# Economics of the "New Economy"*

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**"Technology changes. Economic Laws do not."**

- Carl Shapiro and Hal Varian, "Information Rules", 1999

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## Abstract

The "new economy" has distinctive features where information technology is allegedly the main contributor to increased productivity and information goods are of central economic importance. Because of the nature of information goods, some market phenomena and issues that have secondary effects for industrial goods often have primary effects for information goods. This paper reviews these market phenomena and issues, such as bundling, network effects, lock-in, and standards, and examines their implications. They are not necessarily new economics; some have been part of the economics literature for decades. But these economic concepts explain important features of the new economy.

## I. Introduction

The U.S. economy showed a remarkable record for the four and a half years following 1995. The output of the economy – as measured by real gross domestic product – grew rapidly, the unemployment rate declined, and inflation slowed. This economic expansion had peculiar features where information technology was allegedly the main contributor and information goods were of central importance to the "new economy".

Because the information goods are different from industrial and other regular goods, the nature of competition in these markets may also be different. This paper surveys market phenomena, such as bundling, network effects, and lock-in, that are critical in the information economy, and examines their impacts in the corporate and public arena.

The next section discusses what is new in the new economy. Section III proceeds with the contributions of information technology to economic growth and productivity. We will learn how information goods are different from other goods in section IV. The remaining sections cover market phenomena and issues that are prevalent in the new economy: price discrimination (section V), intellectual property (section VI), lock-in (section VII), network effects (section VIII), standards (section IX), and transaction costs (section X). The last section summarizes the implications of these phenomena and issues in the new economy.

## II. The "New Economy"

The Editor-In-Chief of Business Week, Stephen Shepard, wrote in 1997 "Now that the stock market is apparently going through an overdue correction, a long-running economic debate has flared anew. Is there really a "new economy"? An even better way to ask this question is what is so new about the new economy?

The press popularized the new economy doctrine in the second half of 1990s. But everyone seemed to have his or her own definition. Krugman (1997) summarized it "as a view that globalization and information technology have led to a surge in the productivity of U.S. workers." Furthermore he explains:

> "This, in turn, has produced a sharp increase in the rate of growth that the U.S. economy can achieve without running up against capacity limit. 'Forget 2% real growth,' urges Shepard. 'We're talking 3%, or even 4%.' This increase in the potential growth rate, in turn, is supposed to explain why the United States has managed to drive unemployment to a 25-year low without inflation."

Evidence from the macro statistics (Appendix A) suggests that the real GDP growth rate rose to between 3 and 4 percentage points since 1996 and the unemployment rate fell from about 7 percent in 1992 to 4 percent in 2000, while the inflation rate was around 3 percent since 1992. The failure of inflation to rise when the economy grows and the unemployment rate dips creates a suspicion that there might be something new going on with the economy.

The combination of low inflation and low interest rates propelled the stock market to unprecedented valuation levels, along the way creating $10 trillion of nominal wealth in four years (Gordon, 1998). NASDAQ, where most information technology companies list their stocks, had a cumulative rate of return that surpassed that of the S&P 500 by a wide margin after 1995, before crashing back in 2000 (Appendix B). The dramatic run-up in the technology stock prices was the result of an investment boom in information technology (IT). This IT investment boom has often attributed to the increase in productivity growth (Varian, 2001). U.S. productivity growth in the non-farm business sector (Appendix C) showed an upward trend from 1993 to 2000 (top figure), with an annual trend growth of 2.8 percent in 1995 - 1999 period (bottom figure). So IT may be the underlying "new cause" to the seemingly new economic performance of the new economy.

## III. Information Technology, Growth, and Productivity

To have a better understanding of the relationship between IT and productivity, we will discuss the IT industry, its products and services, key technological innovations that drive the industry, and the contribution of IT to increased productivity.

The Information Technology Association of America (ITAA) defines IT as "the collection of products and services that turn data into useful, meaningful, accessible information." Some of these products and services are semiconductors, computers, packaged programs, telephones, televisions, radios, and network routers. The ITAA classifies them into IT sub industries: hardware, software or services, communication equipment, and communication services (Appendix D).

One of the stylized facts about the technological progress in the IT industry is now popularly known as *Moore's Law* (Moore, 1965). The law says that the number of transistors per microprocessor chip will double every 18 months, or to interpret it in non-technical terms, the price of computing power falls by half every 18 months. The evidence in Appendix E shows that the number of transistors per chip has doubled roughly every 12 to 24 months since 1970. This technological change has translated into an annual decline of computing costs because a chip manufacturer can now produce twice as powerful a microprocessor as it did 18 months ago, for the same price. Statistics show that computer prices declined annually by 12 percent from 1987 to 1994, and 26 percent from 1995 to 1999 (Appendix F).

One key innovation that coincides with the "new economy" is the growth of the *internet* network. The first internet network, called ARPANET, was commissioned by U.S. Department of Defense to connect four hosts in 1969 (Zakon, 1993-2002). The number of hosts had doubled almost every year since then, and reached one million in 1992 and ten million in 1996 (Appendix

G). Two events occurred between 1992 and 1996 that propelled the growth of the internet network even more in the "new economy": introduction of the World-Wide Web (WWW) in 1991, and privatization of the internet in 1995. The growth of WWW sites was even more impressive than that of internet hosts up to year 2000 (Appendix G). By March 2000, the internet population had grown to 140 million people in North America and 300 million in the world (Appendix G).

The combination of the accelerated computing power (Moore's Law) and the growing network interconnectivity (internet) has increased the IT industry' share of total output from 6.3 percent in 1994 to about 7.5 percent in 1998 (Appendix H). Although the IT industry produces less than 10 percent of total output, because of its remarkable growth between 1995 and 1999, it contributed about 30 percent of the total real economic growth during this period (Appendix I).

IT does play an important role in the U.S. economy's growth because of the rapid growth of business investment in IT. IT investment has grown from about \$200 billion in 1994 to \$500 billion in 1999 (amounts are in 1996 dollars) (Appendix J). Notice that real investment in computers grew more rapidly than that of telecommunication equipment and software since computer prices declined much more than prices of other types of IT capital.

The rapid growth of real IT capital spending has contributed to significant IT "capital deepening" (increase in IT capital per labor hour) in the second half of the 1990s based on various studies (Appendix K). The combination of IT capital deepening and IT technical advance (capital quality improvement from IT) gives us the total IT contribution to productivity growth. The consensus of the studies indicates that IT contributed at least half of labor productivity growth from the first to the second half of the 1990s.

If IT capital is productive, we need to know what makes it different from any other technology. Particularly we look at the information side of the "information technology" as a marketed good and learn how it is different from any other good.

## IV. Information Goods

Information goods consist of the information itself and the processors of that information. We define information as anything that can be encoded as a stream of symbols, such as books, music, movies, and programs. Information processors are technologies that are used to store, search, retrieve, organize, transmit, and digitize that symbols, for example computers, CD-ROMs, word processors, spreadsheets, database software, and the internet.

What makes the information goods different from other goods is their production costs which are dominated by the fixed costs of creating the knowledge, or the "first copies" of the information. For example, the design cost of a software is likely to be a larger share of the total cost of its production than is the design cost of an automobile. Once the knowledge has been created, additional copies of the knowledge can be produced very cheaply. Others can then copy and share that knowledge at a minimal cost. Furthermore, the consumption of that knowledge is non-competing, which means it is a public good.

