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Optimal Pricing of Internet Services In the Global Economy

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Abstract:

From what was once a pure public good, the internet now comprises three key dimensions in the global economy: public sector database communications systems, public and private electronic mail services, and electronic commerce. While public sector database communications systems still affect some key sectors of the internet, electronic mail and electronic commerce drive much of the product innovation now taking place. As a quasi-public good, the internet raises fundamental policy questions, notably the assignment of costs in product development, the pricing of internet services by sector users, and the selection of optimal financing modes for its operation and expansion. In this paper, we examine key economic dimensions in the evolution of the internet within a framework for the optimal pricing of internet services.

Optimal Pricing of Internet Services

Introduction

By most measures, the expansion of internet services represents one of most fundamental shifts in technology in several decades. As measured in terms of the number of users, the level and range of services, and in terms of the impact on economic growth and productivity, the effects appear substantial. At current rates of growth, the internet may create more profound changes in the global economy in the 21st century than the introduction of mass production did for manufacturing in the 20th century.

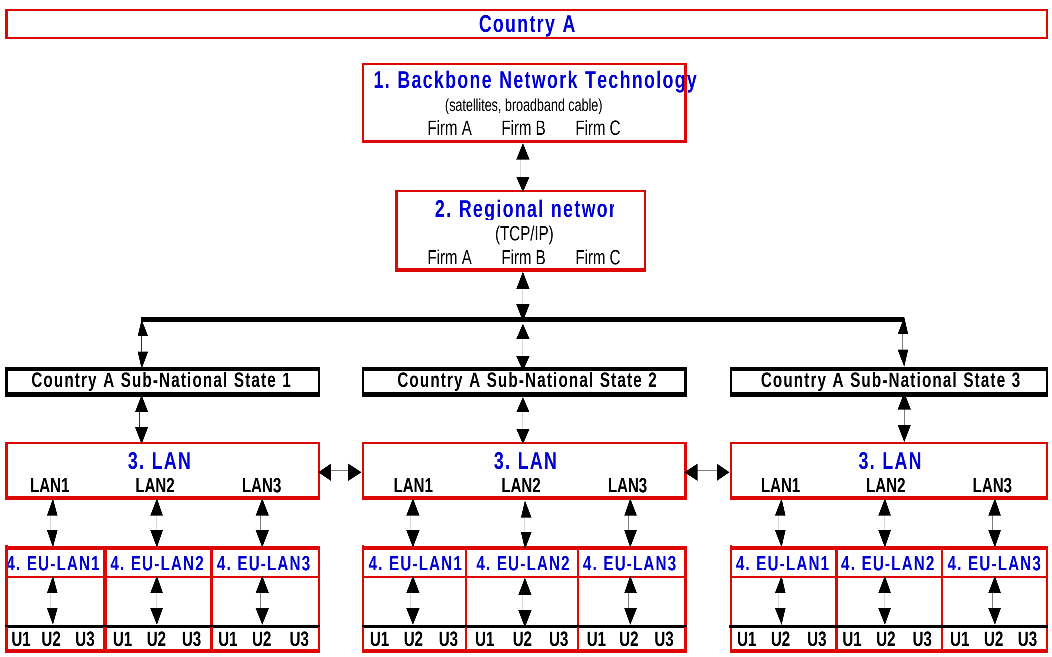
As important as these changes may be, a number of questions arise in the context of internet expansion. We consider here a framework for the optimal pricing of internet services. In so doing, we seek to address two underlying questions. First is how the internet technology consuming sector is affected in terms of the cost and pricing of goods and services. In particular we examine the supply chain of production as well as the elasticity of demand for internet goods in comparison to conventional goods. Second, we look at the characteristics of the internet technology producing sector, in particular the role of network externalities, bundling, and taxation in the internet economy. We then draw conclusions regarding the impact of these characteristics on the level of economic efficiency and public policy.

Evolution of Internet Technology and Services.

The internet has become synonymous with the 'new' economy, i.e., a technology that transcends the boundaries of traditional industries both within and across economies. What is new is that the internet combines the traditional technology of telecommunications once used exclusively for the transmission of voice information with computer technology to transmit data. As television embraces digital technology standards, the integration of voice, video, and data will accelerate the integration of telecommunication and computer technology, with the internet serving as a common gateway. How all of this has come about is covered in any number of sources. The evolution of internet technology is covered in a number of sources, notably Kurzweil (1990), Kidwell and Ceruzzi (1994), Reid (1997), MacKie-Mason and Varian (1998), and Hannon (1998). Berners-Lee (1999), Lewis (1999), and Gleick (1999), among others. In addition, how technological innovation of the internet has helped to shape industries and economic conditions is covered in Jussawalla (1995), Kahin (1995), Brock (1995), and Goffe and Parks (1997).

Internet technology functions at several different levels to exchange information among users. The common grammar of communications is TCP/IP, or Transmission Control Protocol/Internet Protocol. This language connects networks that use local protocols such as Netware™, AppleTalk™, and Ethernet™, among others. Choi, et.al. (1997) characterize four levels of network infrastructure, as illustrated below in Figure 1. These are, respectively, backbone networks, regional networks, local access networks (or LAN), and end users. The backbone functions at a national and international level and consists of a system of high-speed data lines using fiber optic or copper wire leased form long distance telephone companies connected by high-speed routers, as well as cellular systems that rely on satellite transmission technology. Broadband cable with ground-point-to-ground-point links, or upload and download points via satellite, is provided either directly by standard telecommunications firms or by specialized equipment firms producing specific connection technology that is sold and/or leased to telecommunications firms.

Figure 1



Source: Adapted from S.-Y Choi, D.O. Stahl, and A.B. Whinston. *The Economics of Electronic Commerce* (Indianapolis, Indiana.: Macmillan Technical Publishing, 1997)

Regional networks provide service to a broad class of users, either within a given country or across a group of states. These networks collect and distribute messages that pass through the backbone from one local area network to another. In turn, local area networks create common connectivity service to users at an institution-specific level, such as at the corporate or university level. These networks provide local access facilities, including computer servers, operating software, as well as modem connectivity between the local area network and the regional and backbone transmission carriers.

