |
| Brynjolfsson and Kemerer (1996) | Spreadsheets | Hedonic model (product line) | Effects of installed base and product features on price | Consumers place a premium on installed base size, as well as features which adhere to the dominant standard of the time |
| Hill (1997) | Multiple | Case studies (firm) | What are the key competitive strategies to be leveraged in a network industry? | Key strategic issues include licensing, sole provisions, and/or selective partnering, depending on industry contingencies |

*(continued)*

**Table 1. (continued)**

| Author | Industry | Methodological Approach (Level of Analysis) | Strategic Issue | Main Findings |
|---|---|---|---|---|
| Chacko and Mitchell (1998) | Telecommunication, software, communications equipment | Fixed-effects regression model to test installed base size-on-growth effects (industry) | How strongly does installed base size influence growth in a network industry? | Installed base initially has a negative impact on growth, which becomes more positive after a certain critical mass is achieved |
| Majumdar and Venkatraman (1998) | Telecommunications (electronic switching) | Ordinary least squares (OLS) regression on 40 firms (network) | Network effects are decomposed into benefits of both returns to scale and imitation effects | Operational returns to scale strongest early in the technology's life; demand-side returns to scale strong throughout; imitative effect not supported |
| Shapiro (1999) | Multiple | Case studies (firm) | What are the key strategic assets in network markets? | Key assets include installed base, intellectual property rights, innovation capabilities, first-mover advantages, complements, and brand name |
| Liebowitz and Margolis (1999) | Word processors, spreadsheets, others | Quantitative case studies using market share, quality data (industry) | In network industries, does product quality impact patterns of adoption? | Quality appears to play a significant role in industry outcomes, even where strong network effects should be present |
| Gupta, Jain, and Sawhney (1999) | Digital televisions | Consumer choice model/ simulation (technology standard) | How do indirect (complementor) network effects impact the evolution of a network industry? | Actions of complementors play an important role in the diffusion of digital TVs, particularly high-definition TVs |
| Gallaugher and Wang (2002) | Web server software | Hedonic pricing model using 321 product-months (product line) | What characteristics influence the price of a network product? | Market share and price are positively related, and these effects carry over into |

*(continued)*

**Table 1. (continued)**

| Author | Industry | Methodological Approach (Level of Analysis) | Strategic Issue | Main Findings |
|---|---|---|---|---|
| | | | | complementary products. "Mindshare," supporting dominant standards, and consumer trials positively affect price |
| Schilling (2002) | Multiple | Logistic regression (technology standard) | Despite path dependence, what strategic factors influence technology lock-out? | Timing of entry, learning orientation, sufficient installed base influence likelihood of lock-out |
| Bonardi and Durand (2003) | Multiple | Case analyses (product line) | How can core products be repositioned over time to sustain network advantages? | Products must be continuously repositioned based on compatibility, price, and vertical integration with complements |
| Shankar and Bayus (2003) | Video games | Three-stage least squares (3SLS) analysis of 64-product months (firm/product line) | Do network effects vary by firm? | Nintendo overtook Sega's lead in the market because they had a stronger, though smaller, network of users |
| Asvanund, Clay, Krishnan, and Smith (2004) | P2P file-sharing network | OLS regression on characteristics, availability of 170 songs (network) | What role do negative network effects—from free riders—play in adoption of a network product? | As network increases in size, users contribute resources at a decreasing rate; costs of network size may outweigh the value of new adopters at some point |

*(continued)*

**Table 1. (continued)**

| Author | Industry | Methodological Approach (Level of Analysis) | Strategic Issue | Main Findings |
|---|---|---|---|---|
| Venkatraman and Lee (2004) | Video games | Multiprobability regression, network visualization (network) | What factors affect the coordination of video game launches? | Network structure and embeddedness, platform dominance and newness affect developers' launch choices |
| Suarez (2005) | Wireless telecommunications | Conditional logit regression to analyze technology choices of 95 operators (network) | Does the strength of network ties have a greater influence on adoption than gross network size? | Local network ties may be a more effective proxy than gross network size for network value |
| Eisenmann (2006) | Internet | 3SLS analysis of 117-firm sample (firm) | How does first-mover status and the existence of network effects condition firms' investment in customer acquisition? | First-movers generally spend more on marketing efforts, but those in network industries do not significantly do so |
| Weitzel, Beimborn, and Konig (2006) | Simulation data | Equilibrium analysis, computer simulation (network/ technology standard) | What drives diffusion of a communication standard, and what results can we expect? | Network density and topology strongly influence patterns of diffusion; propensity of network industries toward monopoly is overstated |
| Stremersch, Tellis, Franses, and Binken (2007) | Multiple | Time-series analysis of nine high-technology markets (industry) | How strong is the influence of indirect network effects? | Indirect network effects are weaker than expected, and the availability of complements almost always follows availability of the core product (i.e., indirect effects rarely drive direct network effects) |

