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The Integrated Networks Model: Explaining Resource Allocations in Network Markets

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The last decade has witnessed a shift from a focus on the value created by a single firm and product to an examination of the value created by networks of firms (or product ecosystems) in which assets are comingled with external entities. The authors examine these market-based assets in the context of network markets and propose an Integrated Networks model in which three types of networks—user, complements, and producer—add value or enhance the attractiveness of the associated focal product. The authors empirically test the proposed model by surveying information technology professionals on their resource allocation decisions regarding the Unix and Windows NT operating systems. The findings suggest that the value added by these three networks is significantly and positively associated with resources allocated by business customers to competing products. The results also show that the three networks mediate the relationship between stand-alone product performance and resource allocation.

The breakdown of vertical integration due to forces unleashed by globalization, technology, and the Internet has led to a dramatic shift in strategy toward virtual integration of businesses and formation of horizontal alliances to better serve customer requirements. Marketing and strategy researchers have begun to examine competitive advantages and value created by assets that arise from "the commingling of the firm with entities in its external environment" (Srivastava, Shervani, and Fahey 1998, p. 2). These intangible assets, called "market-based assets," meet the definition of asset but exist outside of the firm. In a similar vein, Brandenburger and Nalebuff (1996) describe market relationships as a "value net." Here, firms (competitors, distributors, complementors, and suppliers) and customers compose a game-theoretic co-opetitive[1] environment of interdependencies within a market. Rindfleisch and Moorman (2001) call such interdependencies between two competitors for the purpose of new product development "new product alliances;" Sivadas and Dwyer (2000) refer to it as "cooperative competency." Others have labeled these market-based assets or networks "value webs" (Cartwright and Oliver 2000). Under these frameworks, a firm, its customer base, the makers of products and services complementary to its own product, and even the offerings of its competitors are critical to assessing the strategic position of that firm.

A central notion of market-based assets is that a customer's decision to adopt a product is often influenced by factors other than just the value inherent in the product itself. Chief among these market-based assets are networks of customers, channel members, and competitive suppliers. The firm's ability to leverage these networks can have a significant influence on the revenue and ultimate success of the firm because in many markets—called "network markets"—a significant portion of the utility of a product is created by the existence or expectations of networks surrounding the product (Besen and Farrell 1994). In this article, we further explicate the concept of market-based assets by combining it with work from diffusion (e.g., Bass 1969; Valente 1995), adoption (e.g., Heide and Weiss 1995), strategic alliances (e.g., Sivadas and Dwyer 2000), value nets and value webs (e.g., Brandenburger and Nalebuff 1996; Cartwright and Oliver 2000), whole product concepts (e.g., Lambkin and Day 1989; McIntyre 1988; Moore 1999), and network externalities (e.g., John, Weiss, and Dutta 1999; Katz and Shapiro 1985). We propose and empirically test a model of a buyer's resource allocation decision on the basis of perceptions of these market-based assets or networks.

A wide variety of markets meets the criteria for being classified as network markets. A network market exists if users derive benefits from the following:

- *The user network*, or the extent to which the product is and is likely to be used pervasively within and outside the organization. Buyers like to be assured that there is, or is likely to be, a significant pool of product users in addition to themselves.

[1]Ray Noorda, former chief executive officer of Novell, is credited with the term "co-opetition." Brandenburger and Nalebuff (1996) have taken it as the title of their book. The term describes environments in business that require firms to compete and cooperate at the same time.

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- *The complements network*, or the number and variety of complementary products and services available. Buyers like to be assured that a variety of complements (e.g., hardware, software, services) are, or are likely to be, available in the future.
- *The producer network*, or the number and degree of competition among product vendors. Buyers do not like to be "single sourced" and prefer procurement situations with multiple qualified vendors.

Information technology (IT) examples abound, and computer hardware/software and the fax machine are the most common. However, examples extend far into other contexts. The consumer entertainment market is replete with network markets such as those created by entertainment players and content (e.g., video home system [VHS], digital video disc [DVD], compact disc [CD]). Consumer video games are another example of a consumer network market in which the user network creates a large portion of the value of owning a box (keeping up with the Jones's children), and the quality of the complements network (games) drives the sale of the focal product. Other examples range from financial services (in which a strong complements network makes the provider more attractive), to automobiles (which rely heavily on the complements network of service and fuel stations), to telephones (for which users only receive value when the user network develops), to diamond engagement rings (for which the value of such rings has grown largely because other users have validated the style; Conner 1995).

Network markets are often described as "tippy," that is, that "the existence of incompatible products may be unstable, with a single winning standard dominating the market" (Besen and Farrell 1994, p. 188; Arthur 1989; Valente 1995). Indeed, it has been argued in the literature that the value created by networks can be so great that inferior technologies (based purely on features, functionality, and technical performance characteristics) are able to push aside or hold off superior technologies. Cases such as the internal combustion engine versus the steam engine, VHS versus Beta, and Windows 95 versus OS/2 or Mac OS 7 are often cited as examples in which inferior technologies won despite arriving on the scene later than a technologically superior incumbent.

The purpose of this article is to enhance the understanding of market dynamics, value creation, and competitive advantage in network markets. Our thesis is that buyers allocate resources for the procurement of business assets (e.g., automobile fleets, IT, video systems) on the basis of a consideration of the stand-alone product performance as well as the user, complements, and producer networks.

We have two key objectives in this research and two primary areas of contribution to the marketing literature. First, we develop the Integrated Networks model, a conceptual framework of network markets, and define the three types of networks that are crucial to understanding how consumers allocate resources in network markets. Of the three networks in our model, previous marketing research focuses on the user network (e.g., Givon, Mahajan, and Muller 1995), the complements network (e.g., Bucklin and Sengupta 1993), or the producer network (e.g., Kotabe, Sahay, and Aulakh 1996). By including networks beyond the user network or installed base, we extend the current conceptualization of innovation diffusion, co-diffusion, adoption, and intraorganizational adoption (cf. Bass 1969; Bucklin and Sengupta 1993; Kim and Srivastava 1998; Mahajan, Muller, and Bass 1990), showing that the complements and producer networks also play an important role. Furthermore, we propose that intraorganizational adoption is driven by the strength of each network, as measured by five characteristics: current size, expectations of future size, compatibility, accessibility, and quality. Previous research on user networks focuses on the size of the network and expectations of the future size of the network (e.g., Economides and Himmelberg 1995). Our model's richer conceptualization of how networks create value extends previous work on networks (Martilla 1971; Valente 1995) and network externalities (Katz and Shapiro 1985) by providing more detail on the types of networks and the characteristics of networks that create utility and drive adoption in network markets.

Our framework focuses not on the initial trial or first-time adoption of a product but on the extent to which a product is adopted by a customer and the ensuing commitment of new resources to buy additional units of the product over time. Many organizations have a policy of trying emerging technologies simply to be aware of options, but it is the extent to which a technology is embraced by an organization, the adoption intensity, and the corresponding commitment of new resources or buying additional units during a finite time period that ultimately lead to the success of the supplier firm. Therefore, our emphasis is on understanding how product performance and networks of users, complements, and producers influence the intraorganizational diffusion of the innovation (Kim and Srivastava 1998).

Our second objective and area of contribution is in our empirical test of the Integrated Networks model. Our empirical study provides an early test of the market-based assets theory recently proposed by Srivastava, Shervani, and Fahey (1998, 1999) by measuring consumers' perceptions of these assets and examining their influence on the buyer's decision to purchase a firm's product. Furthermore, our study provides empirical evidence of the power of networks to influence purchase decisions and increases our confidence in research that draws on the concept of network externalities (e.g., Kotabe, Sahay, and Aulakh 1996; Srivastava, Shervani, and Fahey 1998; Valente 1995) by operationalizing, measuring, and empirically testing the Integrated Networks model as well as the network externalities framework nested within it. A dearth of empirical research in this area has prompted calls for empirical verification of network phenomena (John, Weiss, and Dutta 1999). By demonstrating that elements external to the focal product can drive its purchase, the framework provides additional support for the concept of the "whole product" (Lambkin and Day 1989; Moore 1999) and the possibility of market dominance by an inferior technology (Arthur 1994; David 1985; Liebowitz and Margolis 1995).