### A. Production Costs

We said previously that information goods are essentially "costly to produce but cheap to reproduce" (Shapiro and Varian, 1999). Economically speaking, the fixed costs of production are high, but the marginal costs of reproduction are small. Most of the fixed cost is not recoverable when production is stopped; it is a sunk cost. Investors will not be able to recover their investments by selling the design specifications of a particular software once it becomes obsolete.

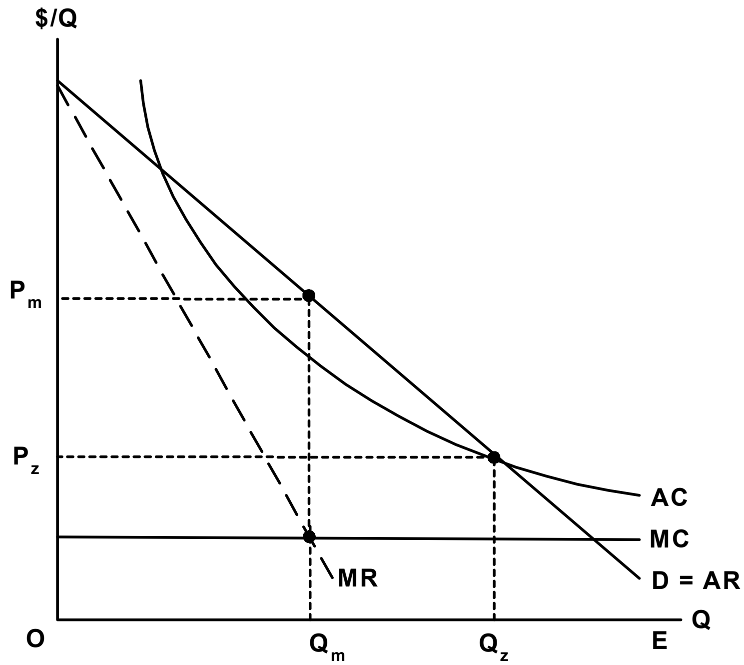


**Figure 1: Natural Monopoly**

Unlike the variable costs of other goods, information goods do not face rising variable costs. A million copies or ten million copies of software costs roughly the same per unit. This is essentially the cost structure in the classic natural monopoly, where average and marginal costs are falling (Figure 1). The substantial economies of scale – high fixed costs and small incremental costs – tends to lead to large scale operations in a concentrated industry[1].

**B. Replication and Redistribution Costs**

If the creators of information goods can reproduce them cheaply, others can replicate and redistribute them cheaply as well. With digitized information and its processors, such as a word processor and an electronic book, easy reproduction of a perfect replica is enabled. The rise of wireless and internet technologies allows an instantaneous transmission of that replica around the world.

[1] Product differentiation limits the concentration in the industry.

This creates a new challenge for the content producers to protect and maximize the value of their intellectual property. It usually requires a tradeoff between short-run consumption efficiency losses and long-run production gains (Liebowitz, 2002). On the one hand, restricting the ability of others to replicate and redistribute would reduce consumption to a less than optimal level. The results would be welfare and revenue loss, due to lower consumption and less exposure to potential buyers correspondingly. On the other hand, unrestricted replication and redistribution at very low (or zero) prices would reduce the incentive of the property owners to produce intellectual properties.

### C. Public Goods

Because information goods, such as ideas, inventions, and artistic expressions, are not physical, they do not get used up when consumed; they are nonrivalrous in consumption. In other words, information goods are public goods. However, they are not necessarily pure public goods because they may be "excludable".

Exclusion of nonpayers from free-riding the benefits of information goods is possible through a legal infrastructure and copy protection technologies[2]. A patent system supports inventions, copyrights protect artistic and literary inventions, and digital rights management (DRM) prevents unauthorized copying of digitized information. Such excludability allows public goods to be produced privately (Demsetz, 1970).

But what is the optimal provision of the public goods? Let us consider the heterogeneous demands in the science fiction genre movie titles (Figure 2). We can think of the all titles in this movie genre, on the horizontal axis, as the public goods, but the screenings of the movie titles are private goods. Consumer 1 (d1) has the least interest in the science fiction titles, whereas

[2] Copy protection is a temporary exclusion since "no copy protection has ever been invented that has not been broken" (Lima).

consumer 3 (d3) has the highest valuation for this genre. Since the movie titles are consumed in *equal* amount by the three consumers, the market demand (Dm) is the *vertical* summation of their demands. Assume that the movie industry supply is horizontal at a minimum average cost equal to marginal cost. The efficient provision of this genre titles will occur at Q* and P* where market demand equals the marginal cost.

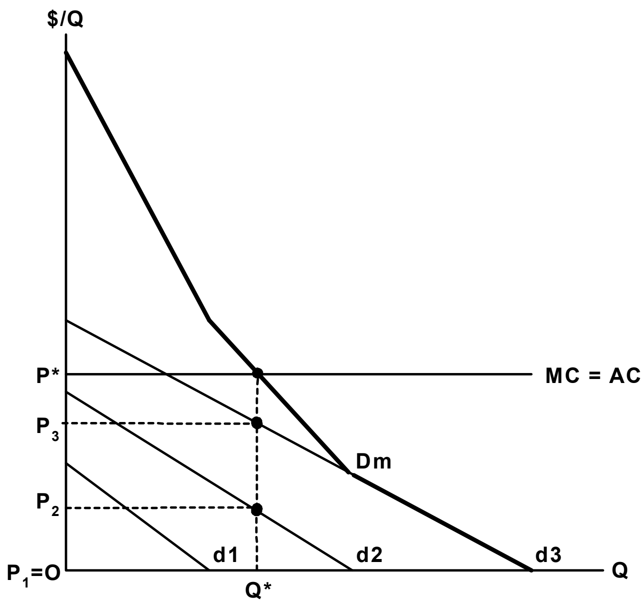


**Figure 2: Private Provision of a Nonrivalrous Good**

If private firms charge a single price equal to per capita share of the marginal cost (P*/3), they may lose revenue from consumers whose valuations are less than this price. With price discrimination at the efficient provision (Q*), the science fiction movie buff (d3) pays P3, the irregular moviegoer (d2) pays P2, and the one with the least interest in this genre (d1) pays nothing. This may mean the science fiction buff pays premium prices to watch each movie multiple times, the medium demand goes only once, and the lowest demand waits for free broadcast on TV. Therefore, the private suppliers of the movie titles should not charge a single price. They should price discriminate.

## V. Price Discrimination

### A. Third-Degree Price Discrimination

Assume that movie producers price discriminate in two movie markets (Figure 3). The first market is the movie fan with inelastic demand (d1), and the second market is the occasional moviegoer with elastic demand (d2). Prior to the price discrimination, movie suppliers charge a single price ($P1_0 = P2_0$) for both markets. The first market with inelastic demand has lower marginal revenue ($mr1_0$), and the second one has higher marginal revenue ($mr2_0$).

Firms can increase their revenues by increasing their prices (P1*) in the inelastic market and lowering their prices (P2*) in the elastic market, thus shifting the outputs in the opposite manner (Q1* and Q2*), until their marginal revenues are equal (mr1* = mr2*) (Liebowitz, 2000). This increase profit because the firms lose a small revenue increment from the first market, but gain a larger revenue increment in the second one.

