Network Externalities and the Provision of Composite IT Goods Supporting the E-Commerce Infrastructure

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Abstract

Theoretical research on networks and technology standards suggests that network externalities, the additional value of a product or service resulting from an existing installed base, have strategic implications. This paper uses the WWW software market to empirically test the network externalities hypothesis in a market of composite goods. Among the findings is that vendors who provide both components to a composite goods market (e.g., client and server) enjoy a higher price premium than do single-product (e.g., server) providers. The results suggest that composite markets exhibit network externalities and yield important managerial implications.

It has been suggested that the economics of a large installed base play a critical role in electronic markets and in markets that support the e-commerce infrastructure (Downes and Mui 1998; Hagel and Armstrong 1997), however little empirical research exists supporting these assertions. To test the impact of installed base in composite goods markets, this paper examines the market for World Wide Web (WWW) software—a key component of the e-commerce infrastructure and one that has a structure similar to other current and emerging Internet-based technologies. Using a time-series data set that includes over 300 cross-sectional observations on 34 commercial web server products, we examine variables influencing price using the hedonic pricing technique. The results are supportive of the network externalities hypothesis, i.e. the size of a web server’s installed base confers additional value (positive network externalities). One of the key findings is that IT products from integrated providers enjoy a price premium over those from single-component producers. The findings of this study have implications for the timing of market entry, product offerings, R&D, mergers and acquisitions, and the adoption of technical standards.

NETWORK EXTERNALITIES AND THE ADVANTAGE OF INSTALLED BASE

Consumers value many products and services based on intrinsic features as well as on the size of the product’s network (installed base). As a result, we see that in many industries, consumers are willing to pay more for products and services that are (expected to be) market leaders.1 This results from an effect that economists call positive consumption network externalities, the additional value conferred to users as a result of an existing installed base. When network externalities are present, the valuation that consumers place on a product or service will increase as the installed base (or network) expands (Katz and Shapiro 1985).

This concept may be particularly important for information technology due to the impact of three critical factors—exchange, stranding concerns, and extrinsic benefits.

1. In terms of exchange, users are attracted to a technology that is compatible with a greater network of users, all else equal, because they can engage in a wider option of value-enhancing exchange (e.g. of information, money, and programs).

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2. Users of IT are highly concerned about being stranded in an unsupported standard (Fichman and Kemerer 1993); hence, users favor products that they believe will continue to dominate in the future.

3. Also, the dominant product is likely to attract extrinsic benefits (Shurmer 1993). These may include add-on products, books and manuals, and skilled workers.

Stranding concerns and extrinsic benefits are particularly important for e-commerce firms, as they imply that network externalities can be generated even in environments that support open standards.

The theory of network externalities suggests that consumers recognize these advantages and should be willing to pay more for IT products and services that are dominant in their respective markets, all else equal. Empirical verification of this concept has been performed using the PC spreadsheet market as a context (Brynjolfsson and Kemerer 1996; Gandal 1994). However, many IT markets exist that have a structure distinctly different from this market; for example, many can be referred to as composite markets, that is more than one class of product is required to derive utility.

Examples of composite markets that support the e-commerce infrastructure include client/server markets such as those for WWW and multimedia streaming software, content authoring/content viewer markets, and markets for broadcast/receiver hardware such as DBS (direct broadcast satellite) and LMDS (local multipoint distribution service). Firms participating in such markets have a choice to produce either component of the composite mix, or both components. In a case focused on the web software industry, Gogan and Applegate (1996) suggest that practitioners have found this choice particularly troubling. However, no study to date has empirically examined the impact of network externalities in the composite IT goods market and whether there are advantages to providing the market with both components. This work explores this question using the market for WWW software as a context to empirically examine whether IT products from integrated providers enjoy a price premium over those from single component producers.

CONTEXT

The context for this study is the market for commercial WWW servers for Microsoft Windows operating systems. For a number of reasons, this context provides an exceptional environment for studying network externalities and their impact in composite markets.

1. Web servers are part of a client/server mix, and since some server developers provide the market with clients (browsers) while others do not, the impact of network externalities in composite markets can be easily tested.

