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Abstract

With the advent of modern telecommunications capabilities, networks are rapidly becoming a competitive necessity in a wide variety of industries. The literature on networks suggests that networks have characteristics (e.g., network externalities) not shared by many other products or services, and thus traditional explanations of product growth or diffusion may not apply. Because there have been few empirical studies on networks, little is known about how networks grow and compete in the marketplace and the impact of network externalities. Using commercial online information networks as a context, this research examines the determinants of network growth. We find that make effect, usability, and compatibility with the dominant technological architecture are important variables influencing network growth. The results are also weakly supportive of the network externalities hypothesis, i.e., the online services industry exhibits some extent of network externalities.

1. INTRODUCTION

With the advent of modern telecommunications capabilities, networks are becoming a competitive necessity in almost all industries. Several studies have reported on successful business applications of networks, including shared electronic banking networks (Clemons 1990; Kauffman and Wang 1994), computerized airline reservation systems (Copeland and McKenney 1988), health care networks (Moynihan 1994), TradeNet (Boon 1994), and wholesale distribution systems (Clemons and Row 1988). In fact, firms not able to adopt business networks in time may be locked out of a wide range of services and the market.

Networks are subject to *network externalities*, i.e., the value of a network to a subscriber increases with the number of its adopters (e.g., Arthur 1988; Oren and Smith 1981; Rohlfs 1974). Thus, a network becomes more attractive to non-subscribers as it grows. Network goods can be both physical and virtual. Physical networks are those in which users and participants are directly connected, such as telephone and fax networks. Virtual networks are products or services in which consumers are related via common usage: they have the characteristics of networks and generate network externalities.[1]

Externalities generated by networks may be both *direct* and *indirect* (Katz and Shapiro 1985). Direct externalities are those which are derived from an increasing installed base. Such benefits result when a new user creates value by adding goods to a network. Indirect externalities are derived from features extrinsic to the product.[2] Prior economic research on networks suggests that network externalities have strategic implications for technology valuation and adoption and traditional explanations of product growth or diffusion may not apply (e.g., Farrell and Saloner 1985, 1986b; Katz and Shapiro 1985, 1986a, 1986b). In recent years, researchers in information systems and marketing have also recognized the importance of externalities in modeling the adoption and diffusion of network goods (e.g., Chismar and Meier 1992; Clemons and Kleindorfer 1992; Conner 1995; Nault and Dexter 1994; Riggins, Kriebel and Mukhopaddhyay 1994; Wang and Seidmann 1995; Xei and

[1]For example, the larger the installed base of a computer software or architecture, the greater the value for its users.

[2]For example, a larger user base may fuel demand, increasing the variety and availability of complementary goods (i.e., software, add-ons, manual service outlets).

Sirbu 1995). However, the literature is largely theoretical, with only little empirical validation of the theoretical models (Brynjolfsson and Kemerer, forthcoming).

In the marketing literature, explaining and predicting market share (or product growth) has been of interest to researchers for years. Changes in market share are often attributed to changes in marketing mix variables: advertising has been used to establish brand loyalty and thereby increase market share, and pricing policies have been shown to create an impact on market shares. In addition to marketing mix variables, several attributes have been used to explain product growth and market share, such as customer service and satisfaction (e.g., Anderson, Fornell and Lehmann 1994; Bharadwaj and Menon 1993; Innis and LaLonde 1994), cost advantages (e.g., Caves and Ghemawat 1992), product features (e.g., Nowlis and Simonson 1996), quality improvements (e.g., Lemmink and Kasper 1994), and order of entry in the market (e.g., Berndt et al. 1995; Kalyanaram and Wittink 1994; Szymanski, Troy and Bharadwaaj 1995).

Despite many analytical models of network adoption and empirical studies explaining product diffusion and growth, to date very few empirical studies have been done on the determinants of network adoption and growth.[3] Thus, little is known about how networks grow and compete in the marketplace and the impact of network externalities. How do competing networks evolve and what characteristics are associated with growth? Are positive network externalities evident and if so, what are the extent of these externalities? Using commercial online information networks as a context, this research examines the determinants of network growth and tests the network externalities hypothesis.