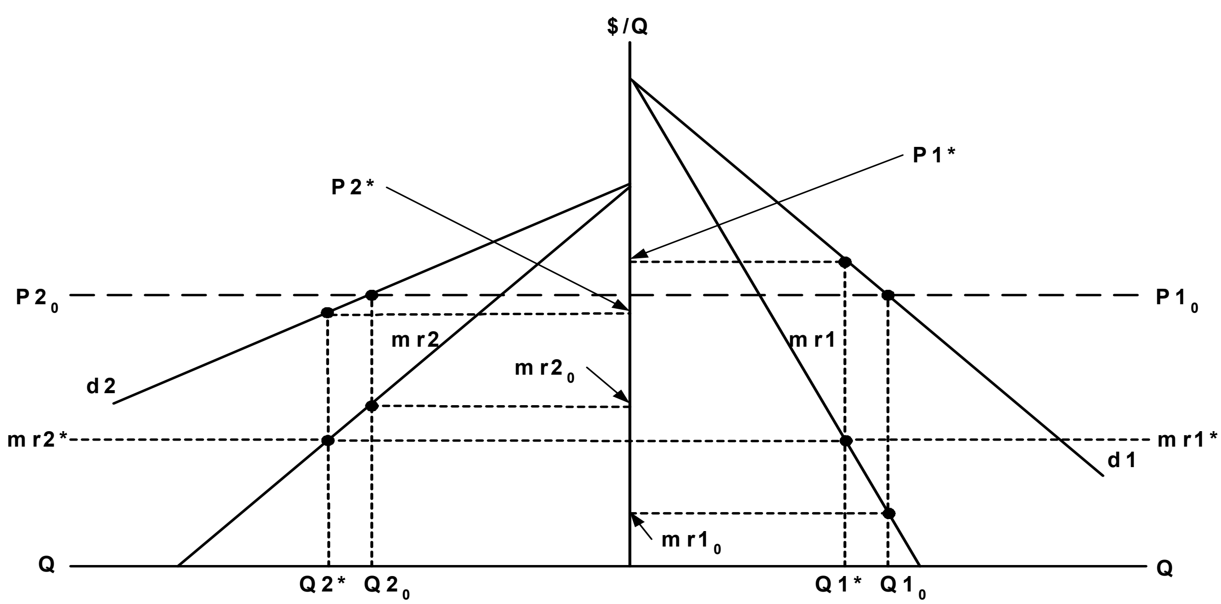


**Figure 3: Third-Degree Price Discrimination**

Therefore, the movie producers can increase revenues by charging the movie buff more in the first run cinemas and charging the occasional moviegoer less in the movie rental stores.

Other methods to achieve the same end are opening night surcharges or not allowing discount, bargain matinees, senior or student or child discounts, second run theatres, etc. All these practices are known as a third-degree or an interpersonal price discrimination, where the sellers charge different prices to different group of buyers. Meanwhile the lowest demand group with the highest elasticity waits to watch the movie on TV[3].

"Typically, textbooks list several conditions that must be met before a firm can price-discriminate in an ordinary private goods market. These conditions include: the absence of competition, in the sense of multiple, non-cooperative sellers; the prohibition of resale; and the availability of information about individuals' demands or demand elasticities" (Shmanske, 1991, p. 56). The first two conditions affect the ability of consumers to engage in arbitrage, buying low and selling high, and thus, in effect, undoing the market separation. Since information goods can be differentiated in many ways, such as delaying the movie in the rental DVD form, having non-cooperative sellers may not be a problem. Patents, copyrights, and copy protection technologies[4] prevent the reselling of videotaped movies from cable TV, or pirated DVD movies. Repackaging movies for cable TV or DVD self-identifies the individual market and their demand characteristics.

**B. First-Degree (Perfect) Price Discrimination**

Businesses have attempted in many ways to price discriminate between different groups of consumers, such as with student discounts, peak hours pricing, and cents-off coupons. They are common practices and probably not difficult to implement. To achieve a perfect or first-degree price discrimination (Pigou, 1920) is much more difficult. It involves charging different

[3] There is even third-degree discrimination on TV, such as premium cable (e.g. HBO), second run cable (e.g. Encore), and broadcast (e.g. NBC).

[4] Copy protection is a temporary preventive measure as indicated in footnote 2.

prices for different units of essentially the same good for the same person, or intrapersonal price discrimination.

Producers can charge a uniform price of P1, P3, or P5 (Figure 4) and earn P1Q1, O3Q3, or P5Q5 respectively. If they know what a consumer is willing to pay at point A, B, C, D, and E, they can capture even more consumer surplus and maximize their producer surplus. The challenge is to learn the maximum price that each person is willing to pay at each point along the demand curve[5].

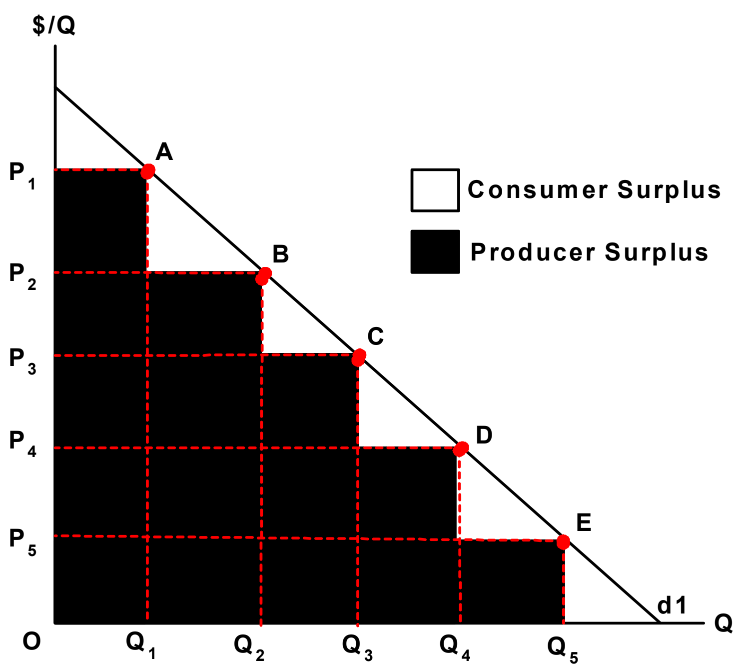


**Figure 4: Perfect (First-Degree) Price Discrimination**

The internet, as a one-to-one communication media, helps acquiring such information. Consumers can actively submit their demographics via online registration and/or passively reveal their interests via their click stream behaviors[6]. Producers can then use this information to charge different prices accordingly. Such personalized pricing is usually impractical in the

[5] Producers also face the challenge of charging each individual a different price without him or her engaging in arbitrage.
[6] The author does not suggest that this is a perfect measure of the individual's elasticity.

industrial economy because of the costs involved in changing the prices, or the so-called menu costs.

Today companies can use business enterprise software that accepts direct orders from the consumers via the internet, tracks their inventory in the real time, and fine-tunes their prices just as fast, thus eliminating the menu costs. The evidence shows that the internet retailers adjust their prices much more often than the conventional retailers, and the prices are changed in much finer increments (Brnjolfsson and Smith, 1999).