*(continued)*

**Table 1.** (continued)

| Author | Industry | Methodological Approach (Level of Analysis) | Strategic Issue | Main Findings |
|---|---|---|---|---|
| Tanrivierdi and Lee (2008) | Software | Longitudinal study of 884 firms (firm) | What is the role of diversification (both market-based and platform-based) in driving performance in the presence of network effects? | Diversification in both platforms and product-markets can influence performance outcomes in network industries |

Examples of such signals include product preannouncements (Shapiro & Varian, 1999) or substantial investments in developing and marketing the product early in its life (Chacko & Mitchell, 1998; Eisenmann, 2006; Farrell & Saloner, 1986).

Finally, the strategic value of *product quality* in network industries remains a source of significant controversy in the literature. Although certain innovative and competitive capabilities are essential to success in network industries (Shapiro & Varian, 1999), the value of capabilities associated with producing high-quality products remains unsettled. In the most extreme cases, a product's network value is thought to subsume any network-independent benefits. As a result, quality differentiation among competing products becomes secondary and adoption of inferior products and product designs may occur. This line of thought is consistent with historical case studies, which have illustrated the dynamics by which an ostensibly inferior technology "locked-in" the market (Cowan, 1990; David, 1985).

However, in a series of articles, Liebowitz and Margolis (1990, 1994, 1995) highlight the role of product quality in determining outcomes in network industries. The authors argue that cases of nonremediable market failure where an inferior product dominates the market must be exceedingly rare, as such outcomes must assume that consumers are unduly constrained in remediating these situations (i.e., switching to the *better* product). Furthermore, they find that in settings where network effects should be strong, such as spreadsheets and word processors, dominant products tend to be those that exhibit the highest quality. Thus, the strategic impact of quality in network industries represents a critical unresolved debate in the literature on strategy and network effects. Given that the production of higher-quality products requires some degree of temporal learning (e.g., Levin, 2000), firms competing in network industries face a trade-off between releasing products early, hoping to establish an early installed base, or delaying releases in hope of producing a higher-quality product, which will induce consumers to switch.

Further complicating research on strategies aimed at installed base development is the lack of empirical corroboration on whether a large installed base actually fosters future growth in network industries. In nonnetwork industries, tests of the relationship between metrics of firm size and growth have produced mixed results (e.g., Evans, 1987; Hall, 1987; Hymer & Pashigian, 1962; Penrose, 1955). And although only a handful of studies have attempted to test the specific relationship between installed base size and growth in network industries, they too find mixed results. For example, Chacko and Mitchell (1998) find a negative linear association

between installed base and growth, which becomes more positive only after a certain critical mass is reached. Similarly, Shankar and Bayus (2003) find the influence of installed base to be asymmetric in the video game console industry, as a firm with a smaller but more powerful network (Nintendo) overtook a firm with a larger network (Sega). Asvanund, Clay, Krishnan, and Smith (2004) go so far as to claim diminishing returns to network size in certain contexts, finding that the influence of "free riders" begins to outweigh the benefits of additional network members in peer-to-peer (P2P) networks.

Taken together, these results suggest that installed base size may be an insufficient predictor of future network growth. Suarez (2005) supports this notion, finding that gross network size is a relatively poor proxy for network value and that other attributes may be contributing to the benefits of installed base in network industries. Such attributes may include ties among network partners as well as the density and topology of a network of users (Weitzel, Beimborn, & Konig, 2006).

*Managing complementary products*. Although strategies that increase direct network value via a large installed base have been the primary focus of the literature on network effects, a relatively smaller set of studies has emerged around the strategic role of complementary products in providing indirect network value to consumers. Complements play an essential role in allowing consumers to derive value for certain goods. For example, computer operating systems have little use without corresponding office productivity software. Similarly, the value of a Blu-ray digital video player is partly dependent on the number of available movie titles available in that format. The management of complements is particularly relevant in network industries, as the availability and diversity of complements can present significant, albeit indirect, network benefits to consumer.

Though the benefits of complementary products are well established in extant theory, there have been relatively few empirical examinations of effective strategies related to complements. One notable exception is Schilling (2002), who finds that poor availability of complements increases the likelihood that a given product, and its sponsoring firm, will be locked-out of the market. Similarly, Gupta, Sawhney, and Jain (1999) suggest that the actions of complementors play a critical role in consumer adoption decisions and suggest specifically that the suppliers of television programming had a significant impact on the installed base growth and diffusion of the high-definition TV standard. Thus, producers of complements may hold substantial influence on consumer expectations about the core product, even after dominant standards have emerged (Clements & Ohashi, 2005). Concurrently, the dominance and newness of a technology may condition the product release decisions of complementors (Venkatraman & Lee, 2004).