2. Examining the market from the server perspective rather than the browser perspective is most appropriate given that many participants have chosen to provide the market with free browsers, an act that may be considered a market-seeding subsidy (Katz and Shapiro 1994).

3. The client/server structure of the web is also similar to many current and future technologies that support e-commerce (e.g. audio, video, push).

4. Web software also represents one of the most rapidly diffused IT innovations of all time, while competition in this market has raised the scrutiny of the Justice Department.

5. Focusing on the Windows market is appropriate, given that during the time of the study, the Windows market was dominated by commercial web servers while the UNIX market was dominated by freeware products provided by the Apache consortium, NCSA, and CERN.

RESEARCH METHODOLOGY, MODEL, AND DATA

To test the network externalities hypothesis and examine the impact of installed base, the hedonic pricing technique was employed to test for factors associated with price. This technique assumes that price is determined as a function of value bundles—factors that contribute to determining the price that a consumer is willing to pay. In hedonic pricing, the dependent variable price is regressed against various independent variables, which in the case of network goods include ‘technology dependent’ features as well as ‘network’ features. This technique has been used in previous empirical tests of network externalities (Brynjolfsson and Kemerer 1996; Gandal 1994) as well as in research on IT pricing (Rao and Lynch 1993).

The conceptual model employed in this study includes factors considered by earlier researchers (e.g. Brynjolfsson and Kemerer 1996), such as network effects, standards that both expand the reach of a network good and increase the benefits offered by a product, intrinsic features that increase the benefits offered by a product but that have no network effects, and control variables for time and duration a product has been on the market. However, the model used in this study extends earlier work in two important ways. The model considers: (1) the impact of the installed base of any complementary composite component (in this case a browser) that is provided by the developer of the primary component (server); (2) the potential price benefits associated with offering a trial version of a product — a trial version of a product should lower a user’s quality uncertainty and hence lower their risk premium and increase the price he or she is willing to pay for a product (Rogers 1995). The conceptual model is expressed below, along with a description of factors tested in the empirical model, their measures, and their hypothesized direction of influence.
\[ P_i = f(N_{pi}, N_{ci}, S_i, F_i, T_i, O_i) \]

where

\[ P_i = \text{price of product } i \]
(\text{log of server price; dependent variable})

\[ N_{pi} = \text{the installed base of the primary product} \]
(server market share percentage; +)

\[ N_{ci} = \text{the installed base of the complement component} \]
(browser market share percentage; +)

\[ S_i = \text{standards attributes of primary product} \]
(1 if server supports links to database products; +,
1 if server supports the SSL security standard; +,
1 if server supports the SHTTP security standard; +)

\[ F_i = \text{product feature attributes of primary product} \]
(1 if server offers a graphic user interface for administration; +,
1 if server offers a remote maintenance option; +,
1 if server offers its own scripting language; +,
1 if server provides its own internal search engine; +,
1 if server allows for separate user-controlled subdirectories; +)

\[ T_i = \text{trialability of the product} \]
(1 if a free trial version of the product is offered; +)

\[ O_i = \text{other variables influencing price} \]
(number of months a product has been offered to the market; +
and month of study; −)

The data set used in this study is a time series containing a total of 321 cross-sectional observations on 34 stand-alone, commercial web servers reflected over 19 monthly periods from August 1995 through February 1997. Data for this study were obtained from a combination of public and proprietary consulting data, industry research reports, a content analysis of the press, and feedback from vendors. Whenever possible, multiple sources were identified and compared to ensure the quality and constancy of the data.\(^2\)

Commercial products from only one platform (Windows operating systems) were included in the study. One difficulty in employing hedonic research is identifying an appropriate subset of variables that effectively proxy features that are most desired by users. A feature list was assembled based on a content analysis of various reviews, books on web site administration, and through consultation with industry consultants. It is assumed that the consistency and redundancy of these approaches offered an appropriate identification of relevant and most desirable features.

RESULTS AND INTERPRETATION

The results in this study were achieved by regressing the variables collected against the log of price. The semi-log form is presented for three reasons: (1) it was consistent with earlier approaches; (2) the model offered the most statistically compelling of various functional specifications studied (although all yielded similarly consistent results); and (3) it implies that each quality improvement adds more than the sum of the variables (e.g. the whole is larger than the sum of its parts).