### C. Second-Degree Price Discrimination, Versioning, and Bundling

If getting valuable information about the consumers is expensive and impractical, the producers can price discriminate by offering a set of related products where everyone faces the same price schedule. This alternative refers to second-degree price discrimination, a product line pricing, or a versioning. For example, Yahoo offers 20-minute delayed stock prices for free and real-time stock quotes for $9.95 a month. The cost structure of the information good explains why the versioning is widely used in the information economy. Once Yahoo builds a basic system to extract the real time stock price, it does not cost much to develop a version that delays the same information[7].

The problem with versioning is "competing against yourself" (Varian, 2001). Consumers with a high willingness to pay might be attracted to the lower priced versions that target consumers with a lower willingness to pay. To solve this "self-selection problem", the producers can lower the price of high-end goods, or lower the quality of the low-end goods. Thus versioning is a trade-off between output efficiency, serving markets that would otherwise not be served, and social costs, reducing quality to solve the self-selection constraint.

[7] This example does not consider the fact that the stock exchanges also price discriminates the stock quotes to Yahoo.

One special form of versioning is bundling (Adams and Yellen, 1976), involves offering two or more distinct products as a package for a single price (in addition to offering them as separate products). Bundling differs from "tie-ins" in that tie-ins do not force customers to purchase individual products in fixed proportions up-front. If you buy an HP laser printer, you may be tied-in to use HP toner cartridges in the future. But you are not forced to buy the printer and stock of toner cartridges as a bundle at the initial purchase. Well-known examples of bundles are movie block booking and Microsoft Office suites. But why do producers sell in bundles instead of individual products one by one?

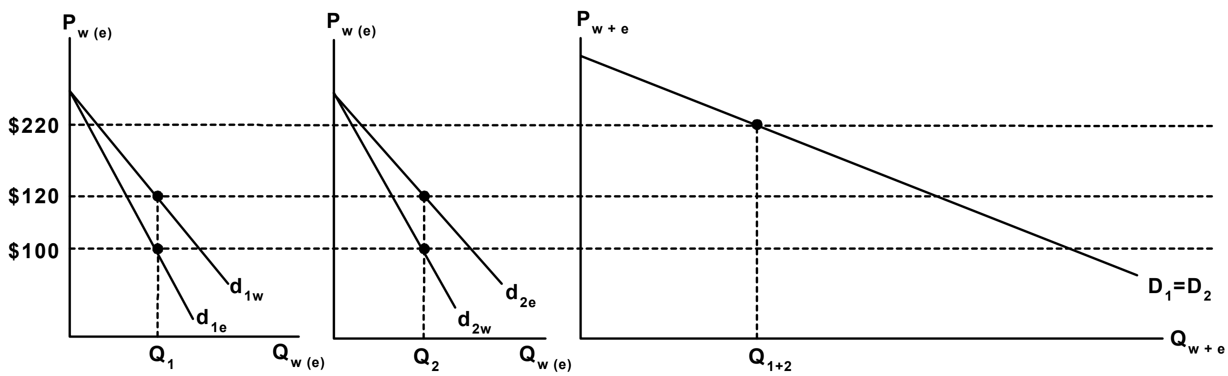


**Figure 5: Bundling and Reduced Dispersion of Willingness to Pay**

If consumers value products differently from one another, the producer can collect more by bundling the products (Stigler, 1963). The assumption is that the consumers ($d_1$ and $d_2$), have heterogeneous tastes, or dispersed willingness to pay ($d_{1w}$ and $d_{1e}$), and they are inversely correlated ($d_{2e}$ and $d_{2w}$) (Figure 5). Thus the producer can extract more consumer surplus from a flatter demand curve ($D_1 = D_2$) or a less dispersed willingness to pay through the bundling. The similar example in Table 1 shows that the bundling of software applications increases revenue for the two consumers with different willingness to pay for each application.

| Willingness to pay | **Microsoft Word** | **Microsoft Excel** | **Microsoft Office** |
|---|---|---|---|
| **Mark (1)** | $120 | $100 | $220* |
| **Noah (2)** | $100 | $120 | $220* |

| Willingness to pay | **Individual pricing $120** | **Individual pricing $100** | **Bundling pricing $220** |
|---|---|---|---|
| **Mark (1)** | $120 | $200 | $220* |
| **Noah (2)** | $120 | $200 | $220* |
| ***Revenue*** | ***$240*** | ***$400*** | ***$440*** |

Note: * assuming that the willingness to pay for the bundle is the sum of the willingness to pay for the components.

**Table 1: Bundling for Software Applications (Shapiro and Varian, 1999)**

Bundling also has an entry deterrent effect (Varian, 2001). It allows a monopoly software vendor to reach not only consumers who value word processor and spreadsheet highly, but also consumers like Mark and Noah, who value only one product highly. Entrants in the word processor market find themselves with shrinking residual demands for their products, making entry less profitable. They may then pursue bundling as a way to enter and compete in the market - a costly and a more risky entrant strategy.

For consumers, bundling has the "spin off" effect on productivity. If producers set individual pricing at $120, Mark will only buy and use the Microsoft Word. With bundling pricing at $220, he will buy both Microsoft Word and Excel as a bundle (e.g. Microsoft Office). Mark may not use Microsoft Excel in the beginning either because he has no current use of it or he has not been familiar with it. Bundling allows him to give the spreadsheet a try and later appreciate the value of it more than if he does not buy it under the individual pricing at $120.

## VI. Intellectual Property

Whereas bundling involves two or more distinct products, copying and sharing an intellectual property involves two related products that are substitutes for one another, namely the original good and its copy. If a copy is an imperfect substitute for the original, then there will be separate markets and demands for the original and its copy. However, if the copy is a perfect substitute, then there will be only one market.

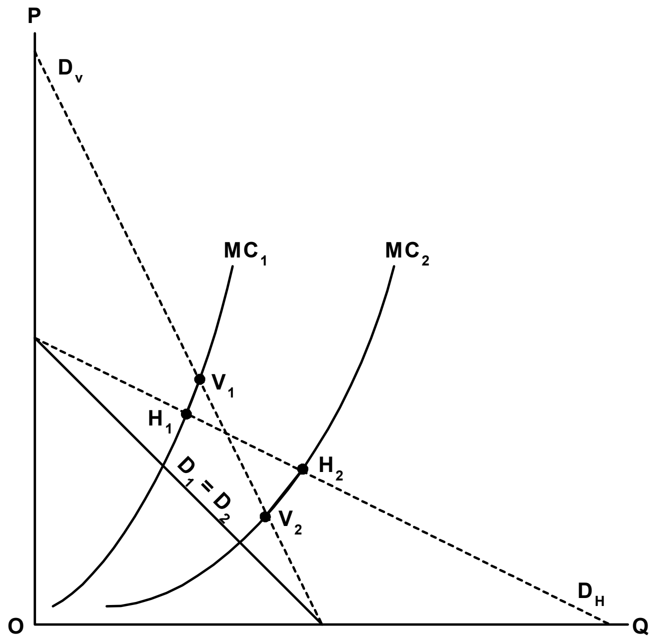


**Figure 6: New and Used Books Markets**

Let us examine the demands for new and used books (Benjamin and Kormendi, 1974). We begin with identical demands for the new books ($D_1$) and the used books ($D_2$) (Figure 6). If we allow the existence of the used books market, the net demand is the *vertical* summation of $D_1$ and $D_2$ to become $D_V$, an approximate outcome of copying the books. If we outlaw the used books market, those who demand the used books have to switch to the new books and the net demand is the *horizontal* summation of $D_1$ and $D_2$ to become $D_H$, an approximate result of restricting the books copying.