Although the concept of networks and network externalities is well integrated into "street knowledge" and has been examined conceptually and analytically, little empirical work exists in this area (David and Greenstein 1990; John, Weiss, and Dutta 1999). Our article differs from the empirical work that exists in four ways.

First, in one study our research incorporates all three networks reported in marketing and economics literature to play a role in driving product selection. Prior empirical research has examined either the user network (e.g., Economides and Himmelberg 1995) or the complements network (e.g., Bayus 1987; Bucklin and Sengupta 1993; Gandal, Kende, and Rob 2000). We measure and test three networks simultaneously: user, complements, and producer. We find that each network plays a significant role in determining resource allocation, even in the presence of the other two networks. Furthermore, we expand the conceptualization of network characteristics that compose the relative strength of the network from two (size and expectations of future size) to five (size, expectations of future size, compatibility, accessibility, and quality).

Second, we increase the validity of the findings in this area. Our research is based on actual perceptions of the purchaser, not on aggregate sales data. We survey purchasers regarding their perceptions of the three networks associated with a focal product and with a competing product as well as their perceptions of both products' technical capabilities and attributes. Previous research using aggregate data (e.g., Bayus 1987; Economides and Himmelberg 1995; Gandal, Kende, and Rob 2000) assumes that network effects are the "black box" between antecedent variables (such as complements or user network size) and consequence variables (such as focal product diffusion or hedonic price) (Brynjolfsson and Kemerer 1996). Although previous research indicates, for example, that CD players' diffusion is positively associated with the number of CD titles available, it does not indicate whether consumers perceive that a greater number of titles are available or whether the perception is tied to their adoption or resource allocation. No such assumption or leap is necessary in our study. We believe that by surveying consumers' perceptions directly, we greatly enhance the internal validity of the previous work that uses aggregate data and the external validity of the analytical work in this area.

Third, we examine network effects in the context of a standards battle: two products competing in a tippy market. Previous empirical works (e.g., Bayus 1987; Economides and Himmelberg 1995) do not consider a competitive situation and the "winner takes all" nature of these markets (Arthur 1989; Hill 1997). We not only examine perceived value of the focal product and its networks but also measure perceptions of the networks of the primary competing product to determine how the relative strength of the networks drives adoption, providing insight into the competitive dynamics of a network market. This provides an empirical extension of previous analytical efforts of network markets (e.g., Arthur 1989).

Fourth, our dependent variable is not a price index that must then be interpreted as a proxy for utility or adoption (e.g., Brynjolfsson and Kemerer 1996; Gandal 1994, 1995). Thus, there is no need to make a leap from hedonic price to purchase. However, we do not examine only initial or first-time adoption. Instead, we measure intraorganizational adoption, or the amount of resources allocated by the purchaser to the focal and competing products on an ongoing basis. Continued purchase by an organization represents a larger portion of overall sales than does initial trial or adoption (Kim and Srivastava 1998). Therefore, it is more likely to be indicative of product success in a tippy market.

Despite the large amount of analytical work in this area, there has been little empirical work, and none that we were able to find, that operationalizes all of the key variables and specifically measures consumers' perceptions of the networks. Our study empirically validates the street knowledge in this area and significantly expands the existing scope of empirical study.

In summary, we make several key contributions to the marketing literature. We offer a more comprehensive model of adoption in network markets, focusing on three networks that have not been examined previously in a single model. We provide a richer characterization of these networks than does preceding work in economics or marketing. We focus not on initial adoption but on intraorganization adoption, or the continued commitment of additional resources to a technology—the source of much technology spending. We contribute empirical evidence on the power of networks by not only testing the Integrated Networks model but also providing empirical support for market-based assets theory and network externality theory.

The rest of this article is divided into four sections. The next section examines the role of stand-alone product performance and user, complements, and producer networks in influencing the extent to which technologies competing for organizational resources (share of purchases, budgets) are embraced by organizations. The second section details methodological issues. In the third section, we discuss our results, and in the fourth section, we examine the contributions and limitations of the findings.

Network Markets and Resource Allocation

Economists and marketers both make extensive use of the term "network." In marketing research, the term has come to have many meanings such as business or social networks (Iacobucci 1996; Valente 1995), but put most simply, marketers consider networks phenomena that describe interconnections among people or organizations.[2]

Economists arrive at a similar meaning, albeit by a different path. Although they originally used the term "network" in "network externalities" to refer to benefits that accrue from connections of physical networks such as telephones or railway lines, the term was extended to include value created by networks of users sharing compatible products or standards.

Figure 1 shows the four key constructs in the Integrated Networks model that drive resource allocation: stand-alone product performance, the user network, the complements network, and the producer network. We describe these subsequently.

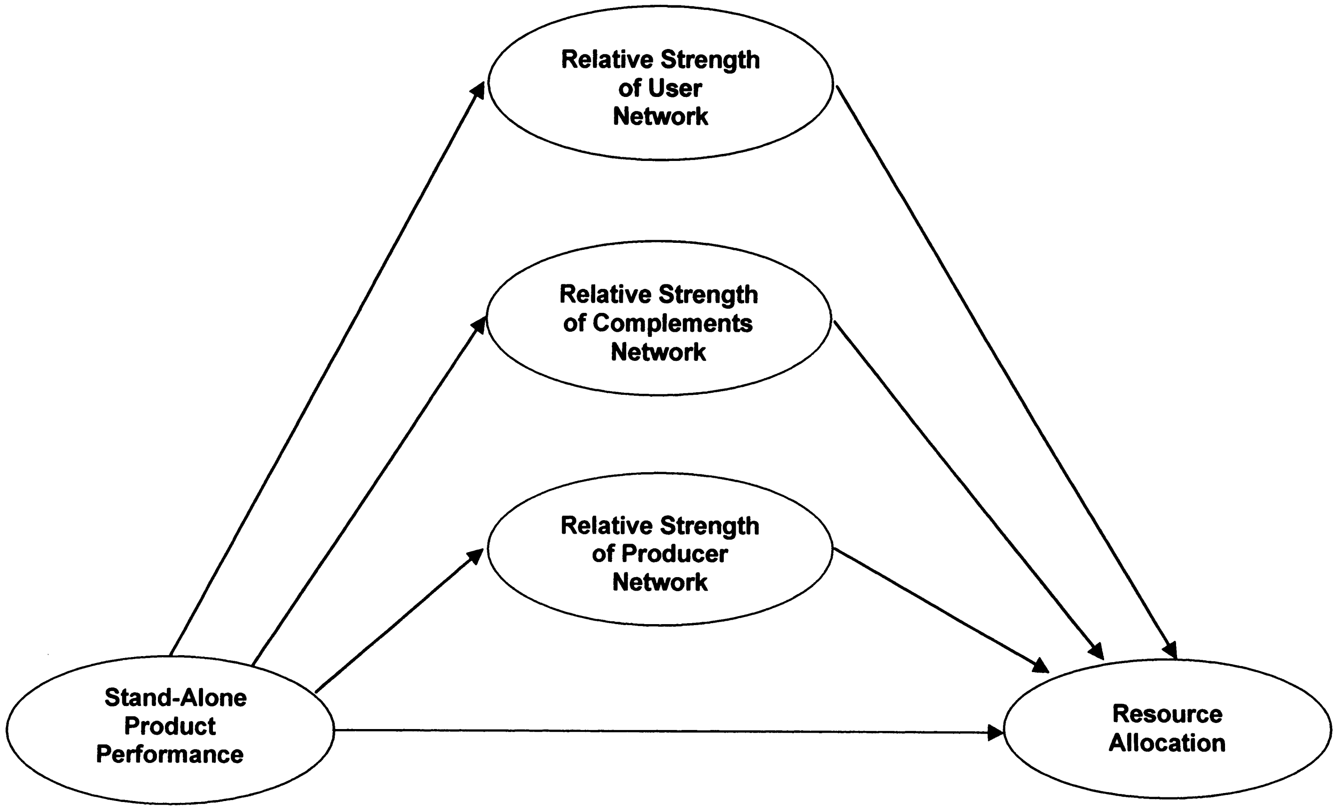
Stand-Alone Product Performance

Fundamental to the notion of selecting one product over another is the utility delivered by the product itself, independent of the value delivered by any network. Product performance[3] is based on the features and attributes of the tech-

[2]We thank an anonymous reviewer for this concise definition.