Nonetheless, more robust findings regarding specific strategic initiatives geared toward the active management and leveraging of complements are surprisingly lacking. This may be due in part to the empirical difficulty of parsing the distinct yet correlated benefits of both installed base size and availability of complements. Stremersch et al. (2007) refer to this dilemma as the "chicken-and-egg problem"—Does a large installed base drive the existence and variety of available complements or vice versa? The authors conclude in their study of several network industries that installed base almost always drives the availability of complementary products—that is, direct network effects tend to drive indirect network effects, rather than vice-versa.

A nascent literature at the nexus of strategy and economics in network industries characterizes consumers of a network product and producers of complements to the product as two sides joined by a common platform (Eisenmann, Parker, & Van Alstyne, 2006; Parker & Van Alstyne, 2005). In this line of thought for example, technologies such as video game consoles can be

seen as a platform that links two distinct audiences—end consumers and game developers. The critical strategic variable in such cases involves determining which side of the platform is subsidized (e.g., game developers) and which side is willing to pay to interact with the other group.

In summary, empirical approaches to strategy in network industries have identified a range of strategic initiatives that can influence the degree of direct and indirect network value to consumers in these settings. However, empirical confirmation of the role of installed base and complementary products as antecedents of firm growth has been surprisingly elusive, with several studies offering conflicting views of the relative value of each. Thus, effective strategy appears to be more complex than the simple presence of an installed base and complementary products. Rather, more specific prescriptions for the active management of these variables are needed. Furthermore, research in this domain has traditionally been hindered by the assumption that these industries are strongly influenced by exogenous and unpredictable events. Though recent research indicates that certain strategic initiatives can increase the firm's chances of winning network battles, a broader contingency framework for determining optimal strategies in network industries remains elusive.

## A Research Agenda for Strategy in Network Industries

Figure 1 depicts our view of a future research agenda that puts strategy in a more central role in creating and leveraging benefits from network effects. As we highlighted in the Introduction section, we build this agenda on three fundamental questions regarding strategy and network industries. First, what are the underlying product, network, and market factors that drive the strength of network effects, or *network intensity*, in a given industry? Second, how can we identify and assess network intensity in various competitive contexts? Third, what are optimal strategies for leveraging network intensity for competitive advantage? In addressing these questions, we hope to widen our understanding of the role of strategy in network industries, guide future researchers to build on previous research, and generate new insights into the key levers of strategy in various network industries.

### *Drivers of Network Effects*

At a fundamental level, network effects arise because of demand interdependence in a product or service (Rohlfs, 1974). That is, when some aspect or attribute in a product causes the buying decision of one consumer to influence the buying decisions of others, we see the basis for network effects (Weitzel, Wendt, & Westarp, 2000). To strategically leverage the benefits of these network effects thus, it is important to first develop a clear understanding of the intrinsic nature of demand interdependence. Why does demand interdependence exist in the first place? Why is demand interdependence stronger for some products compared with others? How can we harness demand interdependence for competitive advantage? To channel future research into thinking along these lines we suggest three primary factors that drive demand interdependence, and thus the strength of network effects: (a) product design (b) complements and (c) social dynamics.

*Product design*. Perhaps the most significant driver of network effects is the basic architecture of the focal product, as demand interdependence intrinsically stems from the manner in which a product is consumed. For example, the generic architecture of telecommunications devices such as telephones and fax machines make them useful only when consumed by more than one