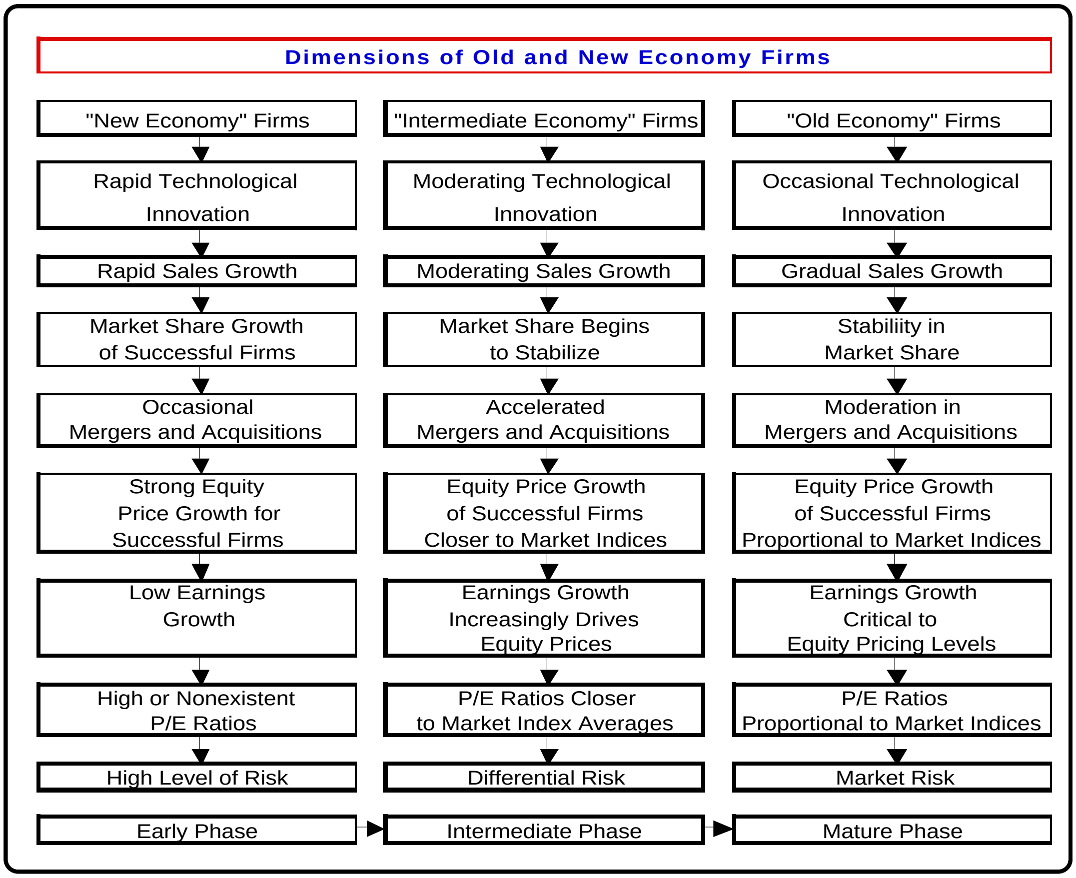
Finally, end users are individuals consumers and businesses that use dial-up services through telephone and/or cable modem technology to connect to a local area network. In addition to the use of TCP/IP, software at the network and individual user level provides a means to organize the compiling of information via search engines or electronic mail, and a system through which this information may be stored, retrieved, and distributed to other users. To facilitate the search process, LAN systems are organized by an institutional protocol, with edu, gov, org, and com representing respectively, education, government, non-profit institution, and commercial enterprise.

Each institution or individual creates an internet site using the URL, or universal resource locator address system, as in http://www.firm.com, which enables search engine programs in portal software to rapidly locates internet sites and files. Portal software consists of programs such as Netscape Navigator™, Juno™, or Microsoft Explorer™, while search engines include Yahoo™, Excite™, Lycos™, GoTo.com™, HotBot™, LookSmart™, About.com™, Google™, and Snap™, among others. In turn, these services can be bundled with e-mail services, as in AOL.com™, Mindspring.com™, or QXL™, for example.

In terms of the economic impact of the internet, we note at least two dimensions. One is the growth of internet firms that bring new technology to the marketplace. Second is the effects that new internet technology produces on traditional firms and industries, particularly in terms of savings in startup, production, and delivery costs of goods and services, all of which are producing striking increases in the level of factor productivity. Recent studies include Evans and Wurster (1999), Woods and Sculley (1999), Kalakota (1996, 1999), Bunnell (1999), among others.

Beyond the rise of internet technology firms, and the change in traditional economy firms, there has been an interim shift in financial markets that intermediate capital flows. In the United States at least, the rapid expansion of internet technology firms has spurred the growth of equity prices. Although our focus here is on internet service pricing rather than internet firm equity pricing, we note that new technology firms seem to defy many traditional rules of financial markets, namely, a close positive relationship between equity prices and earnings. We can summarize the contrast between “new economy” firms and “old economy firms” in terms of the following dynamics shown in Figure 2.

Figure 2

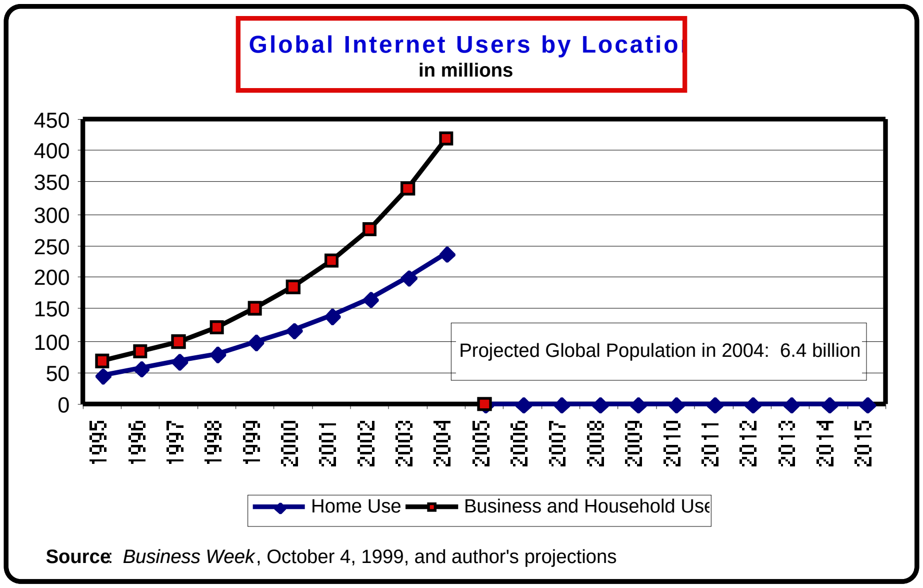


Although innovation is characteristic of many new industries in the early phases of expansion, the rapid evolution of financial asset prices has caused sufficient concern in the United States that equities may reflect an asset bubble that may yet undermine the sustainability of economic growth. U.S. Federal Reserve Board Chairman Alan Greenspan first commented publicly on this phenomenon as “irrational exuberance” in the stock market back in 1996. Echoes of this exuberance can be found in the expansion of optimistic books on the future course of equity pricing, notably Kelly (1999). Since then, the Federal Reserve has reacted to rising stock market prices by gradually raising interest rates to ward off the threat of renewed inflationary pressure. Among those who share the concern of the Federal Reserve as Perkins and Perkins (1999), and Shiller (2000), who argue that equity prices eventually must revert to historical patterns of pricing and industry performance.