Now the question is whether firms in a competitive industry are better off with ($D_V$) or without ($D_H$) the used market. If the marginal cost ($MC_1$) intersects at $H_1$ and $V_1$, where the net demand with the used market ($D_V$) lies *above* that without the used market ($D_H$), a competitive firm will be better off producing with the used market at an equilibrium $V_1$. A monopolist will prefer to produce with the used market as well, but at a smaller output. With the marginal cost $MC_2$, a competitive firm is better off without the used market ($D_H$) at a higher price and quantity. But the monopolist may be better off with or without the used market (Liebowitz, 2000).

Besides the marginal cost consideration, the firm may allow the used market or book copying for three reasons: exposure effects, fair use, and indirect appropriability. The exposure effects refer to advertising or sampling that hopefully will lead to larger sales of original copies. Users sample songs from the Napster to merely "try out" the songs. The assumptions here are the Napster use is a complement, not a substitute, to the CD purchase[8] (Liebowitz, 2002), and songs are experience goods where the users must experience it to value it (Shapiro and Varian, 1999).

Fair use is a common defense to copyright infringement when the copying does not hurt the copyright owner's revenues. The copyright statute defines the following activities as fair use: criticism, comment, news reporting, teaching, scholarship or research. One of the arguments to support the fair use of the intellectual property is that it encourages user innovation. Because users are often better innovators than producers, users are closer to the problem, and should be given options to experiment with the products (Varian 2002). For this reason, an innovative idea is a "knowledge problem" following Hayek (1945):

> "... the knowledge of the circumstances of which we must make use never exists in concentrated or integrated form, but solely as the dispersed bits of incomplete and frequently contradictory knowledge which all the separate individuals possess. ... Or, to put it briefly, it is a problem of the utilization of knowledge not given to anyone in its totality."

Innovative songs, like other information goods, possess this knowledge problem. The No. 1 song in England during 2002 World Cup was a remix of a 30-year-old Elvis Presley single, "A

[8] This is a debatable assumption since the music industry believes that the Napster use is a substitute to the CD purchase and is blamed for the recent decline in CD sales.

Little Less Conversation." A Dutch disc jockey remixed the song for the Nike World Cup ad campaign. He changed the instrumental balance and added a techno beat to create a new modern version. Such user innovation is made possible with the “fair use” of the original song.

If buyers have more liberal intellectual property rights to experiment with songs, and to make copies of original songs, then sellers can charge higher prices for originals. This is because the property right is a *bundle* of socially recognized *rights* to use the resource, not *the* resource itself (Alchian and Demsetz, 1973). Online music buyers may own the rights to download and listen to their music in their computers but not to burn them onto CD. It is these rights that determine the value of what is exchanged (Demsetz, 1967). Thus the buyers are willing to pay more for the original songs if they can make the duplicates, and sellers can collect revenue from copiers. This is the indirect appropriability argument that copying would not harm copyright owners if they can appropriate revenue from it indirectly by charging a higher price for the original (Liebowitz, 2002).

The problem is how much to charge for the additional copying right. It depends on the number of copies made of each original. If every buyer of the original CD record makes exactly one duplicate CD for use in a car, then the net demand for the records would be the vertical summation of the demand for that usage minus the cost of blank CDs, and record sellers can raise prices accordingly. But if some buyers make 100 duplicates and others make none, then the sellers have to price discriminate in the two markets segments. In a peer-to-peer network, such as Napster, Morpheus, Kazaa, where the copying occurs in a large scale, there is a large variability in the number of copies made that makes price discrimination even more difficult.

The solutions that record sellers undertook recently were digital rights management (DRM) and becoming paid online music distributors. DRM, also known as automated rights management (ARM), allow the record sellers to imbed code into the CD that can prevent copying, restrict playing on computers, and/or monitor usage and charge accordingly. On the one hand, DRM is prone to being cracked and may limit fair use. On the other hand, the technology enables a cost effective way to approach perfect price discrimination (Liebowitz, 2002). A decline in CD sales has forced the music industry, with the top five music labels that control 90 percent of the market, to collaborate with online music subscribers to sell the music online (Evangelista, 2002). This will enhance their abilities to price discriminate as well.

## VII. Network Effects

Firms in the information economy also have to consider that copying increases the size of their product's "network", which in turn may increase the value to the authorized users. If more people using Microsoft Word, there will be more Word documents to share, which increases the value of the product itself. Thus even more people will use it. Past literature (Liebenstein, 1950) has anticipated a similar positive feedback called a bandwagon effect (Figure 7). If consumers derive additional values from product attributes other than the functionalities, which in this case are increases in the market size, the demand curve will be more elastic. A derived demand curve (D) that connects point X to Z is more elastic because of the bandwagon effect

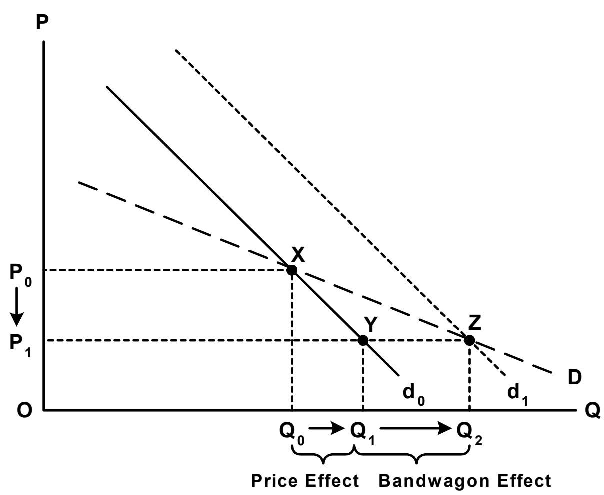

**Figure 7: Bandwagon Effect**

More recent literature (Rohlfs 1974, Katz and Shapiro 1985 and 1994) labels this phenomena network externalities or network effects, meaning that the demand for goods depends on how many people buy them. Both concepts are different depending on whether the effects are internalized (Liebowitz and Margolis, 1994). It is more likely that network owners, not individual consumers, will internalize such effects. If network owners are able to internalize the network effects, they are no longer the (network) externalities.

The literature also distinguishes two types of network effects: direct and indirect network effects. Direct network effects are the network effects that are generated "through a direct physical effect of the number of purchasers on the quality of the product" (Katz and Shapiro, 1985), as previously discussed. Indirect network effects, also known as "market mediated effects" or "chicken and egg problems", are the indirect effects of additional buyers on the value of the main goods via the complementary goods. For example, your decision to buy a DVD player by itself does not affect the value of my DVD player. But having more people owning the DVD players encourages the content producers to sell the DVD software, which enhances the value of my DVD player.

Indirect network effects generally are pecuniary externalities, where external effects work through the price system, thus do not impose deadweight losses and should not be internalized (Liebowitz and Margolis, 1994). Consider the example of a negative indirect network externality that is pecuniary. If a group of VHS tape users joins the network of DVD disc buyers, their increased demand raises the price of DVD players[9]. The higher price certainly harms their fellow network members negatively, but that harm is offset by a transfer of wealth to

[9] We assume that costs rise as output increases for negative externality. The opposite is true for positive externality.

the network of DVD player manufacturers. A similar logic applies to a positive indirect network externality.