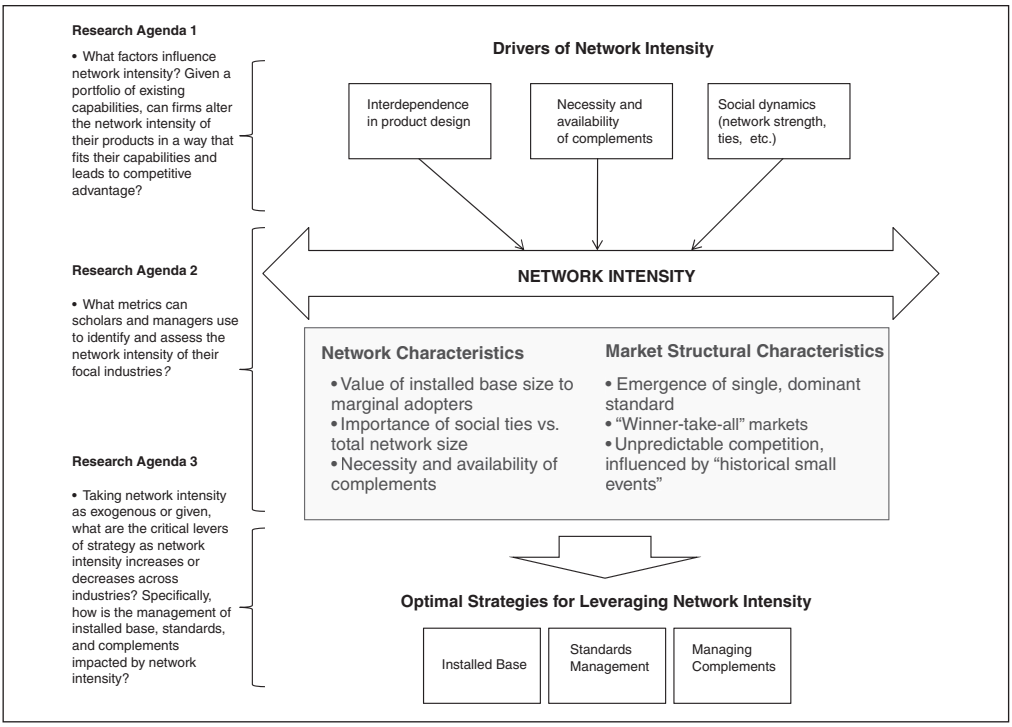


**Figure 1.** A research agenda for strategy in network industries

user. However, interdependence could also be strategically infused through thoughtful designs in a broader spectrum of products, services, or technologies that may not necessarily have any generic architectural characteristics that create demand interdependence. For example, by adding online capabilities to a video game console, a broader community of online participants gets involved in the product's usage. Consequently, as the video game engages a larger cohort of players, each individual player perceives greater value, thus imparting demand interdependence and associated network effects. Another example can be seen from marketing initiatives of cell phone providers such as "family plan" or "in-network" rates. Here, the design of the service is manipulated to induce greater value for larger network size. That is, a consumer perceives a higher likelihood of reduced rates (greater financial value) from larger networks where they more likely find their friends and family as comembers.

Although product design may appear to be an intrinsic driver of network effects, it has received very little attention in prior literature. A few studies that refer to product design do so only obliquely when addressing the issue of product quality. Product quality however in these studies is not seen as a driver of network effects but rather as a representation of *network-independent* attributes. The thrust of these prior studies thus is largely on examining whether network effects trump network-independent attributes that are embodied in superior product quality. Also, it appears as if prior research assumes away product design as an exogenous factor or a preexisting condition that sets the stage for network effects rather than a strategic driver that could be manipulated for influencing the strength of network effects in a market.

Future research could engage in a wide variety of questions around the purposeful infusion of demand interdependence in product or technology design. For example, to what extent does a specific product design influence demand interdependence and consequent network effects in use? When does it make sense to infuse demand interdependence in a product? Under what conditions can a firm appropriate the benefits of infusing demand interdependence in a product? How do dominant designs interact with a product or technology's features to influence network effects? Under what conditions do innovations infused network effects disrupt prevailing technology regimes or dominant designs?

*Nature of complements*. Complementary products are thought to be a distinct yet often ancillary driver of network effects. To understand the underlying mechanisms of the influence of complementary products on network effects it is important to distinguish between the *necessity* and *availability* of complementary products. Some products, such as watches, are inherently stand-alone and do not need complements. In such products complementary products are not necessary for consumers to derive value from using it. Other products work only with complements, such as DVD players (that need DVDs) and video cameras (that need cartridges or storage media). For such products complements are essential for consumers to usefully consume the core product. Necessity for complements nevertheless can be strategically controlled. For example, firms may be able to integrate the required complementary functions into the primary product and thereby eliminate the necessity of complements. For instance, many video cameras now rely on internal digital storage rather than separate cartridges, thus integrating a complementary component into the product design. The point to be noted here is that the *necessity* of complements can vary (or possibly be made to vary) across products and thus can strategically influence the intensity of network effects.

The availability of complementary products influences the intensity of network effects when greater availability enhances the value of a primary product. For example, the greater availability of video game titles enhances the value of a console for a video game player. As pointed out in an earlier section, this concept has already received research attention. However, prior research tends to consider the availability of complementary products as an exogenously determined fact rather than a construct that could be endogenously manipulated. For instance, Venkatraman and Lee (2004) examine the strong positive impact Microsoft's growing base of game developers (and hence availability of complements) has on its competitive success in the videogame industry. The study however overlooks how Microsoft actually enhances its base of game developers or increases the availability of complements; rather its focus is more on ascertaining the influence of the growing availability of complements on market success. Thus, more research targeting the strategic role of creating the availability of complementary products in driving network intensity can usefully extend our prevailing insights.