We next review the literature on networks and standards and several studies related to product growth. The context of this research and hypotheses are then presented. We then discuss the empirical results, and conclude with the implications and limitations of this study.

2. BACKGROUND LITERATURE

When considering network adoption and growth, it is critical to note that networks are different from conventional products and services (Katz and Shapiro 1986b). In the presence of externalities, the value of a network product or service for a consumer increases as the network expands (e.g., Arthur 1988; Oren and Smith 1981; Rohlfs 1974). Network externalities yield a variety of strategic implications which may set apart factors associated with network growth from traditional models of adoption and diffusion.

Since a consumer's utility of a network is directly associated with network size, the consumer is concerned both with the current size of the network as well as its future prospects for growth and market dominance. These two factors are considered in addition to any other characteristics which may be of interest (Katz and Shapiro 1985). The effect of network externalities associated with the selection of a market leader may be strongest in industries where various incompatible standards compete (Farrell and Saloner 1986b) because consumers often are afraid of being stranded; that is, participation in an under-supported standard.[4] Thus, industries subject to network externalities have a tendency toward the establishment of a de facto standard or greater concentration (Farrell and Saloner 1985).

Given that network size is critical in wooing consumers and establishing a defensible market position, large network size is obviously desirable. The establishment of a large network may create an inertia which discourages innovation and movement toward an improved standard (Farrell and Saloner 1986b). Thus, networks with a dominant market position may be able to use this inertia as a barrier against competitor entry, assisting in their ability to maintain competitive advantage and market dominance, or to extract monopolistic rents (Farrell and Saloner 1986a). On the other hand, new and smaller networks have

[3]Two exceptions include Gandal (1994) and Brynjolfsson and Kemerer (forthcoming), who estimated hedonic regression models and found evidence of network externalities in the computer spreadsheet market.

[4]For example, Fichman and Kemerer (1993) cited fear of stranding as significant in the development and maintenance of standards among software development technologies.

a built-in incentive to expand their share as quickly as possible in order to establish a standard and accrue the advantages of positive feedback effect on growth.

This line of work has generated a number of theoretical models, which conclude that network externalities are a determinant of network adoption and growth. Among the few empirical investigations of network externalities, two studies found support for the network externalities hypothesis. Gandal (1994) examined the computer spreadsheet market by estimating a hedonic regression model and found that the dominant firm and those compatible with its standard were able to extract a price premium. Using the same modeling approach but a different data set, Brynjolfsson and Kemerer found results that are broadly consistent with Gandal's. In addition, they found a positive relationship between a spreadsheet's market share and its price.

In the marketing literature, product growth or market share is often attributed to marketing mix variables. Advertising has been used to establish brand loyalty and thereby increase market share. For example, Parker (1995) examined the effect of advertising and found that, due to advertisement, consumers may be satisfied with low-quality products at high prices. Pricing policies may also explain market share. Berndt et al., for example, examined empirically the effects of pricing policies on market shares in the U.S. antiulcer drug market. Quality and service are also frequently cited as impacting market share (e.g., Lemmink and Kasper 1994; Innis and LaLonde 1994).

Network theory suggests the importance of establishing a dominant market position early. While the positive feedback effects of network growth are not evident in traditional products or services, the effects of the timing of entry on market shares have been found significant in several studies. For example, Kalyanaram and Wittink used data on nondurable consumer products and found market share advantages were obtained by early entrants, both in terms of order of entry and time between successive entrants. These results are also supported by Szymanski, Troy and Bharadwaj, who found similar results by performing a meta-analysis research on order entry and market share.

Contrasting with the network theory notion of a positive relationship between share and price, Caves and Ghemawat showed that low-cost advantages were associated with market share. Their work also noted that differentiation-related advantages were more likely to be associated with price premiums. Nowlis and Simonson, who reinforced the later conclusion, suggested product features reduce buyers' price sensitivity by examining the impact of product features on sales and market share.

Despite the importance of network products in the modern economy and a number of theoretical models of network externalities, there has been very little empirical investigation into the determinants of network adoption and growth. While the marketing literature has long examined variables associated with product growth and market share, almost none has been examined within the context of networks.