[3]For the purpose of brevity and readability, the term "product performance" is interchanged for "stand-alone product performance."

FIGURE 1
The Integrated Networks Model



nology as it stands alone, not utility delivered by the product's rate of diffusion, the complements, or other market-based assets that add value to the product. It is this element of utility that is considered when discussion of inferior products arises—the core technological value of the product itself without external factors considered.

The User Network

In network externality theory, the size of the user network is the key driving factor behind adoption decisions (Katz and Shapiro 1985). Both in individual consumer settings and in organizational adoption decisions, a network of previous adopters is believed to encourage adoption among non-adopters by making the product more useful, providing opportunities for word of mouth and observation, or sending a quality signal (Gatignon and Robertson 1985; Hellofs and Jacobson 1999; Martilla 1971; Rogers 1995; Valente 1995).

The influence of the user network is incorporated in most technology diffusion models through the coefficient of imitation or internal influence in marketing's diffusion research (Bass 1969). Early research on networks of innovators describes the ways that technical information and know-how are transferred among social networks of buyers and potential buyers (e.g., Czepiel 1975; Martilla 1971). Czepiel (1975) finds that communication channels link technical decision makers in rival firms for the purpose of information acquisition, validation, and verification. These networks of innovators can include not only those making resource allocation decisions but also the firms producing the product, exchanging information with buyers to enhance the innovation and thus increase adoption of that innovation (Håkansson 1987; Von Hippel 1988).

Research on market-based assets suggests that the utility delivered by an established installed base can lead to faster market acceptance of a product, not only through word-of-mouth effects but also by lending an air of credibility to the organization (Srivastava, Shervani, and Fahey 1998). This accelerates cash flows, thus increasing shareholder value and strengthening the competitive position of the innovating firm. The positive effect of a user network can be so strong and thus important to a product's ultimate success that it may be worthwhile to tolerate some degree of piracy to grow the user base and develop the network externality benefits (Conner and Rumelt 1991; Givon, Mahajan, and Muller 1995).

What is it about the user network that influences adoption? In network externalities theory, economists state that both current size and expectations about future size enhance the strength of a user network (Besen and Farrell 1994; Katz and Shapiro 1985). In turn, a strong user network increases a product's value and, therefore, the resources it attracts and its likelihood of purchase, which creates a positive feedback loop. On the basis of previous research in marketing and strategy, we consider the following additional characteristics that add to the strength of a network: compatibility, accessibility, and quality.

- *Compatibility* in the user network refers to users either inside or outside the firm who are important to the potential buyer or user for reasons such as opinion leadership or compatibility (Gatignon and Robertson 1985; Rogers 1995).

- The degree to which the user network is *accessible* to a potential adopter (verbally, visually, or electronically) can determine the influence the user network can have on that adopter (Gatignon and Robertson 1985; Valente 1995). Accessibility is similar to Rogers's (1995) concept of the observability of the adoption and its influence on other members of the social system.
- Although the quality of the technology itself is captured in the product performance, the *quality* of a network refers to the technological expertise, innovativeness, soundness, reliability, and reputation of users who have adopted the technology. The quality of the members of the user network can influence potential adopters and future resource allocation by exacting a normative influence on the potential adopter through opinion leadership (Gatignon and Robertson 1985; Valente 1995), by signaling identification (Conner 1995; Solomon 1983), or in a business setting, through mimetic isomorphism (DiMaggio and Powell 1983).[4]

Together with current size and expectations of future size, these three characteristics compose a second-order or higher-order factor that we call the *strength of the network.* When these characteristics are measured in comparison with a competing set of networks, we call it the *relative* strength of the network. These characteristics help enhance the utility a user derives from the networks and thus influence the choice of product or technology in network markets.

H_1: The greater the strength of the user network, the greater are the resources allocated to that product.

Complements Network

The complements network is composed of products and services that are needed to make the focal product more productive or complete as part of a whole solution. The whole product (also referred to as a product ecosystem or customer solution) includes not only the focal product but also additional hardware and software, training, support, or other elements needed to create a "compelling reason to buy" (Moore 1999, p. 115). In technological innovations, the whole product is essential to convince users other than technology experts to purchase, or to "cross the chasm" (Moore 1999, p. 7). Marketing researchers have called elements that compose this whole product the industry or product infrastructure (Lambkin and Day 1989; McIntyre 1988).

Just as members of the user network are linked by their purchase of a common standard for a focal product, members of the complements network are linked by their compatibility with the focal product. Complement makers such as game developers for Nintendo are connected in that they compete for a limited number of game licenses allocated each year for a platform that is attractive because it is so widely diffused (Brandenburger and Nalebuff 1996). The greater the number of complementary products (e.g., interactive games), the greater is the usefulness of the focal product (e.g., Nintendo or Sega game console). In addition, distributors of the focal product (providing the complementary service of distribution) are linked by the interdependencies between inventories of focal and complementary products.

Similar to the user network, we propose that the strength of the complements network drives resource allocation and that the strength of the complements network can similarly be characterized by its current size, expectations of future size, compatibility, accessibility, and quality. The complements network is more compatible with the user when it contains elements that are needed to provide backward compatibility with previous systems or interoperability with other users that are critical to the buyer's intended use of the focal product. Complements (such as Universal Product Code [UPC] labels and CDs) must also be accessible before the focal product (UPC scanners and CD players, respectively) can successfully diffuse (Bayus 1987; Bucklin and Sengupta 1993; Sengupta 1998). The quality of the complements network can play a large role in resources allocated to the focal product. Lotus 1-2-3, faster and more powerful than its then-competitors, VisiCalc or Multiplan, became the "killer app" for the original IBM personal computer (PC), significantly influencing IBM's emergence as the desktop computing standard in the business segment (Carlton 1997).

The diffusion and intraorganizational adoption of the focal product may be directly tied to the diffusion rate of complementary products. Researchers point out the importance of thinking beyond the firm's own borders. Bucklin and Sengupta (1993, p. 159) posit that "Product strategies based solely upon the expansion of 'own' demand where complementarities exist may be suboptimal." If developed properly (Rindfleisch and Moorman 2001; Sivadas and Dwyer 2000), relationships with these complement providers can become an attractive market-based asset and instrumental in the success of the focal product (Srivastava, Shervani, and Fahey 1998). Thus, we include the complements network as a key element of our model.

H_2: The greater the strength of the complements network, the greater are the resources allocated to that product.

Producer Network

The producer network is composed of manufacturers that produce products that are functionally equivalent to and compatible with the focal product. Thus, this network includes the original product producer and any other competitive manufacturers that, through licensing or other means, have been able to produce functionally equivalent, compatible products. These products may be imitations, clones, or generics. The co-opetitive role of additional product producers can be critical to the ultimate success of the focal firm's product (Kotabe, Sahay, and Aulakh 1996).