One approach to do so is to examine how the choice between adopting *open* and *proprietary* standards influence the availability of complementary products and hence indirect network effects. Open standards publicize commonly agreed design guidelines or architecture and thereby reduce restrictions in permitting interface between primary and complementary products and even across complementary products. Conversely, proprietary standards conceal the mechanisms for interaction among complementary products and impose tight restrictions in the use of their interface. Open standards can encourage greater participation of outside vendors and hence enhance the availability of complements; Apple, for example, has chosen to open its standards and allow a large community of vendors to develop applications for its iPhone. Proprietary standards however can provide greater control and raise entry barriers for potential

competitors. Apple for example has chosen closed standards for iTunes, a complement to its iPod. In doing so it has limited the range of complementary services available to its iPod but however has created a dominant position for itself in the mp3 music device space. How such choices influence the availability of complementary products and the consequent intensity of network effects is yet to be systematically investigated and could be a promising area for new research.

In summary, although the importance of complements to network value has been well established, how to use complements as a strategic driver of network effects is less clear. Future research could benefit from probing questions that focus on this oversight. Under what conditions should firms make complements necessary to use a core product or simply available to enhance value? When should firms integrate complements into the core product itself? Finally, when firms own a dominant product, when should they focus on open or closed standards with regard to producers of complements?

*Social networks*. Although a product's design may intrinsically drive interdependence in its use and thereby the intensity of network effects, demand interdependence and network effects also arise when a community of adopters are attracted to a product or service because of social dynamics. For example, Facebook enjoys the benefits of network effects as its value increases with the number of adopters of its site. However, the increase in the number of adopters and its associated value is not necessarily a function of the product design alone. That is, the value of the installed base of Facebook is not merely because of its design features or technology that enables the sharing of communication, pictures, or anecdotes—many Web sites may have an equivalent technology and design features. It is the unique structure of the social network that binds its users, the nature of social relationships formed among the adopters, along with the strength of their ties within their community (Burt, 1992, 2005; Granovetter, 1973) that enables Facebook to differentiate itself from its competitors. In other words, Facebook harnesses the power of social dynamics to create network effects.

Recently, there has been a significant increase in interest in the role played by social networks in organizations (see Borgatti, Mehra, Brass, & Labianca, 2009 for a recent review). Much of this interest is on understanding different types of network structures and the strength of individual ties. Also, the broad focus this research has been on the benefits of occupying specific positions in networks and the contingencies created by differing types of network structures and the strengths of its ties. There is an opportunity however for this research to be extended to explain how social relationships create value for the network as a whole and thus influence network effects. That is, future research could examine how the structural and relational properties of social networks drive the intensity of network effects.

Take, for instance, studies examining how occupying certain structural positions or the strength ties within a network influences the sharing of information and knowledge (e.g., Cross & Borgatti, 2004). Such focus on the sharing of information knowledge, commonplace in social network theory, can be usefully shifted to understand how the value of knowledge and expertise accrued in a network (because of the skills of its members, the structural positions they occupy, and the nature of the members' ties) influences the overall value to its adopters and hence the extent of network effects. In other words, the power of social networks to create knowledge can also be seen as a source of demand interdependence and network effects.

More recent trends in social networks literature are also attempting to focus attention on the quality of the actors occupying certain positions/having ties rather than the positions or the relationships per se (Burt, 2009). And, the additional value brought in with by the quality of

actors is typically tied to outcome variables such as innovation or learning (e.g., Gibbons, 2004). This line of thinking however can also be extended to understand how variations in the quality of actors occupying certain network positions or having certain relationships can enhance the value of the network for other network members so as to create network effects.

A related strand of thinking comes from the concept of *brand communities* in the field of marketing (Algesheimer, Dholakia, & Hermann, 2005; Muniz & O'Guinn, 2001). A brand community forms on the basis of attachment to a product or brand and creates value because of consumers sharing a system of values and recognizing bonds of membership with each other and with the whole. For instance, communities around the brands of Apple and Harley Davidson are well known. In such brands, as the community of users grows, so does the benefit derived by each individual consumer. Thus far, the prevailing research on brand communities has focused mostly on the factors influencing its creation (Amine & Sitz, 2004). However, it could be extended to assess how it drives the intensity of network effects.

In summary, understanding the value created by social relationships and ties from the perspective of network effects would not only usefully extend the social networks and brand community literature streams, but also provide new insights on the drivers of network effects.

### *Assessing Network Intensity*

From a strategy perspective, understanding the drivers of network effects enable firms to find more proactive ways of leveraging network effects in their industries as opposed to accepting them as purely exogenous forces. However, understanding these drivers is only a part of this task. It is also important to understand the impact of network effects, and have the ability to identify and assess *network intensity*, or the relative strength of network effects in a given industry. Understanding both the drivers of network effects and their possible outcomes is critical to derive appropriate strategies that best allow a firm to leverage network effects to their benefit.