3. RESEARCH CONTEXT AND HYPOTHESES

To examine the determinants of network growth, we use commercial online information services, a growing and highly competitive market, as a context. A brief introduction to the industry and major players follows. Variables associated with network growth and research hypotheses are then presented.

3.1 The Online Services Industry

Throughout the first half of the 1990s, the market for online services has been characterized by stellar growth.[5] Total subscribers have ballooned from roughly 1.5 million in January, 1990, to nearly 7 million by April, 1995 (IISR 1995). By the end of 1995, the total market was valued at $2.2 billion. Jupiter Communications has estimated that some one third of U.S. households will be on-line by the turn of the century (CNN Business Briefs 1996).

[5]Commercial online information networks are often referred to as online computer networks, online information networks, online information services, or simply online services. We use the term online services hereafter.

Like many industries subject to externalities, the market for online services is dominated by a small group of large players. During the period of study, the six largest firms accounted for nearly 85% of the industry. Table 1 lists the six major players, their ownership, and the date they became operational. As Figure 1 indicates, these firms have experienced radically different growth patterns.

Each of these firms is characterized by their ability to integrate a wide variety of services into a single service interface. These services have evolved over time and have included electronic mail, message bulletin boards, live discussion groups or electronic "chat" rooms, games, celebrity question and answer sessions, software databases, online versions of popular magazines, unique editorial content, online shopping, Internet access, and reams of data (Tetzeli 1994; Consumer Reports 1996).

Table 1. The Big Six Online Services

Firm	Parent	Start Date
CompuServe	H&R Block (1980)	1979
Delphi	NewsCorp. (1993)	1982
GEnie	General Electric (sold 1996)	1995
Prodigy	IBM/Sears	1988
America Online	AOL, Inc.	1989
eWorld	Apple Computer (closed 1996)	1994