The Growth of Internet Service Markets

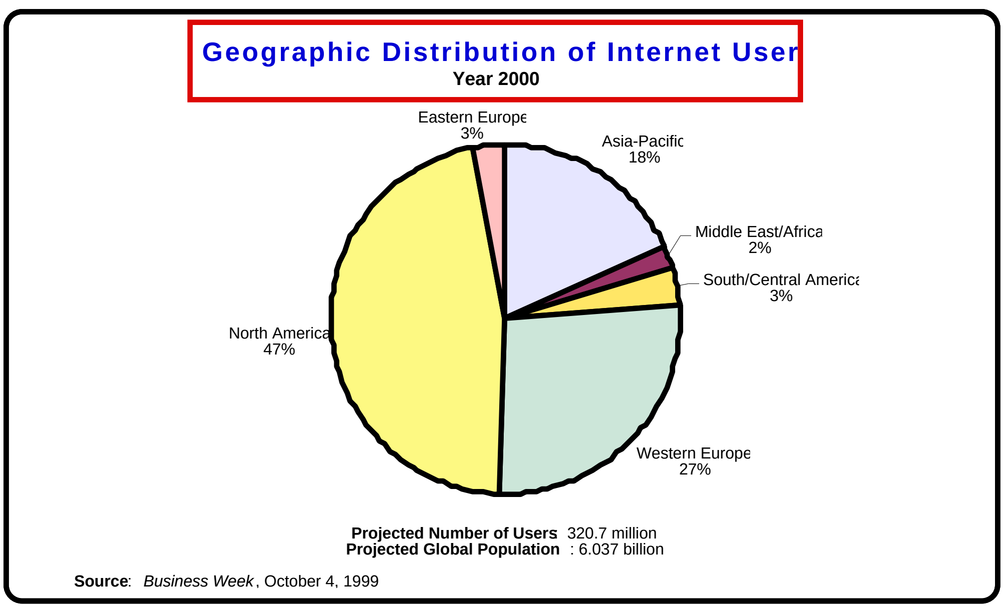
How large is the internet economy, and what kinds of markets are evolving? One way to measure the growth is in terms of the number and distribution of users. With just under 200 million users in early 2000, the number of users is expected to reach 450 million by the year 2004, representing 7 percent of the projected global population of 6.4 billion, as is shown below in Figure 3

Figure 3



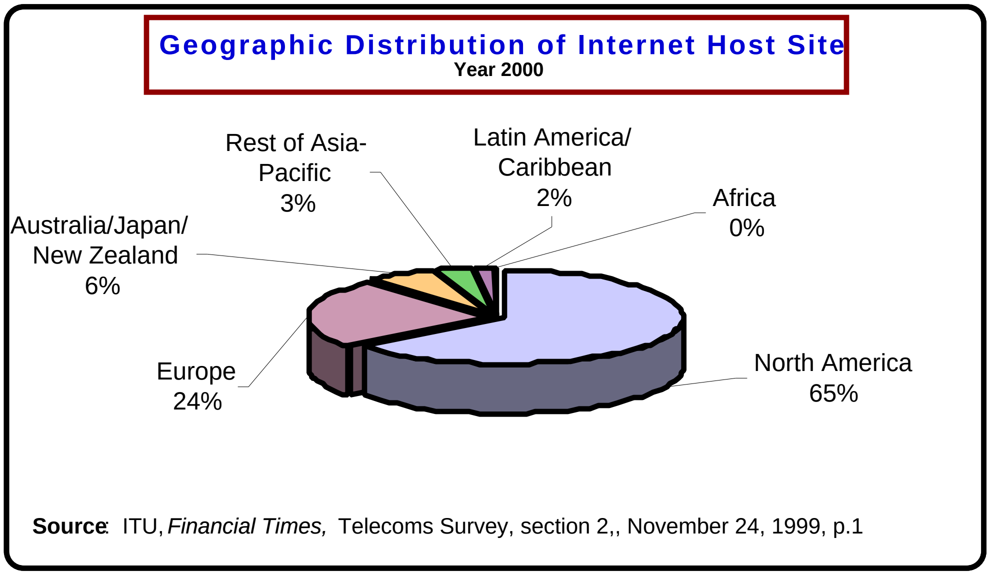
Most users of internet technology are found in more developed economies. Figure 4 illustrates the geographic distribution of internet users as of the end of 1999. Shifts in the geographic distribution are a function of the relative investment in internet technology within regions as well as overall policies that affect the long-term rate of economic growth.

Figure 4



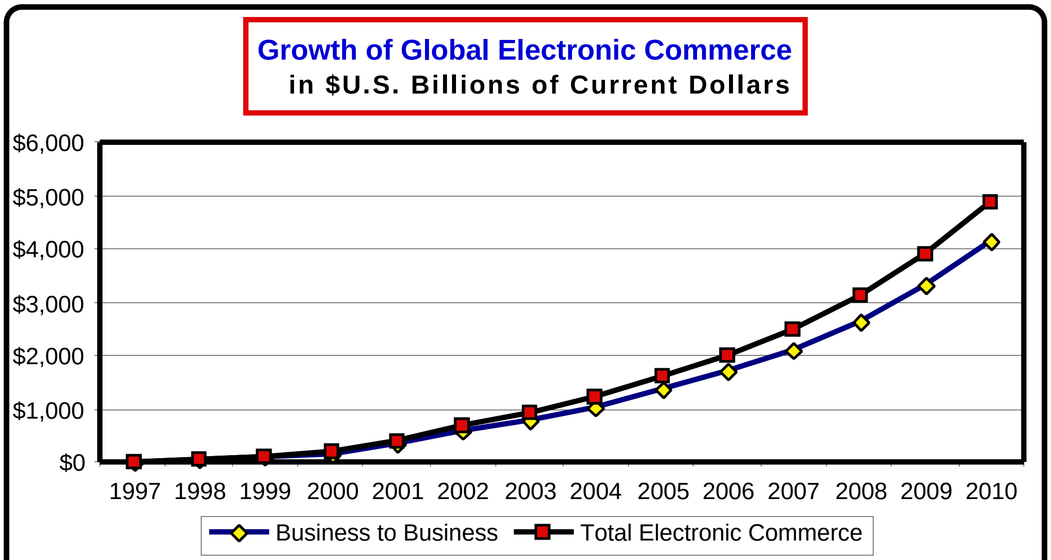
One factor that drives the above distribution is the geographic origin of internet host sites. Figure 5 illustrates the current distribution of known sites as of the end of 1999.