We define network intensity as the relative value to the consumer generated by network size, where network size represents both the number of direct users and the number of available complements. This is different from the value stemming from the pure physical attributes of a product that do not change with the number of other users or available complements. Recall that consumers consider both network value (the number of co-users) and network-independent value (intrinsic features) when adopting a new product. Yet the ratio of network value relative to network-independent value certainly varies across products and services. Video game consoles, for example, would retain some residual value to an individual in the absence of a network of other users. Online auctions, conversely, would have almost no such residual value, as a network of participants is essential.[2] Thus, consumers of online auctions derive a greater proportion of the product's total value from the existence of a network, resulting in higher network intensity.

Although networks have some degree of value in various industries, this proportion of total value to a consumer that is dependent on network size can vary as (a) the benefits of a given good are increasingly realized through network interaction or (b) the gross size of the network is of secondary value to smaller, stronger networks of fellow users (Suarez, 2005). Though the notion that the intensity of network effects varies across industries is not an entirely new one (e.g., Lin & Kulatilaka, 2006; Suarez, 2005), our understanding of specific metrics of network intensity is limited, constraining our ability to verify such a premise. Yet the strength of network effects in a given industry likely plays a critical role in conditioning the effectiveness of a particular firm strategy.

In part, the limitations in our understanding of specific metrics of network intensity are because our empirical understanding of network effects comes from retrospective analyses of network competition, where "winners" and "losers" are presumed to be a consequence of exogenous industry or product attributes. And although attributes such as the number of direct users and available complements may condition the value of a network or the degree of network intensity (per our definition), assessing their precise effects is more complex.

As noted previously, the value of networks can be contingent on several factors and thus merely measuring installed base or counting available complements may not be providing an accurate picture of the intensity of network effects. Not surprisingly, as our review of prior research also informs us, the presumed benefits of network effects do not necessarily or directly correlate with the size of the installed base or the number of available complements. Future empirical work requires an approach that recognizes the intricacy of this construct and appreciates the different contingencies that influence the relative value of network effects. We provide such a tack by suggesting different approaches to identify and assess network intensity. We emphasize on assessment, rather than offer specific measures, because we believe that future research can develop specific metrics that account for various contingencies in their research context. We also suggest ways to discern some of these contingencies based on the different types of strategic drivers of network effects elaborated in the first part of our research framework.

More fundamentally, we suggest two broad approaches to assessing network intensity. One approach looks at the *value* created by either or both direct and indirect network effects; the other looks at the *structural attributes* of the market affected by network effects. By classifying these broad approaches we hope to offer future research an opportunity to channel thinking on these issues and use these ideas as a platform to conceptualize pragmatic and accurate metrics of network intensity.

*Value of a network*. One approach to assess the intensity of a network is to determine the actual value of the network to a marginal adopter. The specific sources of such value may differ depending on the primary drivers of network effects in a given context. For example, if the primary driver of network intensity for a product is its fundamental design, its value may be mainly tied to the total size of the installed base. However, if social dynamics drive network intensity, the gross number of adopters may not be an accurate reflection of the network's value. Here, the structure of the network and the strength of ties among adopters become more relevant in order to assess network intensity. Similarly, if complementary products primarily drive network intensity, value may come from the extent of necessity and availability of complementary products, requiring us to use a different lens to assess network intensity. Future research could thus try to derive specific metrics that capture the value of a network by assessing the primary drivers of network intensity that are relevant to their specific research context.

*Market structural attributes*. Another approach to assess network intensity is to examine its consequent effects on market structure. This approach differs from the earlier approach because the focus is on the outcomes—as opposed to the source—of network effects. Outcomes in network industries are heavily influenced by positive feedback and increasing returns to adoption. Thus, when network intensity is high, we expect to see classic "winner-take-all" dynamics, whereby a single firm may lock-in the market. Such outcomes can be easily seen in market structural variables such as concentration ratios or the increase and stability of relative market shares. These effects may also be seen in the persistence of dominant designs, marketing investments for new entrants, or the strength of switching costs. Conversely, at lower levels of network

intensity, market structures may indicate multiple standards, as consumers value both network characteristics and stand-alone product value.

This line of thinking may also be extended by looking at the structure and relationships of networks of complementary product providers, and comparing these attributes across firms and industries (e.g., Venkatraman & Lee, 2004). The limitation of the market structural approach is that it may be difficult to use in the context of entirely novel industries. However, for entrepreneurs hoping to advance or capture a niche in an existing network industry, this analysis may prove fruitful.

In summary, we would like to stress the point that the network intensity of an industry can be viewed as a continuum, which may be driven by different underlying factors. Consequently, network intensity may vary not only across industries but also across firms and products, depending on the strength of network effects and the specific factors driving them. Thus, the acknowledgement of the influence of network effects as a continuum, as well as the identification and assessment of a specific situation along that continuum, are critical for effective strategy. Our approaches above offer a step in that direction.