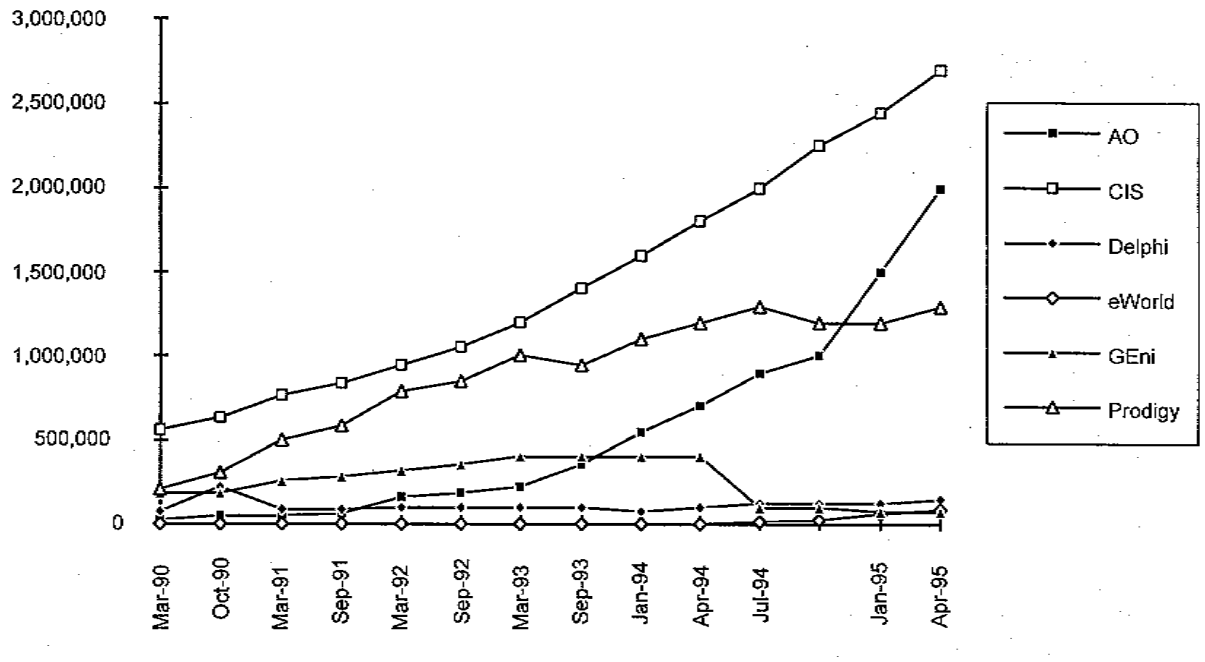

Figure 1. Network Growth in Online Services

Externalities in the online services industry may be derived from a variety of sources, both direct and indirect. These externalities fuel growth in the breadth of users one can contact via e-mail, chat, and other member exchange forums. In terms of indirect externalities, it seems clear that the larger networks support more discussion forums and a broader base of third-party

services such as editorial content, vendor forums, and shopping outlets (Consumer Reports 1996; Duncan 1994). This suggests that as networks grow, content providers and vendors would likely be attracted to larger networks, as these systems provide a broader customer base and hence a greater opportunity for revenue sharing and cross-promotion in other media outlets.

A myriad of pricing schemes has been offered by firms in the industry and these have also evolved with the development of the market. These schemes include charging an initial rate for connection software or subscriber registration, charging an hourly connect rate, charging a flat rate with additional per-hour charges for premium services, and charging a monthly fee which includes a certain number of pre-paid hours with an additional hourly surcharge if these hours are exceeded (IISR 1995).

3.2 Explanatory Variables and Hypotheses

In an attempt to identify the determinants of network growth, we use market share as the dependent variable.[6] We= examine the impact of several variables on market share that have been used in the literature and develop hypotheses that can be tested in our context.

It is a common wisdom that cost-related advantages lead to increases in market share (e.g., Caves and Ghemawat 1992). Thus, the lower the price of a network product, the more attractive it is to potential subscribers. The theory of network externalities, on the other hand, suggests that firms which have a larger installed base can extract greater prices (Farrell and Saloner 1985; Katz and Shapiro 1986b). If network externalities are present and significant, one would expect larger networks to charge a higher network access price. Because the market for online information services is very competitive, we assume here that network subscription cost is a more significant variable explaining market shares and expect it to be negatively associated with network market share.

HYPOTHESIS 1. *Network size in terms of market share is negatively associated with network access price.*

In many industries, leading providers are generally perceived by consumers to be more viable and thus more valuable than others. This *make effect* has been found significant by many empirical studies in other non-network contexts. In the context of network goods, Katz and Shapiro (1985) also suggested that firms' reputations may play a major role in determining network evolution. Thus, make effect should be an important variable influencing network valuation and adoption. Gandal established make effect as significant in terms of value placed on spreadsheet software. Brynjolfsson and Kemerer also found that make effect contributes to the perceived value of Lotus spreadsheet. They argued that because of an early and dominant market position, the long term viability of Lotus was unlikely to be a problem, and consumers making purchase decisions could assume that they would get continued support and further enhancements.

Order of entry, arguably a proxy for make effect, has been found in the marketing literature to influence market share. For example, Kalyanaram and Wittink used data on nondurable consumer products and found market share advantages were obtained by early entrants. These results are also supported by Szymanski, Troy and Bharadwaj, who found similar results by performing a meta-analysis research on order entry and market share. Length of operation may also reduce uncertainty about a vendor's long-term viability, important in allaying fears of stranding (Fichman and Kemerer 1993). We use it as a proxy for make effect and expect it to be positively associated with the market share of a network.

HYPOTHESIS 2. *Network size in terms of market share is positively associated with make effect.*

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[6]This is in contrast to the hedonic regression model in which price is the dependent variable – one would expect to find a positive relationship between a network's market share and its price if network externalities are significant. We are not able to apply the hedonic price model directly because there is no unifying price variable. As described earlier, online services implement a myrad of pricing structures, involving one-part, two-part, or three-part tariffs. By developing a usage-based price variable, however, we attempted the hedonic regression modeling approach.