Similar to the complements network, the growth of the producer network can have a positive effect on product adoption, relative to that of competing product ecosystems. As more entrants compete within a single standard, price reductions may result, increasing the size of the potential market. Increased competition may lead to higher levels of distribution and promotional activity, which in turn can accelerate diffusion of the product (Kim, Bridges, and Srivastava 1999). The addition of clones to the IBM-

[4]DiMaggio and Powell (1983, p. 149) describe isomorphism as a "constraining process that forces one unit in a population to resemble other units that face the same set of environmental conditions." Mimetic isomorphism occurs when firms become more similar through imitation, typically under conditions of uncertainty.

compatible PC camp not only drove prices and margins down but also drew customers away from Apple's Macintosh. Cloners may have more experience with, knowledge of, and capabilities for serving different markets (geographic or otherwise), bringing expertise and access to markets that the innovator cannot serve well (Conner 1995; Robertson 1993). Furthermore, the existence of multiple producers provides a second source to the customer, which prevents the innovating firm from price gouging the user at a later time, and therefore reduces the user's risk in committing to a product (Farrell and Gallini 1988).

The network characteristics that make the user and complements network valuable also describe the strength of the producer network. As discussed previously, current size and future size of the network influence utility. The producer network is compatible with the user if the user has an established, ongoing relationship with its members. A producer network that is not compatible with the user can lead to vendor-related switching costs (Heide and Weiss 1995) as well as losses of utility associated with the termination of existing vendor relationships (Morgan and Hunt 1994). Research in channels and distribution emphasizes the accessibility of producers (Magrath and Hardy 1991; Stern and El-Ansary 1992). Different product producers may be invited into the producer network specifically because they are accessible to a particular group of users (Conner 1995). Quality and reputation of the members of the producer network contribute to the firm's performance by influencing the likelihood of focal product adoption (Fombrun 1996; Rao 1994).

Developing the producer network is not without risk to the innovator. Under different appropriability regimes,[5] the innovator may or may not be able to control the development of the producer network. Also, depending on the appropriability regime, the innovator may or may not profit from the producer network's growth. In addition, the types of competitors that enter and are successful at different points in the product evolution will vary (Lambkin and Day 1989). However, it is expected that in most cases, the diffusion of the focal product will increase with a more developed producer network (Lambkin and Day 1989). Consequently, we hypothesize the following:

> H_3: The greater the strength of the producer network, the greater are the resources allocated to that product.

The Relationship Between Networks and Stand-Alone Product Performance

The Integrated Networks model provides insight not only in understanding adoption and intraorganizational penetration in network markets but also into the relationship between the networks and stand-alone product performance in creating value for the user. Networks are unlikely to develop around a product that is deemed unsatisfactory and unlikely to provide some degree of value for the consumer. Therefore, it is reasonable to conclude that stand-alone product performance—value delivered by the technology, independent of the networks—will influence the development of the networks. However, it has also been proposed that after the networks have begun to develop and deliver value, that value can overwhelm the value uniquely created by the product itself. Technological standards battles studied in previous research include the QWERTY keyboard versus the Dvorak keyboard (David 1985; Liebowitz and Margolis 1990, 1999), the VHS and Betamax contest (Arthur 1994; Liebowitz and Margolis 1995), and the competition between internal combustion and steam engines (Arthur 1989). The relationship between product performance and the networks suggests a mediation scenario, with the networks mediating between the stand-alone product performance and resource allocation. Thus, strongly networked products that are based on lesser technological solutions are often adopted over superior but weakly networked products because, we propose, networks mediate the relationship between product performance and resource allocation decisions.

> H_4: The user network mediates the relationship between stand-alone product performance and the resources allocated to the product.
>
> H_5: The complements network mediates the relationship between stand-alone product performance and the resources allocated to the product.
>
> H_6: The producer network mediates the relationship between stand-alone product performance and the resources allocated to the product.

Methodology

We first describe our instrument and data collection procedures. Next, we assess the reliability of the measures and the discriminant and convergent validity of our constructs. We then examine the association of the networks with resource allocation and the ability of networks to mediate the relationship between product performance and resource allocation.

Context

The context for this study is a network market. We chose to examine a purchase decision made by IT professionals regarding a high-technology product. We surveyed IT professionals at major U.S. firms choosing between the Windows NT and Unix operating systems. We chose this context because operating system choice is typically a sufficiently significant purchase that IT professionals are likely to consider multiple attributes of the available choices. Also, IT professionals have detailed knowledge of the competing products and are able to assess the stand-alone technical product characteristics and performance (i.e., the value delivered by the technology, separate from the networks). In addition, research in technology markets has focused on similar key informants at the organization level (Gatignon and Robertson 1989; Heide and Weiss 1995; Weiss and Heide 1993).

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[5]Teece (1986, p. 287) defines the appropriability regime as the "environmental factors, excluding firm and market structure, that govern an innovator's ability to capture the profits generated by an innovation." These include factors such as intellectual property, whether the innovation is incorporated in a product or in a process, and whether the innovation involves tacit versus codified knowledge.

Because we examine a competitive standards battle, we focus on the relative strength of the networks and collect a comparative assessment of the stand-alone product performance. Network markets are tippy markets, and competition in such markets is appropriately analyzed by methodology that recognizes the interdependencies between competing products' diffusion processes (e.g., Arthur 1989).

Instrument

We developed a questionnaire that was targeted at IT professionals and pertained to their resource allocation decisions in situations in which Windows NT and Unix were both technically feasible options. The survey was initially pretested by three IT professionals at a large university. We modified the survey on the basis of their feedback and submitted it to a sample consisting of 25 IT professionals enrolled in an executive education class. We checked initial scale reliability and modified the survey again, on the basis of reliability measures and comments (written and verbal) from this group. The revised survey was then pretested by three IT professionals at a *Fortune*-500 company, and we made changes on the basis of their in-depth feedback. We then administered the survey to the sample described next.

Sample and Data Collection

The sample consisted of 3000 senior computing executives at large firms in the United States. The names were randomly selected from a list of 5000 top computing executives, provided by Phoenix-based Applied Computer Research. These firms belong to the *Fortune* 1000, *Forbes* 500, or *InformationWeek* 500 or they met at least one of the following criteria:

- They owned a mid-size or mainframe computer (an IBM 308x or larger, an Amdahl, or Hitachi);
- They had 50 or more IT employees;
- They had an IT budget of $4 million or more;
- They owned 200 or more PCs; or
- They owned one of the following types of systems: CDC, Tandem, Cray, Unisys A series, or DEC VAX 7000.

These constraints reduced the likelihood of surveying IT professionals who manage only desktop PCs in which Unix is less likely to be a feasible or realistic choice.

The instrument, a letter requesting the user's assistance, and an offer for a summary of the results were included, along with a business-reply return envelope. Approximately four weeks after the initial survey was mailed, a reminder postcard was sent. Of the 265 completed surveys, 237 were usable. A total of 65 other surveys were returned as undeliverable or because the addressee was no longer employed at the firm. This represented a response rate of 9%. Although this represents below average survey response rates of top management (Menon, Bharadwaj, and Howell 1996), this is not inconsistent with studies of similar target samples (Peet 1998; Vedder et al. 1999). Adequately powered t-tests (Cohen 1988) of means of key variables (network characteristics, product performance, and resource allocation) show no significant differences between those who responded before (n = 194) versus those who responded after (n = 43) the reminder postcard.

Measures

One goal of this research is to significantly extend the empirical effort in network market research by providing the first empirical measurement of consumers' perceptions of network externalities as well as of our proposed Integrated Networks model. Our measures are not proxies for network externalities, nor is our model based on aggregate data. We survey consumers on the current size of the user and complements networks and the expectations of the future size of the user and complements networks, as well as the newly introduced characteristics of each of the three networks: compatibility, accessibility, and quality. Although the measures we develop are specific to our context, operating systems, we believe they can provide guidance for future researchers in network markets.