Direct network effects are most likely positive externalities for bigger network owners and their users. If the effects are not internalized, the social benefits from having additional network users will always be higher than the private benefits. Consequently the equilibrium network size is smaller than the efficient level. The network size in this case does not refer to the *relative* market share of two competing networks, but an overall network activity *within* a particular network.

For smaller competing networks and their users, the direct network effects are negative externalities. As more users join the opposing bigger network (e.g. Microsoft Word), it imposes external costs to the owner and users of the smaller competing networks (e.g. WordPerfect) as their product values are dissipating. This gives us the impression of the "tragedy of the commons" for the "inevitability of a suboptimal network"[10] (Liebowitz and Margolis, 1994). But the owners of the competing networks have incentives to internalize the negative externalities or the network effects. The internalization tactics usually involve format convertibility, free training, and price discounts. These tactics limit the extent of the network effects.

Other limitation to the network effects is heterogeneous tastes or preferences. Some consumers prefer Apple iMacs to IBM compatible PCs, regardless of the network size. Differences in the consumer preferences can be strong enough to overwhelm the need to connect to the rest of the world. Consumers who need video and graphics editing tools probably choose

[10] This is not a perfect analogy because the tragedy of the common frequently illustrates the problem of a common fishery where non-excludability is the main issue.

Apple iMacs, even though they are not compatible with the IBM compatible PCs. Heterogeneous tastes allow the competing networks to survive by serving niche markets well.

## VIII. Lock-In

If we set aside the internalization tactics and the heterogeneous tastes assumptions, network effects may get the users "locked-in" with a single dominant network. The concern is that they may get locked-in with inferior networks or technologies. Considering an example where the users are faced with a decision to adopt one of two technologies (Table 2). The key assumption here is the *increasing returns* of each technology due to the economies of scale or the network effects. As the number of adopters of each technology becomes larger, the technology offers greater payoffs.

| # Adoptions | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Technology A** | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| **Technology B** | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 31 | 34 |

**Table 2: Adoption Payoffs of Two Competing Technologies (Arthur, 1989)**

A first adopter that makes decision based on his private gains is expected to choose the technology A because it offers higher payoffs (10) than that of the technology B (4). But notice that the technology B offers greater payoffs as the number of adopters increases above thirty. Eventually the technology B wins the battle by virtue of the increasing returns from the wider adoption, even though the technology A has higher payoffs initially. But if the technology B cannot win out, the users are locked-in with the inferior technology A.

We can extend the increasing returns model (Table 2) with an initial condition or a historical accident that leads to one of *multiple equilibriums* (Figure 8). The upward sloping forty-five degree line is a condition where to maintain Y percent market share of a particular technology (X), then Y percent of the new purchases of technology must be type X. The Sshaped curve reflects the increasing returns assumption where the probability that the technology is chosen is higher as more consumers adopt it.

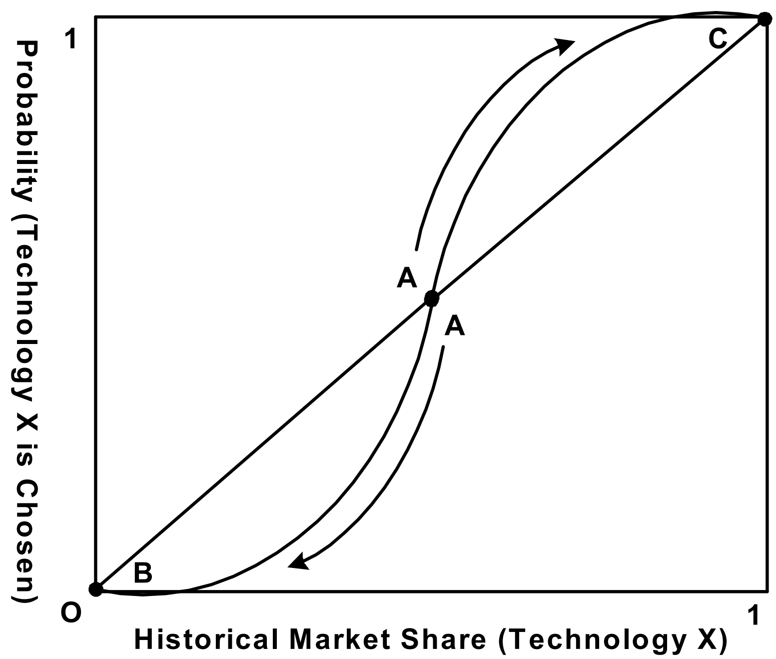


**Figure 8: Lock-In with Multiple Equilibriums (Liebowitz and Margolis, 1996)**

This assumption creates three equilibriums: A, B, and C. Point A is an unstable equilibrium condition that represents the critical mass. Any small movement below the critical mass or point A will lead to a vicious cycle at a B equilibrium, where the fraction that choose the technology is less than the fraction that has chosen it. This will lead to a smaller share for the technology, which will lead to a smaller fraction that choose it, and so on. The opposite movement above the critical mass will lead to a virtuous cycle at a C equilibrium.

But there are problems with the increasing returns and the multiple equilibriums models. Both models do not allow adopters (and entrepreneurs) to play an active role in anticipating and influencing the outcome. The multiple equilibriums model implies that the early adopters make crucial choices that determine the lock-in outcome. But the initial choice is not an entirely a random process.  A path dependent theory explains the initial choice process by considering the consumers' anticipations[11] (Arthur 1989, Liebowitz and Margolis 1995). We define three different forms of the path dependence (Liebowitz and Margolis, 1995): a first-degree, a second-degree, and a third-degree of path dependence.

First-degree path dependence occurs when we make a decision with complete knowledge about the future, the future outcome is just what we predicted, and nothing can be improved upon. You plan to go to college this year and buy a computer for writing term papers. Next year the same computer sells for $500, as you knew it would. So overall you are happy with your decision. This form has a persistence or durability in the decision.

Second-degree dependence occurs because of our imperfect knowledge about the future, where the future does not turn out as we expected, but our chosen paths are correctly based on our limited state of knowledge at the time the choices are made. A few weeks after you buy your computer, computer prices drop faster than what you had anticipated. You realize that your decision is a mistake. It is regrettable but *not remediable*.

The third-degree form claims that we know "better" paths (based on some ad hoc technical criteria) exist but we choose the alternative paths (after considering economic criteria) anyway because we are hindered by coordination, transaction, or switching costs. You know that an Apple iMac gives you a better true performance-to-price ratio than an IBM-compatible PC, but you buy the IBM-compatible PC anyway since all your friends have the IBM-compatible PCs. And somehow you are unable to coordinate your friends to buy the Apple computers. In this form, your seemingly inferior path is remediable but not a market failure.

The first-degree and the second-degree forms are the results of decision-making under certainty / perfect knowledge and uncertainty / imperfect knowledge conditions respectively.

[11] The theory may apply for the suppliers' anticipations as well.

They are very common phenomena. It is the third-degree path dependence that is relevant to the lock-in story. It means that we *could* be locked-in with an inferior technology, even though the outcomes meet our expectations, *if* we take into consideration transaction, coordination, and/or switching costs.

## IX. Standards

The following cases of competing standards illustrate the presence of the network effects and lock-in in the real world: Qwerty and Dvorak keyboards (Liebowitz and Margolis, 1990), VHS and Betamax videocassette formats (Liebowitz and Margolis, 1995), and video game systems (Shapiro and Varian 1999; Kent 2001).