Since systems which are easier to use are more attractive to consumers, usability has been found to be an important variable influencing the acceptance of a product or technological innovation and thus positively impacts market share. Davis (1989), for example, cited perceived ease of use as a critical factor in the technology acceptance model. Ease of use has also been frequently referenced as a critical variable in determining adoption (e.g., Davis, Bagozzi and Warshaw 1989; Moore and Benbasat, 1991; Tornatzky and Fleischer, 1990; Rogers, 1983). In our context, the usability of a network is directly related to its interface, which is cited as an important decision variable for online service subscribers (Pearlstein 1994). We expect that the better the interface, the larger the market share.

HYPOTHESIS 3. *Network size in terms of market share is positively associated with the usability the network interface.*

In addition to pricing and make effect, the offering of additional, sought-after services or features may lead to competitive advantages which may be absorbed into bigger margins and larger market shares (e.g., Caves and Ghemawat 1992; Nowlis and Simonson 1996). In choosing an online service, consumers often have to consider its general feel and Internet access, in addition to its offerings, interface, and costs (Pearlstein 1994). In our empirical test, we examine the following three features: DOS/Windows graphical client for the service, provision of access to non-Web Internet services such as Usenet, gopher and FTP, and provision of access to the World Wide Web.[7] These features are deemed significant given the dominance of the Windows platform and the overall growth in consumer interest in the Internet and World Wide Web (e.g., Yankelovich 1995). We expect them to have a positive relationship with market share.

HYPOTHESIS 4. *Network size in terms of market share is positively associated with the offering of DOS/Windows-compatible graphical access software.*

HYPOTHESIS 5. *Network size in terms of market share is positively associated with a network's provision of access to Internet.*

HYPOTHESIS 6. *Network size in terms of market share is positively associated with a network's provision of access to the World Wide Web.*

In addition to our explanatory variables, the provision of online services (network contents) and other network features may also be valued by consumers and contributes to network growth. In addition, advertising, promotions, service and quality may influence consumers' choice of online information services and thus network market share. Due to lack of data, however, we are not able to include these variables in the empirical study.

4. RESULTS AND DISCUSSION

4.1 Data and Variable Definitions

Data and Sources. To examine the determinants of network growth, we put together a time series data set that includes proprietary data and publicly available secondary data. Data on network installed base, pricing, and start date were obtained from proprietary studies conducted by an industry market research firm. Data quality was ensured by visually checking the growth patterns and comparing it to other sources of data, such as numbers published in the popular trade press and magazines. Data on interface rankings and DOS/Windows compatibility were obtained through a content analysis of reviews of the services in leading computer magazines, including *Byte*, *PC World*, *MacWorld*, and *Consumer Reports*.

[7]Despite the two indicator variables to track the impact of the Internet on network externalities, Internet e-mail availability itself may be an important explanatory variable in that it allows the users of a network to communicate with users of other networks and thus further enhances the network's externality benefit. Although we suspect that the Big Six had offered Internet connectivity for e-mail by the study time frame, this data is not available.

A total of 76 observations were recorded over fourteen periods. Observations were reported semi-annually from March, 1990, to September, 1993, and quarterly from January, 1994, through April, 1995. Only the six largest networks (CompuServe, Delphi, GEnie, Prodigy, America Online, and eWorld) were considered. Other networks were initially considered, however data availability for these firms was sporadic, they lacked the national presence, general content, and were less viable over time than the Big Six. Further, these six largest firms constituted approximately 85% of the total market.

Variable Definitions. The dependent variable SHARE represents a firm's market share. The variable is calculated as the firm's installed base of subscribers divided by the overall industry installed base. A summary of variable definitions is presented in Table 2, and Table 3 provides descriptive statistics. In general, network access costs have decreased over time, to the point that all providers studied now have eliminated their startup costs and have virtually identical pricing structures.