## *Leveraging Network Intensity for Competitive Success*

The notion of network effects as a continuum suggests several avenues of inquiry for strategy researchers. This is because strategic approaches and their effectiveness can vary depending on both network intensity and underlying factors driving it. We suggest that future research should focus on the impact of strategy on network intensity along three particular categories of strategic issues: (a) the management of installed base, (b) the management of standards, and (c) the management of complementary products.

*The management of installed base*. Extant literature on strategy and network effects focuses on the importance of an early installed base of users. However, empirical results from this research do not yet provide unequivocal findings on specifically when and why installed base is beneficial in network industries. This uncertainty about the role of installed base highlights a critical strategic trade-off for firms in network industries: entering early and releasing potentially inferior products, or deferring product releases to improve quality but potentially missing out on a critical installed base of early users. For example, early entry may be more effective when network intensity is high and driven by product design, as first-mover advantages may help solidify market share. Early entry may be relatively less important when the source of network intensity is social networks, particularly when the value of that network may be contingent on factors other than market share. For example, a social network whose value stems from depth and diversity of expertise, early entry into a market without careful thought given to carefully sifting through the backgrounds of the members may diminish the value of the network.

Prior research has focused on several specific strategic initiatives that create installed base, such as entry timing, pricing, and the management of expectations. Future research should elaborate on the specific effectiveness of these initiatives at varying levels of network intensity. For example, should firms focus on managing expectations about the technical quality of their products, the existence and viability of their installed base, or both? Should firms under price products early, in the hope of gaining adopters, or will such strategies lead consumers to believe that their product is “cheap” or subpar? The answers to such questions hinge critically on the nature and degree of network intensity in a given situation.

In sum, firms in network industries face critical decisions regarding entry and product release strategies. When should firms try to capitalize on early entry and product giveaways, and when should they delay entry to improve the quality of the focal product? How does network intensity condition the optimal balance between early product releases, and delays that allow the firm to improve product quality and add valuable features? Extant literature suggests that consumers place a limited value on product quality after a dominant technology has locked-in. However, as network intensity decreases, does quality-based differentiation become more salient to consumers?

*The management of standards*. Although standards may potentially have a significant influence on the impact of network effects to a firm, the active management of standards has received relatively little research attention within the context of networks effects. Standards come into play whenever two products interact or when a product has to be used in conjunction with another. As mentioned earlier, standards can be open or proprietary depending on the extent of restrictions imposed on the use of the interface of the two complementary products. The conditions under which product designers should adopt open or proprietary standards to maximize the benefits of network intensity, yet concurrently appropriate maximum returns from their product design, is an important strategic issue that has received very little empirical attention.

A key issue here is to understand the conditions under which firms can appropriate returns from their innovations (Meyer & Subramaniam, 2004). There is a tendency for firms to perceive proprietary standards as a safer bet that increases their chances of appropriating returns, as they feel they may be able to enjoy monopoly power. But proprietary standards may inhibit the power of network effects by limiting the potential of the product and the size of its market (Casadeseus-Masanell & Ghemawat, 2006). On the other hand if firms understand how to appropriate returns from their innovations, they may be more confident about adopting open standards, thereby more effectively unleashing the potential power of network effects. Thus, understanding the interactions between appropriability, proprietary and open standards, or examining the contingencies under which firms can effectively appropriate returns from their innovations under proprietary or open standards, is a promising area for future research in network industries. For instance, future research could consider examining the different drivers of network intensity as contingent forces that determines the likelihood of success of open or proprietary standards. If say, network effects are driven by a product's intrinsic design, would proprietary standards be a more optimum choice? Conversely, do network effects based on social dynamics require more a more open approach? Would the strength of social network positions or ties influence the choice of open or proprietary standards?

*The management of complementary products*. Finally, though studies of indirect network effects have increased in recent years, most of these studies deal with the existence and diffusion of complementary products. Relatively little is known about the extent to which indirect effects can be actively and strategically managed to the benefit of the core firm. Recall that indirect network effects occur when increased benefits arise because of increased participation of complementors. Creating an ecosystem of complementors that selectively benefit a particular product can unleash the power of network intensity for competitive advantage.

Furthermore, companies such as Microsoft are involved in multiple network industries, and attract a significant number of complementors to core products such as operating systems and video game consoles. Does this reflect simple size and scope benefits of a successful firm, or are there specific capabilities that allow the firm to attract, retain, and link complements across industries? More broadly, under what conditions should firms attempt to create indirect rather

than direct network effects? What are the capabilities involved in creating an ecosystem of complementors that can create indirect network effects? Would the nature of social positions and ties of a network determine the suitability of the extent and type of complements?