### A. Qwerty and Dvorak Case

Christopher Latham Soles patented the Qwerty typewriter in 1868. Sholes and his collaborators addressed a jamming problem by rearranging the keys that were close in succession when struck. Sholes sold the rights to E. Remington & Sons in 1873, and the company made some minor improvements and began manufacturing and selling the Qwerty typewriter. In 1888, Francis McGurrin, who taught himself Qwerty typing, won a famous typing contest in Cincinnati. Some believed that his victory cemented the Qwerty keyboard as the standard. But there were many typing contests with alternative keyboard arrangements competing across the country at that time, and Qwerty won many of the contests.

Professor August Dvorak patented a Dvorak Simplified Keyboard (DSK) in 1936. The design followed ergonomic principle, and was supposed to be easier to learn and allowed faster typings. A 1956 General Services Administration study by Earle Strong showed that it took well over twenty-five days of four-hour-a-day training for Dvorak retrained typists to catch up with their old Qwerty speed. Strong concluded that the investment in the DSK retraining would never be recovered. More recent ergonomic studies found that the advantages of the Dvorak were insignificant: "... the Dvorak keyboard was only about 5% faster than the Sholes (Qwerty)" (Norman and Rumelhart, Cooper ed. 1983).

This case shows that the Qwerty standard *could* be slightly inferior in terms of typing speed. But *if* we take into account the switching costs of retraining ourselves the Dvorak, its slight superiority is probably not worth our time and investment to switch. This suggests that the adoption of the Qwerty standard may not be a market failure even if it is marginally inferior to Dvorak.

**B. VHS and Betamax Case**

Many people claim that Betamax was a superior format but everyone bought VHS because it was a more established format, and people chose VHS irrespective of the superiority of the Betamax. The fact was that the Betamax was the first on the market with a two-year head start. The superiority of the Betamax format was a myth as well. Reviewers found that the format has no advantages in picture quality. The major product differentiation between both formats is the playing time. Sony bet on a tape compactness or a portability as what consumers wanted, and JVC-Matsushita chose larger tapes or longer playing time.

This case is a reminder that what was thought to be a problem of lock-in with an inferior technology, after further scrutiny, may turn out to be a false inferiority claim. VHS won the format war because it gave consumers what they valued most. Thus the VHS standard was an efficient choice.

**C. Video Game Systems Case**

The video game story is different from the previous two cases. In this case, the consumers were locked-in with a different network for each successive generation of technology.

Atari had the largest installed base of the first generation (8-bit) of a video game system in 1983. Then Nintendo entered the U.S. video game market in the mid-1980s and took over market leadership with a 16-bit system. Afterward Sega regained the market from Nintendo with the first 32-bit system. Finally Sony drove Sega out of the video game hardware market in the 64-bit system category.

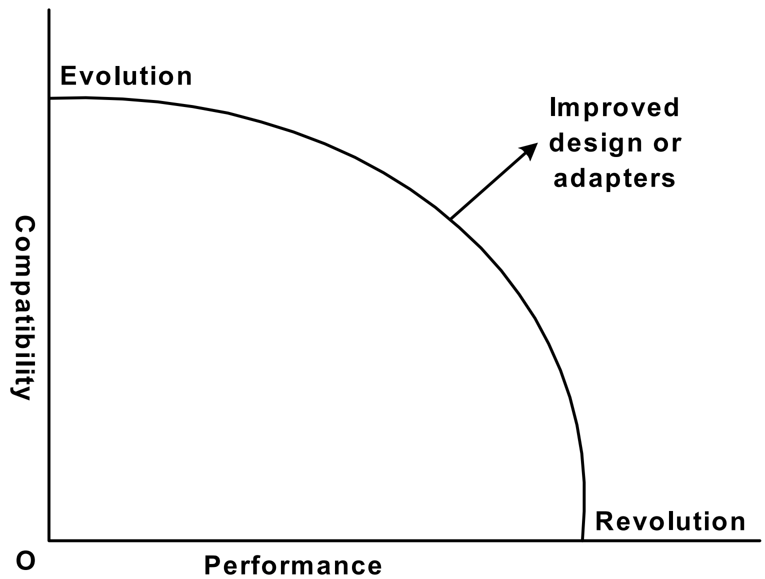


**Figure 9: Compatibility-Performance Trade-Off (Shapiro and Varian, 1999)**

Each new entrant in the next generation system offers a superior performance (revolution strategy) than the established incumbent, who has to sacrifice some performance to ensure compatibility and thus maintain existing consumer adoption (evolution strategy). Figure 9 illustrates this trade-off between compatibility and performance. Successful market entrants in this industry prove that network effects, lock-in, and switching costs are less relevant than otherwise supposed. Consumers *might* be locked-in with an inferior video game system *within* each generation of technology, but technological changes enable a wrong path to be disconnected from a new path.

## X. Transaction Costs

Technological changes in the new economy, such as the internet and enterprise business software, enable business executives to lower transaction costs by outsourcing departmental functions; payroll, manufacturing, information systems, and finance have all been targeted for the outsourcing. The business executives review all internal functions and ask the following questions: "Can we buy this capability from someone else? Or should we need to staff and manage that function internally?"

In the economics literature, Coase (1937) asks similar but deceptively simpler questions: Why do firms exist? Why do we use a command-and-control hierarchy inside a firm, instead of going to the markets for negotiations and explicit contracts? "Why doesn't one worker on the assembly line negotiate with the worker next to him about the price at which he will supply the partly assembled product (Varian, 2002)?"

The answers rest on the costs of making transactions. It is less costly and more effective to use the hierarchy than going to the market to get some business activities done. The literature cites three categories of transaction costs: search and information costs, bargaining and decision costs, and policing and enforcing costs. These costs limit of how much a firm can grow. But there are other considerations as well.

The first is human behavioral considerations where bounded rationality and opportunism exist (Williamson, 1975). Bounded rationality refers to human behaviors that are "*intendedly* rational, but only *limitedly* so" (Simon, 1961, p. xxiv). Physical limitations in receiving, storing, retrieving, and processing information without errors take the form of limited knowledge, foresight, skill, and time. It is because of these limitations that organizations are useful instruments for the achievement of human purpose (Simon, 1957, p. 199). Internal organizations allow parties to deal with complexity, uncertainty, and incompleteness of market contracting in adaptive and sequential fashions. Firms perform sequential budgeting processes across the hierarchy and review actual against budget on a regular basis so that they can adapt to changes in the market and meet their financial objectives. "Such adaptive, sequential decision processes economize greatly on bounded rationality" (Williamson, 1975, p. 25).

Opportunism is a realization that economic agents are guided by their self-interests or "frailty of motives" (Simon, 1985, p. 303) that give rise to *strategic* behaviors. "The reason the assembly-line worker doesn't negotiate with the person next to him is that it's too easy for him to say, 'Give me a good deal or I'll stop the line' " (Varian, 2002). We also recognize that strategic manipulations of information and misrepresentations of intentions for self-gains are common in market transactions. These opportunistic behaviors do not imply that the market is flawed, but rather the prevalence of rivalries among *small numbers* of bidders. The unreliable reporting that may arise from the small numbers problem can be more effectively managed within the internal organization with its bounded hierarchy and internal audit.