Figure 5



In terms of the value of electronic commerce, estimates vary, but point to a growing level in absolute terms, and relative to the projected size of GDP. Figure 6 illustrates the evolution of internet commerce spending. With a current global Gross World Product on the order of U.S. $35 trillion, electronic commerce now accounts for approximately 2 percent, but may increase to between 4 and 5 percent by the year 2004. It is this growth in the share of Gross World Product that is so dramatic.

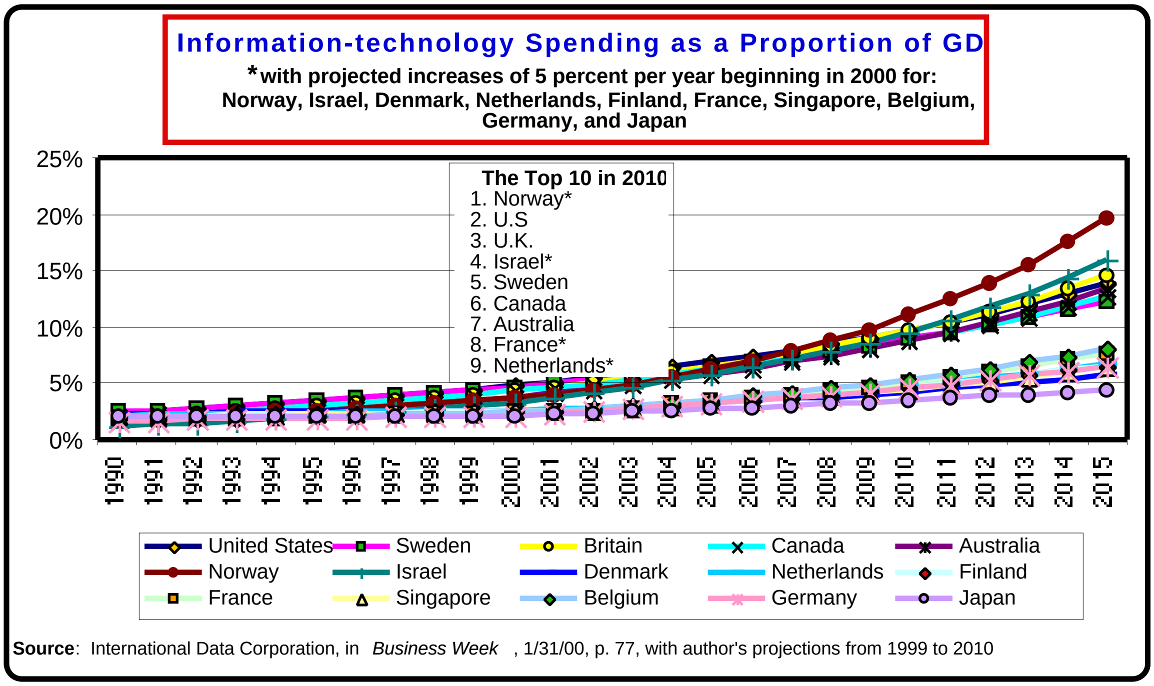
Figure 6



Source: Cable & Wireless, *Financial Times* , Telecoms Survey, November 24, 1999, p. 1, author's projections

While income is a major determinant of the geographic distribution of internet users, host sites, and the level of internet commerce, spending on internet technology to enhance service capacity, is another. Figure 7 illustrates the direct relationship between information-technology spending as a proportion of GDP, with a projection of the top share countries in 2010 based on current trends.

Figure 7



Taking a closer look, the easiest way to understand the internet economy is in terms of the market categories of transactions. Within both the goods and services sector as well as in the financial sector, we can identify four types of internet service market categories: Business to Business, or B2B, Business to Consumer, or B2C, Consumer to Business, or C2B, and Consumer to Consumer, or C2C. Figure 8 illustrates these four categories, along with an indication of representative firms in each category:

Figure 8

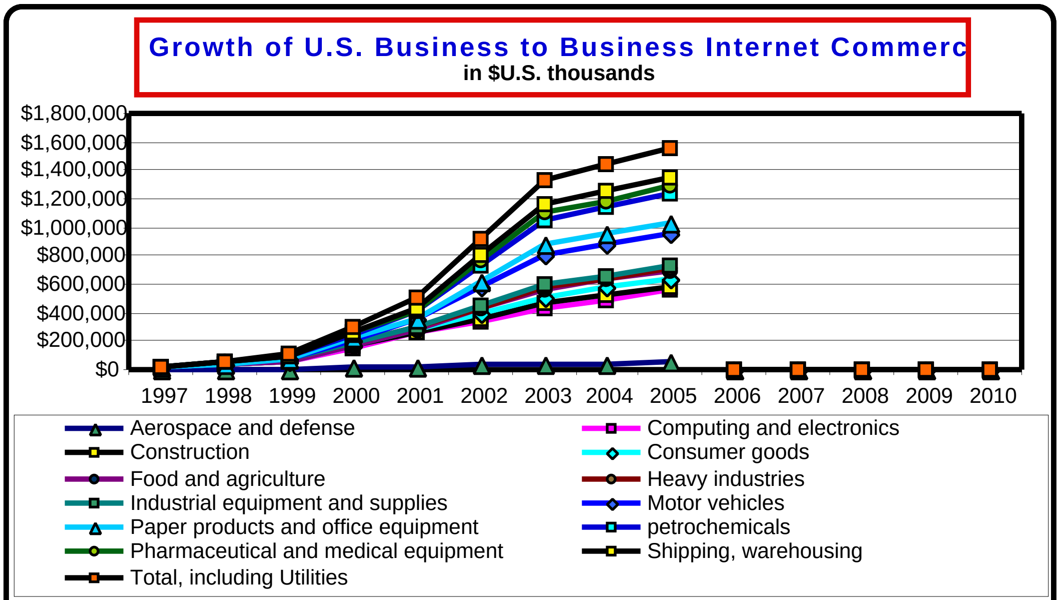
Electronic Commerce Matrix

Business	**B2B** GM/Ford EDI networks	**B2C** Amazon Dell
Consumer	**C2B** Priceline Accompany	**C2C** Ebay QXL

Source: *The Economist*, E-Commerce Survey, February 26, 2000, p. 11

Of these four categories of internet service markets, the largest by far is the B2B market. Total B2B sales represented just under U.S. $110 billion in 1999, but are projected to grow to as much as U.S. $1.4 trillion by the year 2004, as shown below in Figure 9.