In sum, we believe that these three domains—drivers of network effects, assessing network intensity, and leveraging network intensity—represent logical and potentially valuable next steps in research at the nexus of strategy and network effects. Although each of these streams may offer independent insights, we believe that they are fundamentally interrelated (Figure 1). Proper assessments of network intensity can only be undertaken with a full understanding of the factors influencing network effects in a given setting. Similarly, understanding optimal strategies for a given level of network intensity is in turn dependent on an accurate assessment of the intensity. Thus, the most valuable empirical works in this domain will be those that account for the complex and related nature of network effects, network intensity, and firm strategy in these settings.

## Discussion and Conclusion

As emerging technologies increasingly rely on networks of consumers to achieve maximum value, understanding the fundamental strategic characteristics of network industries is vital for scholars and practitioners of strategic management. This article has reviewed recent theoretical and empirical advances at the nexus of network effects and strategy, and developed a framework that widens our perspective of strategy's role in network industries thereby offering several potential extensions in this domain.

To date, the literature on strategy in network industries has focused largely on the primacy of installed base in these settings. Accordingly, attention has mostly been restricted to those strategic initiatives that are thought to engender the growth and development of an early installed base. In parallel, prior research has also acknowledged the impact of the availability of complements on network effects. However, extant studies have overlooked highlighting how to strategically manipulate the availability of complements. More generally, exogenous factors are presumed to drive the significance of installed bases and complements. This overarching premise has constrained our knowledge of endogenously created effective strategies in network competition. Emerging bodies of research however suggest that strategy could play a critical role maximizing a firm's potential for success in these settings. If such strategic attributes are indeed critical levers of success in network industries, then their specific impact on firm growth in network industries, as well as the moderating contexts of such growth, merits further consideration.

To further broaden our understanding in this area, our framework centers on three primary questions. First, what are the fundamental strategic drivers that influence the strength of network effects in a given industry? Although the existence of network effects and their effects on technology adoption and diffusion have been well documented, the confluence of factors that actually drive consumers' desire for network interaction is less clear. A more robust understanding of the micro- and macrolevel antecedents that impact the formation of network effects is essential for further advancement of strategic perspectives on network competition. In this article, we categorize these antecedents into three areas: product design, complements, and social networks. In doing so, we not build on prior insights but offer fresh perspectives that widen our understanding of how network intensity could be strategically manipulated. For instance, we discuss how the influence of product design on network effects is not necessarily determined exogenously but also can be endogenously maneuvered. We also highlight the

power of social networks in driving network effects. Indeed social networking sites are a setting where network size may be secondary to other characteristics such as the strength of ties developed or the power of brands. And, although technology may provide a foundation to enable the mechanics of social networking, many of its value generating attributes may not be a function of technology alone but other "social" attributes such as the structure and strength of relationships. In highlighting these issues we also offer fresh avenues for future research.

Our second question focuses on the assessment of network intensity. Here we highlight how the value of networks can be contingent on several factors and provide an approach to assess network intensity that recognizes the intricacy of this construct and appreciates the different contingencies that influence the value of network effects. We also suggest considering the different strategic drivers of network highlighted in our earlier research question as a basis to identify the contingencies affecting the value of network effects. Based on this premise we offer two broad approaches to assess the intensity of network effects, by looking at the value created by either or both direct and indirect network effects and by examining the structural attributes of the market affected by network effects. Our approaches recognize network intensity as a continuum and offer a way for future research to observe differences in network intensities across different levels of analyses: product, firm, and industry.

Our last question discusses optimal strategies for leveraging network intensity. We categorize the types of optimal strategies into the management of installed base, the management of standards and the management of complements. In elaborating on these categories we not only build on prior research but also offer fresh perspectives and ideas. For example, in the section of the management of installed base, although we reinforce prior insights on different strategic initiatives we also highlight interdependencies among these initiatives and how their effectiveness can be influenced by broader contingencies. We also bring in several fresh perspectives in the discussion of the management of standards such as the trade-offs between open and proprietary standards. In managing complements we highlight the importance of viewing complements as a strategic variable that needs to be thoughtfully employed to harness the full potential of network effects.

It is important to note that in elaborating on these three questions, we create a nested set of contingencies that widens our perspective of the role of strategy in network effects. The strategic drivers of network effects offer an understanding of the contingencies that could affect the value of networks and hence the assessment of network intensity. Similarly, these strategic drivers along with an appreciation of their impact enable us to understand how best to leverage network effects for competitive advantage.

In conclusion, this work builds on the significant theoretical and empirical advances on strategy in network industries and describes several areas of inquiry that would benefit scholars and practitioners alike. In an increasingly networked world, these potential avenues of research would offer valuable insights into the complex and often unpredictable characteristics of network industries, and the means by which firms can leverage strategic advantages into market dominance.

## Authors' Note

The authors are listed alphabetically, each contributing equally to this study.

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## Notes

1. Though network effects can manifest in products, technology designs, or services, we use "product" here for simplicity.
2. Liebowitz and Margolis (1999) describe this residual value as the "autarky value" of the product.

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