Figure 1 is offered for ease of interpretation. The interior of the diagram includes the conceptual formulation of the model used. The exterior of the diagram includes the variables studied along with the direction of influence (positive or negative) of the coefficient. Variables labeled insignificant were not significant at the 90% confident interval and were dropped from the refined model. The refined model proved quite descriptive, with the adjusted \( r \)-squared value indicating that the model explained roughly 77% of the variance in the data. All variables in the refined model were significant above the 99% confidence level. Residual diagnostics did not suggest concern and appropriate tests for multicolinearity and serial correlation were also performed, with all results falling within acceptable parameters.

Two market-share variables were tested as sources of network externalities—server share and browser share. Earlier models had shown that, all else equal, consumers are willing to pay more for products that dominate their respective markets (Brynjolfsson and Kemerer 1996). By exploring the market share for both servers and browsers and their relationship to server price, we were able to test for the significance and relative network benefit yielded from each of these components. Of particular interest is the result that browser share remained in the refined model while server share dropped out. One interpretation for this is that although the server market generated far greater revenues for participants than the browser market, there were many more browser users in existence. The
abundant pool of browser users drove awareness of the dominant server producer, raising product awareness and reducing quality uncertainty and stranding concerns. The coefficient of the browser share variable, .0117, suggests that with all other factors held constant, a 1% increase in the browser’s installed base warrants a price that is slightly over 1% higher than its competitors ($e^{0.0117} = 1.0117$; or 1.17%). During the time of this study, Netscape clearly dominated the browser market, with a market share varying from 74–83%. Netscape’s dominance of this market suggests a price premium accruing from network externalities within the range of 87–97%. Although a number of factors limit the generalizability of any conclusions from these results, the findings of this study suggest strong price advantages for firms that are able to capture market share for the complementary component in a composite goods mix.

The variables for security protocol (SSL and S-HTTP) and the ability to link a server with a database may also be considered as constructs for network benefits. Variables for product market share offer a more pure representation of network benefits than do the one/zero indicator variables for network extending standards. However, Gandal (1994) points out that standards extend the reach of a network, and thus should be considered for their ability to generate positive network externalities. In this case, the use of security standards allows a product to be extended to a larger number of applicable contexts (such as secure transactions) while the ability to link to external databases provides the product with access to additional data networks. Similar indicator variables for file accessibility and data access were employed in Gandal’s (1994) study of the spreadsheet market. The estimation results reveal that both the database linking and SSL features are positively associated with product price, consistent with the network externalities hypothesis. However, support for the S-HTTP security standard was not significant enough for inclusion in the model. SSL and S-HTTP are competing, although not mutually exclusive security standards, but the SSL standard (mean .4205) is much more popular than the S-HTTP standard (mean .1489). Thus these results may be interpreted as being supportive of the existence of network externalities in this market as witnessed via a significant premium being placed on the more popular security standard. As such, firms confronted with the choice of offering an innovative, but non-standard feature vs. complying with the appropriate standard would be wise to consider the network benefits associated with a standard’s popularity.

The one/zero indicator variable proxying trialability also proved highly significant. An interpretation of this is that firms that offer a trial version of their servers were (ceteris paribus) able to price their products nearly (1.5) times higher than those not offering a trial version. This may be taken as a validation of Nejmeh’s (1994) assertion that the Internet can be a strategic tool for the software enterprise. In this context, the Web allows the firm to reap advantages from distributing demonstration versions at a low, fixed cost. This may be particularly true for firms with a smaller installed base, who may wish to offer trial versions to reduce consumers’ quality uncertainty in order to compete with their bigger rivals. This also supports Rogers’ (1995) assertion that there is a risk associated with adoption and that trial versions of products help reduce this risk. In this context, offering a trial version seems to have translated into a substantial valuation premium.
Since the focus of this study was to examine the impact of network externalities, the purpose of examining intrinsic features was simply to act as a control for quality. As expected, all one/zero indicators for features that were considered for the model were significant and positively related to the product’s price. However, unexpected results were yielded by the number of months a product had been on market and by the month, or time period, of the study.