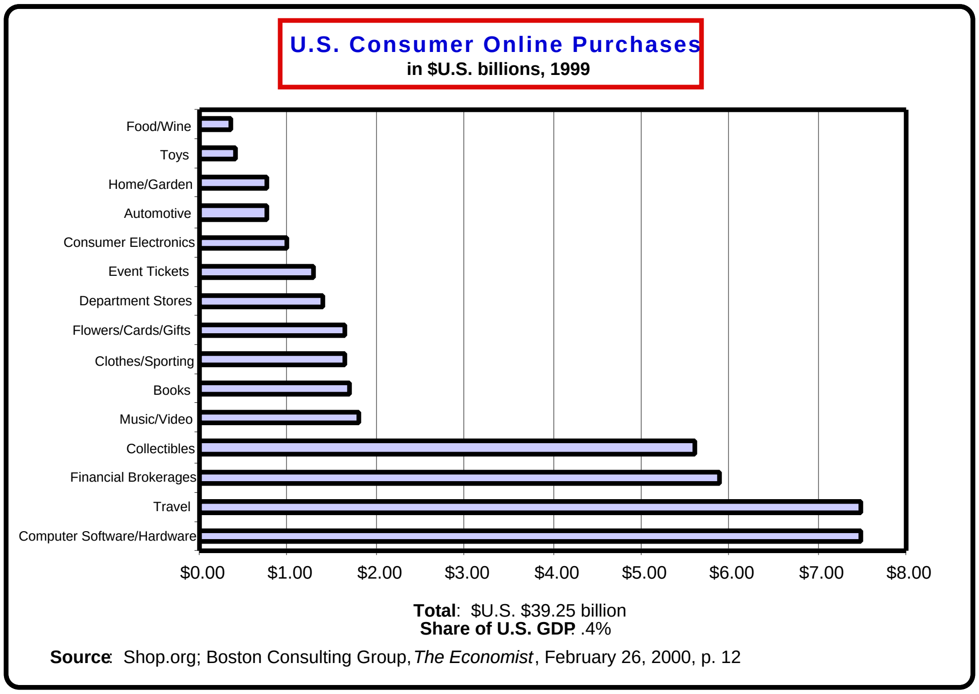
Figure 9



Source: *The Wall Street Journal*, July 12, 1999, p. R7, with author's projections

The second largest category is B2C, or business to consumer internet sales. Households now spend on average 7 hours per week, or 17 percent of the 27.1 hours per week spent on all forms of media technology.[1] While they may gather information from a variety of sources to make traditional and online purchase decisions, the principal categories of business to consumer expenditures as of the end of 1999 represented just over $39 billion, or approximately 0.4 percent of U.S. GDP. Figure 10 summarizes these purchases by principal category.

Figure 10



The remaining categories represent, respectively, approximately $2 and $1 billion, respectively, for C2B and C2C electronic commerce. Together, the size of internet commerce in the U.S. economy in 1999 represented a total of approximately U.S. $152 billion, or 2 percent of U.S. GDP. At current rates of growth, the share of electronic commerce in the U.S. GDP could grow to as much as 5 percent by the year 2004, even though the effects of this commerce on productivity and economic growth may be much greater.

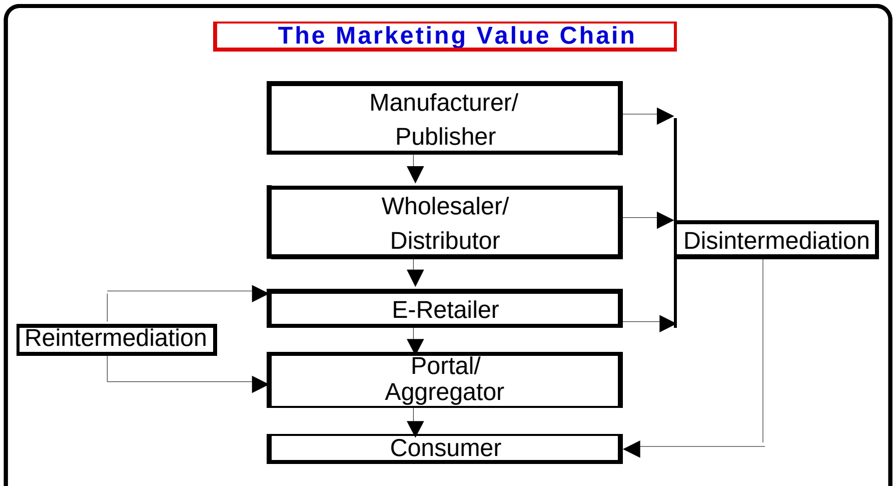
Pricing Strategies in the Internet Economy

What are the key ways in which internet technology affects the pricing of goods and services, and the size distribution of firms? In raising this question, it is useful to draw a distinction between markets in which traditional firms are consumers of internet technology in the marketing of their goods and services as opposed to markets for the production of internet technology itself. We look first at pricing strategies among firms that primarily are consumers of internet technology.

The Internet Technology Consuming Sector

A principal difference that internet technology makes in the production and distribution of goods and services is that it permits substantial savings in the marketing value chain. Figure 11 illustrates how internet technology reduces the distribution chain, thus generating substantial differences in inventory and ordering costs, as well as in startup costs for firms. Instead of goods and services moving from manufacturing through a wholesale distributor, it passes directly to an electronic retailing site which provides closer access to end use consumers. Since electronic retailing provides rapid feedback on ordering frequency and sales responsiveness, manufacturing inventories can be reduced substantially, achieving lower production costs and prices.