Table 2. Variable Definitions

SHARE	Market share calculated as the firm's installed base divided by the overall industry installed base
STARTUP	Startup cost, the fee charged to users for registration and/or purchasing access software.
PER_MONTH	Minimum monthly fee charged to users to maintain their current account, usually including a number of free hours of access to the network.
PER_HOUR	Hourly rate charged for premium services or time in excess of any fee hours offered.
MAKE	The number of months a firm has been in service, i.e., the duration between observation date and the service start date.
INTERFACE	The usability rank, with a value of 1 if rated as the best and a larger number if rated as a less usable interface.
WINDOWS	A dummy, with a value of 1 if Windows compatible graphical client interface is provided.
INTERNET	A dummy, with a value of 1 if access to Internet services is offered.
WEB	A dummy, with a value of 1 if access to the World Wide Web is provided.

Table 3. Descriptive Statistics

Variables	Mean	Std. Deviation
SHARE	0.15	0.13
STARTUP	13.41	21.43
PER_MONTH	8.13	3.77
PER_HOUR	4.13	3.32
MAKE	39.46	19.40
INTERFACE	2.66	1.23
WINDOWS	0.41	0.49
INTERNET	0.21	0.41
WEB	0.08	0.27

STARTUP refers to subscriber registration fee. PER_MONTH represents the minimum monthly fee charged to users to maintain their current account. PER_HOUR refers to the hourly charge in excess of any free hours or flat fee service offered

by the network. As described earlier, online information networks implement a variety of pricing schemes. However, three price elements are common to most of the firms (although not each firm has to have all the three together).[8]

MAKE, coded as the number of months a firm has been in service, is used as a proxy for make effects. INTERFACE captures the concept of usability. INTERFACE represents a usability rank arrived at via a content analysis of several press reports evaluating system ease of use. A high ranking was recorded as one, so larger numbers indicate a less usable interface.

WINDOWS, INTERNET, and WEB are used as variables to capture important services or features offered by online networks. They are binary coded and represent the existence of a DOS/Windows graphical client for the service, provision of access to non-Web Internet services such as Usenet, gopher and FTP, and provision of access to the World Wide Web, respectively.

4.2 Estimation Results

To test our research model, we employed regression analysis techniques. Appendix 1 presents a correlation matrix of the explanatory variables. It appears that the pairwise correlations between PER_HOUR and PER_MONTH, WINDOWS and PER_MONTH, and INTERNET and WEB are high (> .50) and deserve attention. To avoid potential problems due to multicollinearity, we applied the three price variables, PER_HOUR, PER_MONTH and STARTUP, one at a time, resulting in three separate models.[9] Similarly, only one of the three variables, WINDOWS, INTERNET, and WEB, is introduced.[10]

The results of model estimation are presented in Table 4, 5, and 6. Time dummies were introduced for control purpose. Thus there were thirteen dummy variables (T1 through T13), one for each observation period (the first period does not require a dummy variable). As INTERNET and WEB are insignificant across all models, we only present results for models that include WINDOWS.[11] For all the three models, the adjusted R^2 values are in the range 0.74 to 0.77. The expected signs on the dummy variables are negative, reflecting a decline in market dominance over time.[12]

SHARE is found to be positively associated with MAKE ($p < .01$). This is consistent with the findings by prior research (e.g., Gandal 1994; Kalyanaram and Wittink 1994). Of the six firms, only one (eWorld) was started in the 1990s. The other five started their service much before the rest of the competitors entered the field, and hence were able to create strong brand image. Indeed, CompuServe, started in 1979, was the industry leader until recently, and still is among the top two. In short, make effect does significantly influence network growth.

The study also shows INTERFACE (usability) to be strongly associated with SHARE ($p < .01$). The rise of America Online is testimony to the effect of the usability on network market share. Entering the industry only in 1989, America Online was able to rapidly increase its share based largely on its "friendly" interface.

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[8]The number of free hours of access may influence network market share. One could use it as an independent variable to test its impact should time series data across networks become available.

[9]We found potential problems of multicollinearity in the data matrix if all three price variables were included in a model.

[10]Due to multicollinearity problems, using any combination of three variables resulted in unstable coefficient estimates.

[11]In other words, the results for the other six models are not included in this report.

[12]Removing all time dummies from model estimation, we derived qualitatively the same results in terms of the signs or coefficients of the explanatory variables, adjusted R^2, and interpretation. These models (without time dummies) were also tested for cross-sectional correlation and autocorrelation. We found no serious problems.