It had been initially expected that a product’s price would be positively associated with the length of time it had been on the market, since users would value a network that had achieved lasting market durability. However, the months that a product had been on market yielded a negative relationship to price. An explanation for this effect may be the economics of the software industry. Software development has a high fixed cost, while production has a marginal cost near zero (Negroponte 1995). Firms may introduce products at a high initial price, with early adopters subsidizing the bulk of development. Also surprising was a positive relationship between the month of the study and price. This suggested that, all else equal, server products seemed to increase in price over time. These results are contrary to the quality-adjusted price declines over time identified in other studies of IT (e.g. Chow 1967; Gordon 1993). One explanation for this effect is that as the Internet continued to grow, Internet software was recognized as being more valuable to an organization and new manufacturers coming to market reflected this perceived higher valuation in higher product prices. Further tests, however, demonstrated that the time indicator can be removed without altering the interpretation of the results.

CONCLUSION

The results of this research yield important and interesting implications for both researchers and practitioners. For researchers, this study provides much needed empirical support for the network externalities hypothesis in IT markets. Many previous econometric studies of IT pricing have ignored the impact of network externalities, so this work suggests ways to strengthen future analyses by considering network benefits. Also, to the authors’ knowledge, this is the first study to empirically examine the impact of network externalities on IT markets that can be classified as composite-goods markets. This study demonstrates that network benefits are accrued outside of the single-product IT networks that were the focus of earlier empirical work. This work also suggests that network externalities are important even in markets that are largely based on open rather than proprietary standards. Additionally, this work extends existing modeling techniques in a way that accounts for the uniqueness of composite goods networks and for the influences of trialability.

For practitioners, this study suggests a number of managerial implications.

1. Network externalities seem to be significant in client/server markets, even in those markets with open standards. This suggests the wisdom of moving early in order to quickly establish an installed base from which to derive positive demand-side economies of scale.
2. Providing complements may yield price-based benefits. The results of this study suggest that the installed base for complementary composite products was positively associated with a firm’s ability to command a price premium. Such network benefits may influence a firm’s decision to invest research and development funds to create composite complements and/or to seek to merge with or acquire firms in markets that offer the composite complement.
3. The study offered evidence that adherence to dominant technology standards yields price benefits. Results suggest that products supporting the more popular standard command higher prices. These results are particularly interesting for firms that are faced with a choice between investing in an innovative standard vs. supporting a popular standard.
4. Offering a trial version was shown to be positively related to price. Trial versions may act to lower consumers’ quality uncertainty and the risk premiums associated with purchases, and thus increase their willingness to pay.

The outcome of any empirical study is subject to context, sample, and temporal biases. Though our explanatory variables were driven by the theory of networks and standards, it is possible that other factors influencing consumer value and price may have been left out. Hence as with all such research, managerial implications should be interpreted with a degree of caution. However, it is hoped that the strong support for prior theoretical assertions and the consistency of our results with earlier empirical work will continue to raise management awareness of the importance of network economics in strategic decision-making.

Notes

1. For example, Gandal (1994) and Brynjolfsson and Kemerer (1996) showed that, ceteris paribus, consumers are willing to pay more for spreadsheet products that are recognized market leaders.
2. Monthly web market share data was derived from a survey conducted by Netcraft Consultants. Netcraft’s survey was chosen because it represents the most frequently cited survey of web server market share and hence is likely the closest proxy to the average consumer’s perception of market size. Results from Netcraft’s survey were nearly identical to year-end data provided by Zona Research. Browser share data was compiled from two sources – Yahoo and the University of Illinois – with values compared against a third data set provided by Interse. Data from the first two sources were more complete than the
third, however the third was used to offer tolerance limits for additional testing. Such tests did not alter the significance or direction of results or the conclusions drawn in this study.

3 Kauffman and Wang (forthcoming) examined the impact of technological compatibility on competitive network growth using nationally shared electronic banking networks as a context. They found support for their hypothesis that technological compatibility resulted in additional growth of the electronic banking industry, as well as the individual national shared networks. Though shared electronic banking networks can be classified as composite goods, the focus of their study is on the impact of network externalities on aggregate network growth.

References