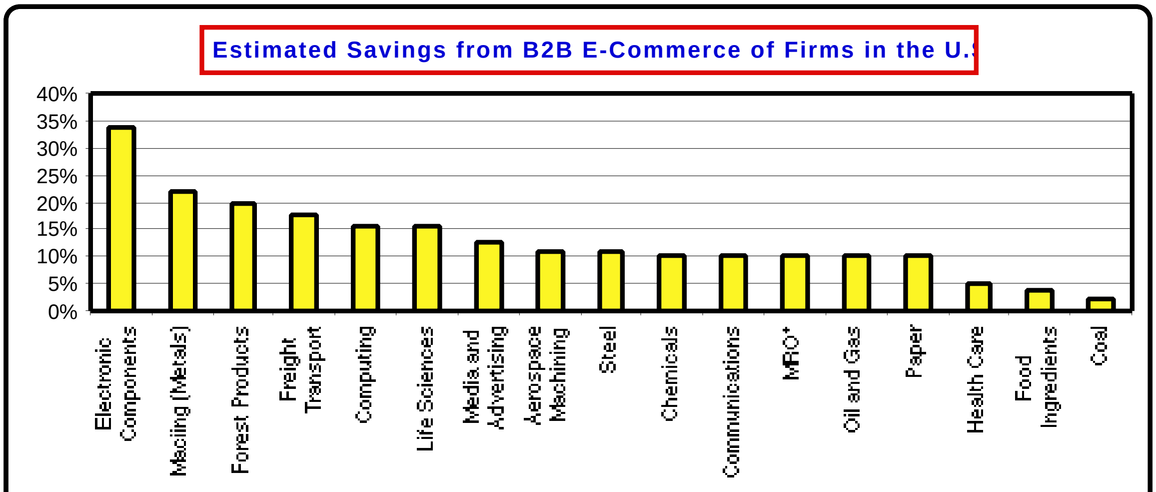
Figure 11



Source: *The Economist*, E-Commerce Survey, February 26, 2000, p. 15

How substantial are the savings from electronic retailing? While there are substantial variations across product lines, there are early indications that greater reliance on electronic sales can generate savings of 30 percent or greater over traditional costs of production. Figure 12 illustrates the results of a recent survey reported in *Business Week*. What they imply is that factor productivity in the economy can be affected substantially through increasing use of electronic sales of goods and services.

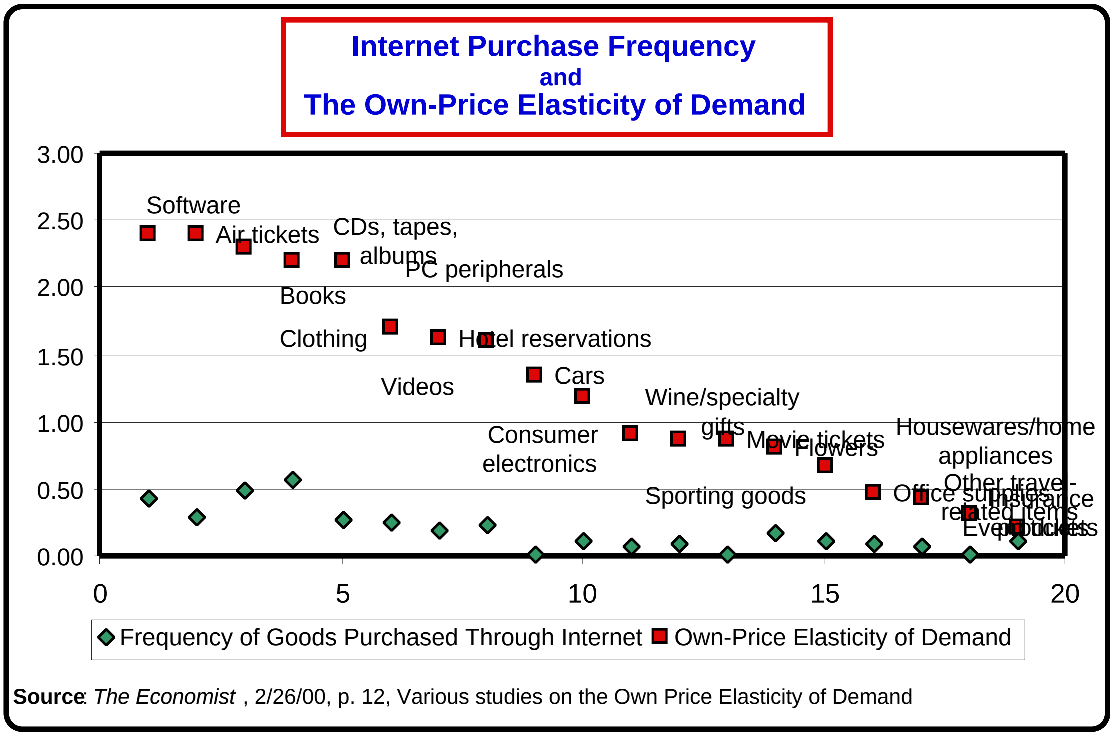
Figure 12



Source: Goldman Sachs, in Business Week, January 17, 2000, p. 37

One additional way to gauge the impact of internet technology on traditional economy firms is in terms of the underlying price elasticity of demand. Goods and services marketed through the internet tend to be far more competitive than those that are marketed through traditional channels. Consumers at the household and firm level have access to low cost price comparisons that search engines make available to them. As a result, goods and services most likely to be marketed through the internet tend to have higher own-price elasticities of demand than those that are not. Using the data from Figure 12, and estimates of the own-price elasticity of demand, we find a correlation of 0.82, and which is summarized in Figure 13.[2] As such, internet goods tend to be more competitive than those that operate through more segmented markets. Moreover, outside of transportation and distribution costs that generally rely on traditional technology, there is relatively little room for price discrimination.[3]

Figure 13



As traditional economy sectors rely more on internet technology, there may be changes in the degree of competition. Thus far, there is little evidence to suggest that rising concentration will result from greater use of internet technology as the size of markets expands from local, to regional, national, and international scale. However, this may not be the case where the internet technology producing sector is concerned.

The Internet Technology Producing Sector

As noted above, while the internet serves as a way to market goods and services in the traditional economy sector, it also functions as a market where internet technology itself is produced and sold. Computer software and hardware represent one of the most important markets thus far in internet sales, and in turn contributes to the expansion of capacity for the marketing of traditional economy goods and services. While the internet technology producing sector shares with the traditional economy consuming sector a relatively high own-price elasticity of demand for many products, there are distinctive features that raise questions for the optimal pricing of resources. These characteristics are: network externalities, bundling, traffic congestion, and bias in taxes and subsidies. We treat each in turn.

Network Externalities

A network exists when the value of a product to the user increases as the number of users of the product grows. Each user derives private benefits from the purchase of an additional good, but this also confers network external benefits on existing users. Examples of such network externalities include operating systems for desktop and mainframe computers, computer instructional chips as well as desktop applications that permit easier and more rapid sharing among users in a network environment. Where heterogeneous networks exist, there may be an under-supply of a given technology, thus causing market failure.