Table 4. Model Estimation Results with STARTUP

Variable	Coefficient	t-ratio
MAKE	0.0015	9.11***
INTERFACE	-0.036	-4.80***
WINDOWS	0.15	7.52***
STARTUP	0.0012	2.82***
T2	-0.21E-01	-0.51
T3	-0.20E-01	-0.50
T4	-0.26E-01	-0.64
T5	-0.48E-01	-1.19
T6	-0.42E-01	-1.04
T7	-0.34E-01	-0.84
T8	-0.72E-01	-1.76*
T9	-0.74E-01	-1.88*
T10	-0.76E-01	-1.93*
T11	-0.78E-01	-1.98**
T12	-0.82E-01	-2.07**
T13	-0.85E-01	-2.15**
T14	-0.88E-01	-2.23**
Constant	0.095	2.82***

Adjusted R^2 = .77
Significance: *P < .10; **P < .05; ***p < .01

Table 5. Model Estimation Results with PER_MONTH

Variable	Coefficient	t-ratio
MAKE	0.0013	6.69***
INTERFACE	-0.027	-3.27***
WINDOWS	0.19	8.19***
STARTUP	-0.0013	-0.43
T2	-0.46E-02	-0.11
T3	-0.85E-02	-0.19
T4	-0.13E-01	-0.30
T5	-0.46E-01	-1.05
T6	-0.48E-01	-1.02
T7	-0.39E-01	-0.82
T8	-0.82E-01	-1.65
T9	-0.80E-01	-1.66
T10	-0.82E-01	-1.67*
T11	-0.83E-01	-1.70*
T12	-0.88E-01	-1.84*
T13	-0.91E-01	-1.89*
T14	-0.93E-01	-1.92*
Constant	0.098	2.68***

Adjusted R^2 = .74
Significance: *P < .10; **P < .05; ***p < .01

Table 6. Model Estimation Results with PER_HOUR

Variable	Coefficient	t-ratio
MAKE	0.0014	5.06***
INTERFACE	-0.30	-2.53***
WINDOWS	0.18	8.24***
STARTUP	-0.00093	-0.21
T2	-0.87E-02	-0.20
T3	-0.13E-01	-0.30
T4	-0.19E-01	-0.42
T5	-0.52E-01	-1.17
T6	-0.58E-01	-1.30
T7	-0.51E-01	-1.09
T8	-0.95E-01	-2.05**
T9	-0.94E-01	-2.10**
T10	-0.96E-01	-2.13**
T11	-0.97E-01	-2.15**
T12	-0.10	-2.24**
T13	-0.10	-2.30**
T14	-0.11	-2.35**
Constant	0.10	1.87*

Adjusted R^2 = .74
Significance: *P < .10; **P < .05; ***p < .01

WINDOWS is found to be positively associated with SHARE (p < .01), as expected. As an example, America Online was launched as a Macintosh service in 1989, and its user base did not experience any significant growth until it offered a Windows PC-based service in 1993. The membership, which was 180,000 in September, 1992, doubled in one year and became 350,000 in September 1993. Similarly, Apple Computer launched its Macintosh-only eWorld service in 1994, and after the initial surge in membership the service experienced almost nil growth until it had to be closed down in early 1996.

The results on the relationship between network access price and network growth are mixed. We had expected all three price elements to be negatively associated with market share. However, only STARTUP is found to be significant (p < .05). The positive correlation between STARTUP and SHARE is contrary to what one may expect. This result, however, is consistent with the theory of network externalities: larger networks are able to charge their subscribers a higher premium for joining the networks.

The results should be interpreted with caution: 1) because not all firms have startup cost in their price structure (for example, America Online pioneered providing free client software to potential subscribers); and 2) because of the lack of significance of PER-HR and PER_MONTH variables. The results are only weakly supportive of the network externalities hypothesis, i.e., the online services industry exhibits some extent of network externalities. Indeed, we estimated several hedonic regression models using network access price variables as the dependent variables, but found no support for the network externality hypothesis.[13]

[13]By developing a usage-based price variable, we attempted the hedonic regression modeling approach. The results of the hedonic price analysis are available from the authors upon request.