Specific Decision Area

The first question of the survey was highlighted in a section titled "Your Specific Decision: What Decision Are You Making Today?" and asked the respondent to consider a recent or upcoming decision. The respondent was asked to select from a list or to write in the functional area of that decision (e.g., CAD/CAM operations, accounting, engineering, design use). Respondents were told that this was their specific decision area and were asked to answer all questions with respect to that decision context. Included in nearly every item are the words "specific decision area" to help ensure that the respondent reported on the networks affiliated with the operating system and the attributes of the operating system itself in that specific context. We did this to encourage a consistent perspective by the user as he or she responded to the survey and to avoid an aggregation bias across decisions made in a particular year.

Resource Allocation

We asked the user to estimate the percentage of the operating system/application/workstation budget that was to be spent on Windows NT–based services and goods and Unix-based services and goods in 1998. Again, we instructed the user to focus on the specific decision area he or she had indicated at the beginning of the survey. We used the percentage of this budget to be spent on Unix as the dependent variable. Because it is a percentage bound by 0 and 1, we replaced responses of 0 or 1 with near approximations (Cohen and Cohen 1983), and we performed a logit transformation. The transformed variable ranges from –5.29 to 5.29 with a mean of –.85 and a standard deviation of 2.26. Skewness is –.15, and kurtosis is –.01.

Assessment of Stand-Alone Product Performance

Stand-alone product performance measures the user's perception of the Unix and Windows NT operating systems as independent technological products, separate from the networks surrounding these products. We asked the users to assess the importance within their specific decision area of ten technical operating system attributes using a five-point response scale ranging from "not at all important" to "very important." The attributes can be grouped into three general categories: complex computing capabilities of the operating system (e.g., multiprocessor support, scalability, clustering, high performance features), manageability of the operating system (e.g., ease of recovery from crashes, security, ease of manageability, networking), and robustness of the operating system (e.g., robustness/stability, maturity). The list of attributes was developed from an extensive search of technical publications pertaining to operating systems (e.g., *Byte* 1996; *Edge: Work-Group Computing Report* 1996; *Information Week* 1997) and was pretested by IT professionals. After users rated the importance of each attribute, we asked them to rate each operating system's performance on a scale of 1 to 5, ranging from "does not provide this capability at all" to "provides this capability very well."

For eight of the ten attributes, Unix was rated significantly higher than NT (NT was rated higher on "ease of manageability" and "networking"). To avoid multicollinearity problems in subsequent analyses, we collapsed ratings into one item that represented stand-alone product performance. We computed this item by taking the Unix rating, subtracting the NT rating, and multiplying the result by the importance score.[6] Thus, this is a relative scale in which a large positive number indicates a belief that Unix is the superior operating system and a large negative number indicates a belief that NT is the superior operating system. This value has a mean of 19.13, standard error of 3.75, skewness of –1.15, and kurtosis of 2.93.

Perceptions of the Three Networks

We measured each characteristic of each network using a multi-item scale. The items consist of statements such as "This operating system has a sizable market share today in my specific decision area" and are followed by two five-point scales, one for NT and one for Unix, anchored by "strongly disagree" to "strongly agree." We did not include the current size of the producer network and the expectations about the future size of the producer network in the instrument. Pretests showed that questions related to size of the producer network cause confusion among users. Idiosyncratic to this industry, each operating system, regardless of its standard interfaces and alliances, is developed by a single firm; therefore, we did not measure current size and expectations of future size of the producer network in the survey. We subsequently discuss scale refinement procedures (final scales are provided in Appendix A).

Control Variables

Previous research in adoption has found other variables to be associated with resource allocation decisions. Because they are not the central focus of our framework, they are included in our analysis as control variables. The first category of control variables is associated with cost and includes cost of heterogeneity (owning more than one operating system), total cost of ownership of the operating system (Rogers 1995; Weiss 1994), concern for compatibility (Weiss and Heide 1993), and the financial switching costs associated with switching from one operating system to another (Burnham, Frels, and Mahajan 2003; Weiss 1994). The second category is associated with the firm's decision-making process. These include the firm's risk aversion (Puto, Patton, and King 1985; Tellis and Gaeth 1990) and innovativeness, measured as organizational centrality (Gatignon and Robertson 1989; Mansfield 1968). Final scale items are provided in Appendix B.

Scale Refinement and Analysis

To obtain a measure of the relative strength of one network over the competing network, we followed the subsequent procedure. For each item that measured a network characteristic, we subtracted the response given for NT from the response given for Unix, creating a relative scale in which a positive number indicates a belief that the Unix operating system scores higher on that particular item and a negative number indicates a belief that NT scores higher on that particular item. Peter, Churchill, and Brown (1993) warn against potential problems with the use of such difference scores: understated or overstated reliability, spurious correlations, and discriminant validity. In Appendix A, we show the reliabilities of the component measures (measures for each individual operating system) as well as the combined scores (calculated as proscribed by Peter, Churchill, and Brown 1993), all but one of which are at or above the .70 recommendation provided by Nunnally and Bernstein (1996). The exception is accessibility of the user network in which reliability is .66. Thus, we do not face the reliability issues Peter, Churchill, and Brown caution against. Because the individual measures that make up the difference score (the component measures) are not included in further analysis, Peter, Churchill, and Brown's concerns regarding spurious correlations or discriminant validity are also not applicable. Peter, Churchill, and Brown also discuss a variance restriction problem that is not applicable in these measures because the measures do not have a "more is always better" connotation.

The survey contained 71 items that measured the network constructs. We submitted these items to the iterative purification process recommended by Churchill (1979), Gerbing and Anderson (1988), and Bollen (1989), consisting of exploratory factor analysis, reliability analysis, and confirmatory factor analysis. This process led us to retain a total of 42 items, which are provided in Appendix A. Confirmatory factor analyses (Anderson and Gerbing 1988) show that the measurement models fit the data well (normed fit index [NFI] and comparative fit index [CFI] > .90; see details in Appendix C). We checked the characteristics of each network for discriminant validity to assess the uniqueness of each characteristic by setting the correlation of each pair of two measures to 1.0 within the measurement model and checking the degradation of the χ^2 measure (Anderson and Gerbing 1988). We also tested unidimensionality and convergent validity of each construct according to procedures recommended by Anderson and Gerbing (1988). For

[6]We conducted regression analyses that included the operating system ratings without this arithmetic manipulation. We compared these with similar analyses that included the collapsed measure. The two yielded similar adjusted R^2 figures and similar significance for other variables in the equation, but we could not interpret the signs and significance of the operating system attribute ratings because of high multicollinearity among these items.

the control variable measures, we used scale purification processes similar to those used for the network characteristics. Fit indices are provided in Appendix B.

For 8 of the 13 network characteristics measured, NT was rated as having a stronger network than Unix, whereas Unix's networks were rated stronger in only two cases: quality of the producer network and quality of the complements network. There was no significant difference between the products in the size of their user networks, the quality of their user networks, or the compatibility of their complements network.

Finally, we explored the existence of second-order factors of "relative strength of network" following methods outlined by Gerbing and Anderson (1984), Bollen (1989), Marsh (1987), and Rindskopf and Rose (1988). We found that three second-order factors fit the data better than the first-order factors on many measures and only marginally worse than the first-order factors on a few measures. On the basis of recommendations by Marsh (1987) and Rindskopf and Rose (1988), we use the second-order factors on the basis of their fit with the data, their theoretical attractiveness, and their parsimony (see Appendix C). Discriminant validity tests (Anderson and Gerbing 1988) conducted on the second-order factors show that the three second-order strength constructs are distinct from one another. Correlation coefficients among all variables are shown in Table 1.

We tested five structural models using AMOS 4.01 (Arbuckle and Wothke 1999). Model 1 is the full model as is shown conceptually in Figure 1 (for clarity, Figure 1 does not include the first-order factors, indicators, error terms, or control variables).[7] To test for mediation, we followed procedures described by Baron and Kenny (1986). Model 2 regresses resource allocation on stand-alone product performance, excluding the mediators from the model (Path C in Barron and Kenny [1986]). Models 3, 4, and 5 each regress one of the mediating networks on the stand-alone product performance (Path A in Barron and Kenny [1986]). In Models 1 and 2, in which resource allocation is the dependent variable, the six control variables are included in the model with single-item indicators and the error variances set to (1 − variance) × reliability (Jöreskog and Sörbom 1989, p. 153).