In the presence of network externalities, internet firms often seek to gain early advantage in a market to ensure future growth of revenues and profits. Much of this behavior builds on the framework of transactions costs that shape firms and markets first put forth by Coase (1937), and more recently by Williamson (1975). Where there may be significant switching costs and imperfect information on alternatives, markets acquire path dependence on a given technology, regardless of whether it is superior or inferior to alternative ones (Arthur, 1989, 1990, 1994). As a result, a firm may acquire a dominant position as consumers and compatible producers seek to exploit the presence of network externalities in crafting new products and choices. What does not follow is that a firm may have done so through initial dominance in a market, or even a technically superior product.[4]

Chance events can create path dependence that tips the market against technically superior alternatives, and are more likely in the presence of significant switching costs, imperfect information in general, and asymmetric information in particular.[5] Thus, while Microsoft today is charged with violating antitrust laws, it only gained path dependence against initially successful competitors such as Apple, Sun, and CPM when IBM contracted out to Microsoft for an operating system for its desktop computer system launched in 1981. Such chance events could equally disrupt the dominant position of a firm today as new technology is introduced. Thus, one of the characteristics of internet markets is the rapid proliferation of new technological innovations as firms seek to achieve path dependence in hopes of eventual dominance as network externalities are created and realized.

Not all network externalities are positive. Proliferation of unsolicited fax or e-mail messages constitute a form of electronic junk mail that does not necessarily enhance consumer satisfaction. Shimon (1996) points to the reduction in economic efficiency arising from junk mail. Similarly, network congestion from highly variable traffic creates costly delays in search and communications that undermines the efficiency of a system. We will return to this issue in the context of congestion pricing strategies.

Do network externalities that are essentially positive justify an increased role for government intervention? The classic argument regarding positive externalities is that private markets will provide an under-supply, and that under such circumstances, government should provide a subsidy to achieve a socially optimal solution. In terms of policy options, as long as the costs of public sector intervention are less than the external benefits from networks, there is a theoretical case for such subsidy. However, many observers (Katz and Shapiro, 1994; Liebowitz and Margolis, 1994, 1995a, 1995b) point to the limited empirical support regarding the extent of network externalities to justify an expansion of government intervention, even though the theoretical issue may be clearly understood. What makes the issue more complicated is that market-driven efforts to maximize network externalities may result in classical monopoly outcomes that may be equally inefficient.

Most observers would suggest that if network externalities resulted in a single firm achieving dominance, only if it resulted in higher prices would it met the test of a classical monopoly. Instead, what has happened in the software desktop applications market where Microsoft Corporation has achieved a dominant position, prices have actually declined. McKenzie (2000) takes a close look at the Microsoft antitrust case and concludes that the firm’s dominance in operating systems does not meet the test of a classical monopoly. In the period from 1986 to 1990, when WordPerfect™ was still dominant, word processing prices rose by 35 percent. In the period since then, from 1990 to 1997, when Microsoft Word™ became dominant, software prices fell by 75 percent. The test here, then, is whether Microsoft is using predatory pricing, that is, deliberately charging below marginal cost pricing initially to gain market share in order to drive out rivals, and then proceed with raising prices. As McKenzie (2000) notes, even such falling prices by Microsoft have not prevented new entrants from competing in the operating systems market, as with Linux™ and FreeBSD™, or with continuing competition from other desktop applications manufacturers.

The Economics of Bundling

One implication of the presence of network externalities is that it leads firms to adopt zero or below marginal cost pricing strategies for the introduction of new products as a strategy for achieving path dependent dominance. This is another way of stating that firms may sacrifice short-term profits in exchange for the present value of longer term rates of return at least equal to the opportunity cost of capital. Seen from this light, the decision by Microsoft to give away its Internet Explorer™ software program, and to later bundle it in its operating system looks like a rational strategy for achieving market dominance. This decision then forced once dominant Netscape Communicator™ to seek a partner through its merger with AOL, itself once considered a rival. Similarly, firms such as Adobe may offer free versions of its Acrobat Reader™ software in the expectation that adopters will purchase compatible products whose rates of return underwrite the costs of the zero cost startup package. Or one could cite computer printer manufacturers who offer their equipment at below marginal costs of production, but recoup the difference through more profitable resale of printer cartridges and paper.

Katz and Shapiro (1994) describe the bundling behavior of firms as 'penetration pricing' in that it permits a firm to achieve a lower eventual price of its product once economies of scale or scope can be realized. It resembles predatory pricing in antitrust, but differs in that it is predicated on the realization of both network externalities as well as potential economies of scale and/or scope. Farrell (1989) goes further to suggest that pre-announcement strategies designed to ward off switching actually is likely to lead to the adoption of a better technology. This proposition may be accurate but only to the extent that information is symmetrically distributed, as noted by Lemley (1996).

Bundling also creates periodic incentives for rivals to create informal network alliances that can achieve greater potential for market penetration and growth. In the 1980s, the Sematech consortium provided an opportunity for rival firms to work on computer standards issues, one result of which was the development of the Power PC chip developed by Motorola that could run both IBM and Apple software programs. More recently, the development of the universal system bus, or USB, connection, has been designed to overcome some of the compatibility issues arising from separate use of serial and parallel cable connections for computer hardware and peripherals. However, the likelihood that such alliances are permanent is not great since participating firms invest in them on the proposition that it will yield ultimate returns in the form of market sales and profitability. Braunstein and White (1985) review these issues and the challenge of adopting universal standards of technical compatibility within the framework of antitrust precedents.

The literature on bundling dates from Stigler (1963), and was modeled formally by Adams and Yellen (1976) and refined further by Eppen, Hanson, et.al. (1991). Schmalensee (1984) finds that pure bundling reduces the diversity of the population of consumers since the standard deviation of consumer valuations for a bundle is less than the sum of the standard deviations of valuations for its components. As such, bundling enables a firm to capture consumer surplus, thus increasing profitability.

Bundling may establish a path dependent winner-take-all market, as appears to be the case with Microsoft's Windows and desktop applications programs. This effect of bundling differs from technological economies of scale or scope such as put forth in Spence (1981) or Baumol (1982), network externalities as put forth in Farrell and Saloner (1985), or even financial market imperfections such as asymmetric information, as described in Bolton and Scharfstein (1987). The question is whether a likely winner-take-all market represents de facto classical monopoly or whether it results in increasing consumer welfare.

Optimal Pricing of Internet Traffic Density

One byproduct of the growth of internet commerce is traffic congestion. Under the current system, users pay essentially flat fees for internet access, while traffic density across the internet may vary substantially at any given time. Under the current Transmission Control Protocol (TCP) system, when traffic builds, information packets begin to queue and the corresponding time to complete transmission slows. Greater speed is achieved when user demand declines, or when greater modem speed and bandwidth capacity is installed. The question is what pricing system can achieve the most efficient allocation of internet service use.