5. CONCLUSIONS

Network products and services are increasingly important. Despite several theoretical models of networks, there has been a lack of empirical studies on the determinants of network growth. To bridge this gap, we focus on a developing, contemporary industry not previously studied, the online services industry. The results indicate a positive relationship between network market share and make effect, usability, and DOS/Windows compatibility. More specifically, the study suggests that make effect and usability contribute to network market share, and it reinforces the notion that platform choice can be significant in generating network growth and establishing a new network service.

Contrary to what one may expect, we found a positive and significant relationship between network start-up cost and network market share. We interpret it as an evidence of the existence of network externalities: networks with a larger installed base are able to charge their subscribers a higher premium. The coefficients for per-hour and per-month charges, though negative, are insignificant. It may be that in the presence of intense price competition, price rather than the nature of the content determines the market leaders at least in the early part of the industry life cycle. Overall, we found only weak support for the network externality hypothesis.

The study provides several implications for researchers as well as practitioners. It identifies and verifies the factors influencing network growth. All the variables studied here enhance the network value perceived by customers. This has implications not only for the online service providers (for example, how "open" are new features and facilities), but also for the content providers. By taking into consideration ease of use along with the content, the content providers can build popular sites. Further, if they follow standard technological architectures, they can be less dependent on the network provider.

The study provides further empirical verification of the theory of networks in a context not previously studied. The online services industry is a rapidly growing and volatile industry. The weak support for network externality theory when viewed with the particular time frame studied (early phase of the industry life cycle) may indicate the need for a contingency model incorporating the age of the industry. While the impact of pricing and access to broader network services on the Internet are more closely aligned with the unique characteristics of the online services industry, other implications may be more generally applicable among software and other IT related network goods.

Future studies can build on our efforts by incorporating content-based variables and a better operationalization of the price variable. Another interesting variable is the profile of the network subscribers as these networks may attract different types of customers.[14] As suggested by Shurmer (1993), the relative sources of network externalities vary across different types of users and may justify the ability of various standards to successfully compete without a single one dominating. The ability of an online service to charge a premium may be dependent not only on the installed base but also on the "quality" of the installed base.

There are certain limitations to this study. First, we restricted our analysis to the top six firms only due to lack of reliable data for other services. However, we do not believe that incorporation of other firms in the analysis will significantly change the results since the market share of all other firms combined is less than 15%. Second, the particular time frame selected for the study (March 1990 to April 1995) may call for caution in interpreting the findings on network growth and network externality. The time period selected may reflect the early part of the life cycle of the online services industry before Microsoft entered the arena. Also, the competitive factors that are dominant in this stage may not be valid once the industry matures (particularly as access shifts from a proprietary to Internet-based model). Third, we do not consider congestion externalities, although the negative impact of an over-crowded network may work to reduce market share. Difficulty in operationalizing and gathering this data precluded inclusion of possible congestion effects in this study, however such effects may be significant for competition in physical networks such as the online services market. Last, several important variables (e.g., content-based, advertising, and promotions) were excluded due to lack of reliable data.

[14]For example, it has been reported that Prodigy attracted older customers than its rivals (Higgins 1995), and that CompuServe is better geared toward technical/professional users while AOL is more focused on the home use market (Heim 1995).

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APPENDIX 1. CORRELATION MATRIX FOR EXPLANATORY VARIABLES

	SHARE	STARTUP	PER_MONTH	PER_HOUR	MAKE	INTERFACE	WINDOWS	INTERNET	WEB
SHARE	1								
STARTUP	0.366	1							
PER_MONTH	0.132	0.035	1						
PER_HOUR	0.215	-0.001	-0.602	1					
MAKE	-0.442	-0.067	0.302	-0.428	1				
INTERFACE	-0.224	0.151	-0.049	-0.317	-0.49	1			
WINDOWS	0.73	0.357	0.539	-0.198	0.011	-0.294	1		
INTERNET	0.151	-0.098	0.24	-0.043	0.045	-0.146	0.494	1	
WEB	-0.157	0.045	0.145	-0.043	-0.106	0.242	-0.044	0.567	1