[7]Hess's (2000) paper on unidentified recursive models is not a factor in our model, as we have no correlated error terms.

Results

We present the results in Table 2. Model 1, the full model, shows support for H_1, H_2, and H_3. In testing H_1, we show that the relative strength of the user network is positively associated with the resources allocated to Unix ($\beta = .32$; $p < .001$). In support of H_2, we find that the complements network is significantly and positively associated with resource allocation ($\beta = .21$, $p < .01$). In support of H_3, we find that the producer network is significantly and positively associated with resource allocation ($\beta = .34$, $p = .001$). No control variables are significant in Model 1. Thus, we find support for H_1, H_2 and H_3.

Testing H_4–H_6 requires information from Models 1–5. First, we examine Model 2 to determine if the stand-alone product performance is indeed positively associated with resource allocation when the mediators (networks) are not present. Model 2 shows that this is indeed the case ($\beta = .47$; $p < .001$.) Second, we examine Models 3–5 and find that the networks (the mediators) are indeed positively associated with the stand-alone product performance: Product performance → user network, $\beta = .63$, $p < .001$; product performance → complements network, $\beta = .57$, $p < .001$; product performance → producer network, $\beta = .62$, $p < .001$. Finally, we examine the size and significance of the relationship between product performance and resource allocation in Models 1 and 2. Although this relationship is significant when the mediators are absent (Model 2), it is not significant in the model that includes the mediators (Model 1): Product performance → resource allocation, $\beta = -.04$, $p = .74$. Thus, the three requirements for mediation are met, and we find support for H_4–H_6.

The only control variable that is significant in either Model 1 or Model 2 is "cost of heterogeneity," which is significantly and negatively associated with resource allocation ($\beta = -.18$, $p < .05$) in Model 2, indicating that as the perceived cost of owning multiple operating systems increases, the resources to be allocated to Unix decrease. This is reasonable given the encroachment of NT into Unix markets during the 1998 time frame and resource constraints related to IT infrastructure.

TABLE 1
Correlation Coefficients Among Independent, Dependent, and Control Variables

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Relative strength of user network (X1)	1.00										
Relative strength of complements network (X2)	.80*	1.00									
Relative strength of producer network (X3)	.67*	.71*	1.00								
Stand-alone product performance (X4)	.58*	.61*	.55*	1.00							
Concern for compatibility (X5)	–.05	–.03	–.03	–.12	1.00						
Risk aversion (X6)	.06	.07	.05	.08	.00	1.00					
Innovativeness (X7)	–.12	–.12	–.07	–.08	.04	–.12	1.00				
Cost of heterogeneity (X8)	–.35*	–.37*	–.30*	–.37*	.23*	–.12	.12	1.00			
Relative total cost of ownership (X9)	–.08	–.08	–.07	.09	.00	.05	.07	.11	1.00		
Financial switching costs (X10)	.04	.05	.00	.05	–.15*	.12	.01	–.21*	–.08	1.00	
Percentage of resources allocated to Unix (X11)	.65*	.60*	.57*	.49*	–.02	–.02	–.07	–.32*	–.03	.02	1.00

*Significant at least at the level of $p < .05$.

TABLE 2
Relationship of Networks and Stand-Alone Product Performance to Resource Allocation‡

Structural Path	Hypothesis	Model 1	Model 2	Models 3, 4, and 5		
		Full Model	Product Performance → Resource Allocation	Product Performance → Network Mediator		
Relative strength of user network → resource allocation	H_1	.32***				
Relative strength of complements network → resource allocation	H_2	.21**				
Relative strength of producer network → resource allocation	H_3	.34***				
Product performance → resource allocation	H_4, H_5, H_6	–.04	.47***			
Product performance → relative strength of user network	H_4	.64***		.63***		
Product performance → relative strength of complements network	H_5	.58***			.57***	
Product performance → relative strength of producer network	H_6	.62***				.62***
Control Variables						
Concern for compatibility → resource allocation		.04	.08			
Risk aversion → resource allocation		–.05	–.02			
Innovativeness → resource allocation		.05	.03			
Cost of heterogeneity → resource allocation		–.09	–.18*			
Relative total cost of ownership → resource allocation		.09	.03			
Financial switching costs → resource allocation		.02	.01			
Squared multiple correlation of resource allocation		.43	.26			
χ^2		2603.42	85.25			
degrees of freedom (d.f.)		1157	21			
CFI		.89	.98			
NFI		.82	.98			
Root mean square error of approximation		.07	.11			

*$p <= .05$.
**$p <= .01$.
***$p <= .001$.
‡Standardized path coefficients.

Discussion

Findings

In recent years, new theory regarding network markets has been advanced (Srivastava, Shervani, and Fahey 1998, 1999) simultaneously with a call for more empirical research in this area (John, Weiss, and Dutta 1999). Our research extends the theoretical development of market-base assets and networks and provides empirical evidence on the influence of such networks on intraorganizational adoption decisions. In this study, we operationalize and test our conceptual framework, the Integrated Networks model, that explains intraorganizational diffusion and continued resource allocation in network markets. Although many markets are network markets, in this study we test our model in the operating system marketplace. The results show that networks can be characterized by five dimensions—size, expectations of future size, compatibility, accessibility, and quality—that can be represented by a higher-order factor of network strength. We find that each of the three networks—user, complements, and producer—is positively and significantly associated with resource allocation.

Furthermore, we find that the networks mediate the relationship between product performance and resource allocation. Thus, in a network market, the direct effect of standalone product performance on resource allocation may be insignificant. We posit that this is due to mediation by the strength of the networks, and our findings support this. Of the ten stand-alone product performance attributes we measure, Unix outperforms NT on eight, suggesting that respondents believe it to be the superior operating system. If product performance were the driving determinant of product adoption, we would expect Unix to be the favored choice. However, on average in 1998, 61% of the budget of each respondent was spent on NT. In addition, those who rated Unix's product performance superior, but perceived NT's networks stronger, were more than twice as likely to allocate resources to NT, compared with Unix. Why would this be the case? Our model suggests that it is due to the relative strength of the networks associated with NT and the networks' mediation of the effect of product performance on resource allocation. Of the 13 network characteristics we measure, NT outperforms Unix on eight of these measures, and Unix's networks rate stronger than NT's in only two cases. Thus, we present this as empirical evidence that in a market in which networks matter, the relative strength of the networks presents an important influence on purchase decisions and thus presents a mechanism by which a less preferred technology can gain market share.

Theoretical Contributions

This research makes several key contributions to the marketing literature. First, this article contributes a model of adoption in a network market that builds on our understanding of diffusion, adoption, and resource allocation. It extends our knowledge on what networks exist and influence adoption decisions as well as how those networks can be characterized. We contribute to the work in market-based assets and the "whole product" concept (Lambkin and Day 1989; McIntyre 1988; Moore 1999; Srivastava, Shervani, and Fahey 1998, 1999) by explicating the assets that exist in the marketplace and complete a technological product offering. We extend research in diffusion (e.g., Bass 1969; Mahajan, Muller, and Bass 1990) by suggesting that the coefficient of imitation, appropriate for aggregate models, can be augmented with other network characteristics when data from consumers can be gathered, which provides a richer characterization of the installed base (user network) and the way it influences consumer decisions. Furthermore, we show that both the complements and the producer networks can be as relevant as the user network in determining resource allocation. Most important, we show that when considered in one model, all three networks play a significant role in determining how consumers allocate their resources. Each of these three networks can be characterized by its current size, expectations of its future size, its compatibility and accessibility to the potential adopter, and the quality of its members. These characteristics determine the strength of the network.