There currently are at least four models for optimal pricing of internet traffic density. The first is a flat rate system where the rate covers all fixed, or sunk, costs, and provides for some allowance for marginal costs of operation. Flat rate systems are easy to understand, promote high use, but do nothing to address the problem of network congestion. Srinagesh (1995) reviews this model in light of existing alternatives.

A second approach is the telephone model in which one pays a two-part tariff. The first part is designed to cover the fixed, or sunk, cost of service while the user charges reflect the marginal cost. Under the current system, the telephone model does provide for changes in costs based on time of day and day of week variations, but these do not fully reflect the marginal costs of operation. As such, even in an unregulated market, the result is that service providers tend to invest in bandwidth capacity, much like the electricity generation model where peak-load pricing is only partly used. If there is an advantage of the telephone model, it is that it at least moves in the direction of marginal cost pricing, and thus is superior to the flat rate system.

A third approach is a precedence model in which technical priorities are assigned to information packets and pass through the TCP queuing system. Bohn, et.al. (1994) offer this system as a technical solution to internet traffic congestion. While it makes intuitive sense, it provides no way to evaluate the economic value of the priority system, nor any clear way how priorities would be determined or monitored.

The fourth approach is the smart market mechanism put forth by MacKie-Mason and Varian (1995). This model involves a dynamic bidding system in which the price of sending an information bundle is determined instantly to reflect the level of network congestion. This could work in terms of available message units in a system, or in terms of an economic price within a budget, and would be displayed on a screen at the time when an initial transmission command is established. A user then has the choice of whether to pay the premium that arises in a congested time period, or to defer transmission until traffic density declines. Of the four alternatives the smart market comes closest to achieving economic efficiency in theory. What does not appear to be the case is that it is translating into practical applications, particularly the software that would enable such an optimal pricing system to be put into practice.

Taxation and the Internet Economy

Rapid though the rise of the internet has been, the expansion of internet commerce poses a dilemma for economic policy, namely, whether internet commerce should be subject to taxation. Within national boundaries, interstate commerce generates differential impacts on state and local tax revenues. Because reciprocity agreements have not been established, firms that ship goods from some states do not result in the imposition of sales and/or excise taxes in another state to which goods have been shipped. Given that internet commerce may generate disproportional growth in interstate commerce, state and local governments may lose revenues. To those who find that the overall tax burden already is excessive, the rise of internet commerce is welcomed as a way of effectively reducing the burden, even though the distributional and efficiency consequences may not yet be fully understood.

Given the potential loss of revenues, some have proposed that the federal government impose a uniform tax rule on internet commerce. Thus far, the U.S. government has resisted the imposition of such a rule, even though it has become an issue at the national level. In terms of optimal taxation and optimal pricing, there are two approaches that one can consider.

First is to adopt the stance that the tax burden is fixed and optimal, and then to consider what rate of taxation on internet commerce would compensate for the loss of tax revenues from in-state industries and firms who lose on a net basis to internet commercial firms. Apart from the difficulty of determining whether the present tax burden is optimal, this approach also assumes that firms will not themselves adopt internet commercial strategies that will enable them to capture revenues from out of state that would otherwise be lost.

The second approach is to consider what combined rate of internet and traditional taxation will generate a level of revenues sufficient to satisfy distributive and compositional goals consistent with a desired rate of economic growth. This is a complex issue not likely to be answered within the context of a standard economic model, but one which should be addressed simply because it could provide clearer guidance on the question of whether any or some level of taxation on internet commerce should be adopted. To the extent that states find themselves faced with raising taxes on traditional sources and/or being compelled to borrow or reduce spending will undoubtedly result in greater focus on this issue. What this does not resolve is what, if any, role should be applied by the Federal government other than that of coordination.

Conclusion

Optimal pricing of internet services depends ultimately on whether economic efficiency is achieved. At the internet consumer level, the internet affords an opportunity to move closer to a more competitive marginal cost pricing environment than in many traditional segmented markets. At the internet technology producer level, pricing strategies involve network externalities and bundling in which dominant firms may emerge. While this appears initially at odds with the competitive model, where prices are falling and services are expanding, innovation may generate a stream of products in which the technical efficiency of the internet can improve. In terms of access, peak-load pricing combined with expanded capacity investment will undoubtedly allocate resources to internet technology growth, albeit in less than the economically most efficient manner. Finally, taxation of the internet will depend ultimately on the impact of internet commerce on issues of income distribution, the optimal composition of goods and services being produced, and the extent to which changes in the burden of taxation in combination with monetary policy result in raising or lowering the rate of economic growth.

Endnotes

[1] Jupiter Communications, NFO Interactive, as reported in *The Wall Street Journal*, December 6, 1999, p. 8

[2] Houthakker and Taylor (1970) provide estimates for most of these goods and services. Though dated, more recent estimates would most likely provide continuing affirmation of the positive correlation.

[3] There is even less room in the case of music, and some forms of text data distributed through the internet. MP3 music technology may bypass audiocassette and cd-rom technology by permitting consumers to purchase and download items directly from the internet. In turn, MPEG technology may do the same thing for video, though this is so far constrained by the limits of broadband distribution capacity.

[4] David (1985), Besen and Johnson (1986), and Arthur (1990) provide illustrations of the issues surrounding the respective adoption or rejection of the QWERTY keyboard, the VHS over the Betamax videocassette system, and AM Stereo. Path dependence is comparable to Stephen Jay Gould's theory on evolution, that certain species survive not because they are necessarily superior but because a series of random events generated the series of probabilities that determined the eventual path of adoption or extinction. To the extent that path dependence consistently rejects technically and economically inferior products suggests that the presence of imperfect information can undermine the role of markets in generating an economically efficient allocation of resources. Besen and Farrell (1994) suggest that firms may use advertising to steer the formation of consumer expectations of a market technology standard, thus raising the bar on switching costs. Farrell and Saloner, (1986b) also point to product early announcements, sometimes that acquired the reputation of 'vaporware' in the software industry, as a tactic to ward of switching to another system. Both practices are characteristic of imperfectly informed markets regarding the likely direction of future technology.

[5] Switching costs represent a type of entry barrier to competition. They are higher, the more pervasive are the sunk costs of a technology and the more dominant is the market share of an existing firm. Klemperer (1987a, 1987b, 1989) illustrates the nature of switching costs on path dependence in a market technology.

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