We examine not first-time adoption or trial but rather intraorganizational adoption or the continued commitment of resources to a product or platform. The degree of intraorganizational adoption is more critical in determining the success of a product, because most sales of technological products are additional purchases by firms that have already tried the product (Kim and Srivastava 1998). Therefore, we examine continued resource allocation of two competing products.

Second, we advance the field's understanding beyond that which was previously analytically modeled to that which is empirically validated, providing future researchers with an expanded model of how purchase decisions are made in network markets (Arthur 1989; John, Weiss, and Dutta 1999). Our study further defines and provides an empirical examination of market-base assets (Srivastava, Shervani, and Fahey 1998, 1999) and demonstrates the influence of these firm-external assets on purchase decisions. In addition, this article contributes an empirical validation of the Integrated Networks model as well as the preceding model of network externalities. Prior to this study, a direct measure of consumers' perceptions of network externalities has not been undertaken, and analytical models have dominated (John, Weiss, and Dutta 1999). The empirical research previously undertaken relies primarily on aggregate data (e.g., Economides and Himmelberg 1995; Gandal, Kende, and Rob 2000); however, we directly measure consumers' perceptions of the characteristics of the three networks and their relationship with resource allocation decisions. This complements prior analytical and aggregate work and also extends that work significantly.

Third, in demonstrating that the networks mediate the relationship between the product performance and resource allocation, we provide evidence that with strong networks, a less-preferred technology may gain increased market share through the value delivered by its networks (Arthur 1989; Liebowitz and Margolis 1995; Valente 1995). Again, this further validates the criticality of managing the market-based assets in a network market.

Managerial Implications

Managers in network markets can draw many lessons from the Integrated Networks model. First, the framework encourages managers to develop not just the user network (as would network externalities or diffusion), but the complements and producer networks as well. All three types of market-based assets aid in creating a whole product, allowing the firm to "cross the chasm" by attracting early majority adopters crucial to product success. The Sega Dreamcast game system, introduced in 1998 and widely regarded as superior to other gaming consoles at the time, failed to reach expected sales levels because game developers (Sega included) were unable to introduce enough games (complements) simultaneously with the console. The market quickly tipped away from Sega Dreamcast, and Sega ultimately exited the market. One reason often cited for the VHS's triumph over the Sony Betamax was Matsushita's willingness to grow the producer network by licensing its design, whereas Sony chose to remain a sole provider. Again, the market tipped toward the product with the stronger network.

Second, the recognition of network strength as the underlying construct composed of multiple first-order constructs expands the strategic levers available to managers in network markets. Instead of solely increasing the size of the networks or influencing expectations regarding the future size of the networks as might be suggested by the original network externalities theory, the Integrated Networks model encourages managers to develop the networks on several dimensions, seeking users, complements, and producers that are compatible with the adopter, accessible to the adopter, and of the appropriate quality to provide utility to the adopter. For example, the diffusion of high-definition television has largely depended on the complements network, not only broadcast programming as is commonly cited but also other forms of digital input such as DVD players (Heller 2001).

Such implications apply to both entrant and incumbent firms. In our study, Windows NT (the workstation operating system entrant) had not surpassed the incumbent (Unix) on stand-alone technological performance. Nevertheless, our findings show that IT professionals intended to allocate a larger portion of their resources to NT rather than Unix, because of the strong networks Microsoft developed around NT. Thus, when an entrant's product is able to perform adequately (we do not mean to suggest that an unusable product can succeed solely through its networks), its managers should quickly address the market-based assets or networks associated with the product.

Likewise, an incumbent must protect its networks from encroachment by entrants. Our study reinforces the notion that having a superior product is not enough. Long-dominant game console makers Sony and Nintendo have worked diligently to strengthen their networks in the face of Microsoft's entrance to their network market with the X-Box. Microsoft's action in the desktop market demonstrates its own belief that its networks are crucial. In 1995, Microsoft was the incumbent in the desktop operating systems market, and it fought fiercely to protect its networks against Netscape's browser, which threatened to break the applications barrier to entry Microsoft constructed. Microsoft ensured a growing user network (consumers) by wielding its power with one of its key complements, computer manufacturers. By encouraging the manufacturers to put Internet Explorer (and only Internet Explorer) on the desktop and by bundling Internet Explorer with Windows, Microsoft significantly degraded consumers' accessibility to desktop-entrant Netscape. Microsoft's willingness to use legally risky tactics shows the criticality it attached to maintaining its strong networks.

Limitations

The results of the study must be considered together with its limitations. We conducted the study using single respondents from a sample of large firms regarding resource allocation in a single product market. For generalizable conclusions, we would need to establish the effects across a broader cross-section of goods and services. To assess the generalizability of the scales, we would need to establish their reliability as well as their convergent and discriminant validity in multiple contexts. Thus, we do not have evidence that our findings are not context specific.

Our empirical setting, operating systems, has strong network effects relative to other markets. Operating systems alone provide critical functions but rely heavily on complements such as application software, hardware, and user skills to be truly useful. Furthermore, one of the main functions of computing today is connectivity, and therefore the importance of users owning compatible systems may be exaggerated in this context when compared with markets that are further removed from the concept of a physical network providing the infrastructure links between network elements. When applying the results of this study to other contexts, the importance of networks in each context should be considered.

It is idiosyncratic that there is only one producer of one of the technologies (Microsoft's Windows NT) and multiple product producers of the other (e.g., IBM's AIX, Sun's Solaris, Hewlett-Packard's HP-UX) in this market. Therefore, we did not measure the current size or the expectations of future size of the producer network. This may also limit the generalizability of the results.

Further Research

Economists have assumed that the growth of the user network precedes that of the complements and producer networks, but strategic maneuvering by firms to attract complements (such as electronic games) prior to focal product availability suggests otherwise. Future studies might investigate the interdependencies among the networks and the influence each network has on the development of the other two.

Contingency variables are likely to delineate various competitive scenarios within network markets. What competitive environments make particular aspects of the Integrated Networks model more critical for success, more amenable to favorable strategic manipulation, or more open to threats by other firms? The extensions the Integrated Networks model makes to network externality research will shed light on the strategic levers that can be used by managers of firms sponsoring a particular technology. The use of the Integrated Networks model in other empirical contexts in which networks are likely to be more and less important will validate the axes along which the model provides meaningful insights.

Finally, research conducted from the perspective of the technology-sponsoring firm would also provide insight into network markets and standards battles. Combined with the Integrated Networks model, investigations of technological bandwagons, standard-setting alliances, and standards committees provide a starting point for such research. The shareholder value created by such market-based assets could then be more accurately assessed. Likewise, research on complementary product strategies (Bucklin and Sengupta 1993; Sengupta 1998; Teece 1986) and licensing activities (Conner 1995; Farrell and Gallini 1988; Kotabe, Sahay, and Aulakh 1996) would provide insight into how a firm might proceed in attempting to develop networks, increase adoption and resource allocation, and make its product the de facto standard.

As researchers continue to examine network business markets, and as the question of dominant inferior technologies continues to be raised, the Integrated Networks model should aid in future empirical work and in future theory building. Our work complements research on market-based assets (Srivastava, Shervani, and Fahey 1998), the value net (Brandenburger and Nalebuff 1996), and the value web (Cartwright and Oliver 2000), emphasizing a whole product or product ecosystem perspective to providing the customer with a complete solution (Lambkin and Day 1989; Moore 1999). Network markets represent a significant portion of the world's economy, and understanding such markets becomes more critical to managing that segment of the economy. As firms continue to address adoption issues in network markets, this expanded view of the forces behind these markets should aid in the decision-making process.

Appendix A
Network Final Scale Items, Confirmatory Factor Analysis (CFA) Loadings, and Cronbach's Alpha Coefficient*

User Network

Current Size: Difference Score α = .80, Unix α = .80, NT α = .77

.79** Today, this operating system has the largest installed base of users in my specific decision area.

.82 This operating system has a sizable market share today in my specific decision area.

.73 The larger market share worldwide in my specific decision area is currently held by this operating system.

Expectations of Future Size: Difference Score α = .93, Unix α = .93, NT α = .93

.87 In the future, I expect this operating system to have the most users in my specific decision area.

.84 In the future, this operating system will probably have a larger market share than any of its competitors in my specific decision area.

.89 Over the next few years, I think more and more IT professionals in my specific decision area will choose this operating system for their use.

.84 In the future, this operating system is likely to attract many more users in my specific decision area.

.82 Over the next few years, I expect the installed base for this operating system to grow rapidly in my specific decision area.

Compatibility: Difference Score α = .89, Unix α = .91, NT α = .89

.90 People in our firm currently use this operating system.

.92 People in our firm, within my specific decision area, currently use this operating system.

.85 Outside of my specific decision area, there are many people in our firm with whom I need to be compatible, who use this operating system.

Accessibility: Difference Score α = .66, Unix α = .87, NT α = .87

.81 Currently, it is easy to find members of this operating system's installed base to help me make decisions regarding this operating system.

.85 It is easy to contact members of the installed base who have adopted this operating system.

.87 If I need information about this operating system, I can readily find a member of the installed base to provide that information.

Quality: Difference Score α = .88, Unix α = .92, NT α = .89

.89 Today, IT professionals in my specific decision area who are "in the know" about technology use this operating system.

.78 IT professionals who currently know a lot about operating systems have chosen this operating system.

.85 IT professionals in my specific decision area whose opinions I respect use this operating system.

.81 IT professionals in firms that lead our industry today have adopted this operating system.

Complements Network

Current Size: Difference Score α = .85, Unix α = .89, NT α = .87

.88 Today, there is a great deal of hardware, software, skills, and support in my decision area available for this operating system.

.79 At this time, this operating system has the largest amount of hardware, software, skills, and support available for my specific decision.

.83 Today, most hardware, software, skills, and support for my specific decision area are compatible with this operating system.

Expectations of Future Size: Difference Score α = .86, Unix α = .90, NT α = .90

.85 Over the next few years, more and more hardware, software, skills, and support for my

Appendix A
Continued

specific decision area will be compatible with this operating system.

.89 In the future, I believe that this operating system will have more hardware, software, skills and support than its competitors.

.86 Over the next few years, I expect the amount of hardware, software, skills, and support to grow very rapidly for this operating system.

Compatibility: Difference Score α = .71, Unix α = .83, NT α = .78

.73 The hardware, software, skills, and support needed for backward compatibility in my specific decision are compatible with this operating system today.

.83 Most hardware, software, skills, and support that I need for my specific decision today are available for this operating system.

.71 Hardware, software, skills, and support that my area currently needs in order to interact with other units in my firm are available for this operating system.

Accessibility: Difference Score α = .77, Unix α = .86, NT α = .85

.78 The hardware, software, skills, and support for this operating system are well distributed or widely available.

.71 I have seen many ads for hardware, software, skills, and support for this operating system related to my specific decision.

.85 Today, it is easy to get help with hardware, software, skills, and support for this operating system.

Quality: Difference Score α = .78, Unix α = .86, NT α = .82

.79 The hardware, software, skills, and support for this operating system in my specific decision area are generally of very high quality.

.84 The hardware, software, skills, and support available for this operating system are highly reliable.

.76 The hardware, software, skills, and support available for this operating system are the most technologically advanced for my specific decision area.

Producer Network

Compatibility: Difference Score α = .77, Unix α = .90, NT α = .77

.80 I already have a good working relationship with the firm(s) that develop this operating system.

.76 I have service contracts with the firm(s) that develop this operating system.

.78 I already have procedures established for purchasing from the firm(s) that develop this operating system.

Accessibility: Difference Score α = .71, Unix α = .84, NT α = .86

.86 I am currently familiar with the firm(s) that develop this operating system.

.54 I have seen many ads by the firm(s) that develop this operating system.

.58 Today, this operating system is widely distributed and is easy to obtain.

Quality: Difference Score α = .84, Unix α = .91, NT α = .86

.88 Firms whose quality I respect develop this operating system.

.77 The firm(s) that develop this operating system has/have a reputation for knowing a great deal about operating systems.

.85 Firms that I trust develop this operating system.

*"Difference Score" signifies the coefficient alpha of the difference scores (computed as recommended by Peter, Churchill, and Brown 1993), "Unix" signifies the coefficient alpha of the Unix measures, "NT" signifies the coefficient alpha of the NT measures.
**This column contains CFA loadings, all significant at the $p < .05$ level.

Appendix B
Control Variable Final Scale Items, CFA Loadings, and Cronbach's Alpha Coefficient

Decision-Making Variables: χ^2_{13} = 19.53; NFI = .99; CFI = .99

Risk Aversion: α = .70

.37* My firm is the type of firm that often tries new IT products at least once.

.65 When my firm buys IT prod-ucts, it buys only well-established brands. (R)

.76 My firm is cautious in trying new/different IT products. (R)

.68 My firm does not like to buy something unknown where there is the risk of making a mistake. (R)

Innovativeness: α = .82

.69 When existing rules and procedures are not adequate to make an IT decision, instructions are requested from senior IT management.

.81 When problems arise in the technology selection process, the decision maker goes to senior IT management for an answer.

.84 When an unusual situation is encountered in the IT decision-making process, senior IT management is consulted before moving forward.

Cost Variables: χ^2_{24} = 86.39; NFI = .92; CFI = .94

Concern for Compatibility: α = .68

.56 When my firm considers which operating system to purchase, compatibility with our existing systems is not an issue.

.55 Technically speaking, we are concerned about how compatible this operating system will be with the other computer-based systems in our firm.

.87 System compatibility is not an issue as we consider adopting an operating system.

Appendix B
Continued

	Cost of Heterogeneity: α = .89
.77	It is much less expensive for us to use only one operating system, either Windows NT or Unix, than to use both.
.93	Our installation costs are much lower if we standardize on a single operating system.
.88	Our training costs are much lower if we have only one operating system in our decision environment.
	Financial Switching Costs: α = .66
.55	Switching to a new operating system would require us to spend a great deal of money on new hardware.
.69	Switching to a new operating system would require us to spend a great deal of money on new application software.
.65	Switching to a new operating system would be very expensive in terms of restructuring our system maintenance and our help desk facilities.

Relative Total Cost of Ownership—Formative Scale
End points of "not at all expensive" and "very expensive"

- The street price of the operating system itself and the hardware on which it runs, per seat.
- The cost of installing the operating system and its associated hardware in your decision environment.
- The cost of maintaining the operating system and its associated hardware (e.g., system administration, system back-ups, operating system upgrades, new application installation, and upgrades).
- The cost of providing a "help desk" to the users in your decision environment.
- The cost of training users in your decision environment.

*This column contains CFA loadings, all significant at the $p < .05$ level.
Notes: (R) = reverse scored.

Appendix C
First- and Second-Order Factor Fit Indices and Comparison of χ^2

	User Network		Complements Network		Producer Network	
	1st	2nd	1st	2nd	1st	2nd
CFI	.96	.95	.95	.95	.97	.97
NFI	.92	.92	.92	.93	.95	.95
Incremental fit index	.96	.95	.95	.95	.97	.97
Goodness-of-fit index (GFI)	.89	.88	.90	.89	.96	.96
Adjusted GFI	.85	.85	.86	.84	.92	.92
Parsimony GFI	.65	.67	.60	.63	.51	.51
Parsimony NFI	.76	.78	.70	.73	.63	.63
Root mean square residual	.12	.15	.09	.08	.08	.08
d.f.	125	130	80	85	24	24
χ^2	266.78	293.08	191.79	230.32	51.81	51.81
Change in χ^2		26.30*		38.53*		0
Change in d.f.		5		5		0

*$p < .05$.

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