The second consideration depends on transaction characteristics: uncertainty, frequency, and asset specificity (Williamson, 1985). If the transaction is subject to uncertainty, where long-term contracts are usually required, a hierarchical form of organization is often favorable. The hierarchical relationship has a formal control over both parties of the transaction, thus potential disputes are presumably easier to settle. Transaction frequency matters because the more frequent the transaction, the more internal organization can save on transaction costs. Asset specificity refers to the degree to which an asset can be redeployed without sacrificing its productive value, where high asset specificity indicates low redeployment likelihood. It relates to the notion of sunk costs and a risk of premature obsolescence. If a transaction involves highly specific investments, internal organization can better assure that the risk of premature obsolescence is offset by potential long-term efficiencies.

Overall, bounded rationality, opportunistic behavior, uncertain environment, frequent contracts, and asset specific investments are positively related to the costs of making transactions, the expansion of firm size, or the adoption of internal organization (Figure 10). Understanding this theory, we can now assess the claim of new economy advocates that information technology, including the internet, can lower the transaction costs and shrink company boundaries. They predict that companies will downsize, outsource, and spin-off non-critical functions.

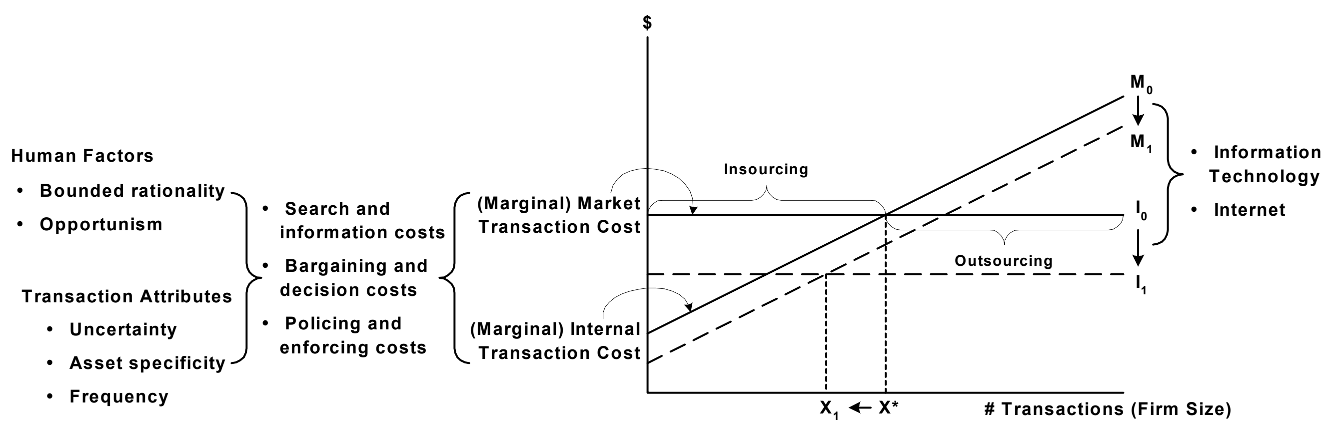


**Figure 10: Transaction Costs and Outsourcing**

Figure 10 shows that a firm will manage groups of activities internally, and grow up to X* where the costs of managing those activities internally is equal to the costs of outsourcing them in the market. The internet might reduce the firm size from X* to $X_1$ if it reduces the costs of using the market ($M_0$ to $M_1$) by *more* than it reduces internal communication costs ($I_0$ to $I_1$) (Varian, 2002). It certainly lowers the search and information costs. But similar inventions "like the telephone and telegraphy, which tend to reduce the cost of organizing spatially, will tend to increase the size of the firm" (Coase, 1937, p. 397). Thus, the impact of the internet can work on either direction.

Bargaining and decision costs still require the presence of managers and lawyers. Bounded rationality is a big part of the reason. But the process has been streamlined with implementations of internet auctions, electronic forms, digital signatures, and other codifications and standardizations.

The firm incurs the policing and enforcing costs to ensure that opportunistic behaviors of employees are kept under control. The temptation to be opportunistic is part of human nature and will always be there. But information technology has enabled suppliers, customers, and employees to monitor each other without direct observation. internet business software allows companies to check their supplier's shipment or their customer's receipt from the shipper's websites from far distances using tracking numbers, which lowers the market transaction cost. Computerized financial systems, inventory management systems, and electronic vehicle management systems (EVMS) ensure that employees perform their tasks accordingly, thus reduces the internal transaction cost.

Certain core company functions are strategic and critical to the success of firms, and may not be open to the outsourcing. If we leave these core functions outside our controls, they are open to opportunistic behaviors in the market, which may not be aligned with our objectives. On the one hand, rivalries among large numbers of bidders will drive the market transaction costs of providing these critical functions below the internal transaction costs. On the other hand, the transaction costs may not be the key determinant factor. There is also an issue of trust and/or ownership as well.

## XI. Summary

Several economic studies have confirmed the “new economy” doctrine, which suggests that information technology contributes significantly to labor productivity. These findings coincide with the emergence of information goods as the central theme in the new economy. Although the old economics still apply to the new economy, some market phenomena and issues play more critical role because of the nature of information goods.

Unlike regular industrial goods, information goods are “costly to produce but cheap to reproduce” (Shapiro and Varian, 1999). This cost structure resembles that of the classic natural monopoly, implying large-scale operations in a concentrated industry. Information goods are also cheap to replicate and redistribute. This requires a balancing act between short-run consumption efficiency losses and long-run production gains (Liebowitz, 2002).

The non-rivalrous but excludable nature of information goods suggests that they are public goods, but not pure public goods, yet the private provision of these goods is possible. The optimal provision of information goods requires private firms to price discriminate.

In two different markets, firms can increase revenues by increasing prices in the low marginal revenue market and decreasing prices in the high marginal revenue market, until their marginal revenues are equal (Liebowitz, 2000). Technology enables companies to charge different prices for different units of essentially the same good for the same person, or intrapersonal price discrimination. Companies use the internet to learn the maximum price that someone is willing to pay. Business enterprise software makes price changes in real time, thus eliminating menu costs. Alternatively, companies can offer a set of related products or “versions”, or bundle them as a package. Bundling not only can enhance revenue, but also has a market entry deterrent effect (Varian, 2001).

The issue of whether companies should allow copying depends on marginal cost, exposure effects, fair use, and indirect appropriability. Fair use encourages user innovation. Indirect appropriability may be problematic if there is a large variability in the number of copies made. The new solution involves digital rights management (DRM). It is prone to being cracked and may limit fair use. But on the other hand, it enables a cost effective way to approach perfect price discrimination (Liebowitz, 2002).

Network effects seem to imply that an incumbent network will get larger (positive externality) and opposing networks will get smaller (negative externality). But competing networks have the incentive to internalize externalities, and consumers may have heterogeneous tastes that allow competing networks to survive by serving niche markets.

The concern that users may get "locked-in" with inferior networks is based on the increasing returns assumption that gives rise to multiple equilibriums. Even if the wrong chosen paths meet our expectations, the lock-in problem *could* still be possible, considering transaction, coordination, or switching costs. The Qwerty case may illustrate this point. The Betamax case reminds us that some inferiority claims may be false. The video game case suggests that the lock-in may not be a problem when technology changes rapidly.

Information technology certainly lowers the costs of making transactions, which has implications on firm size and the extent of outsourcing. The internet reduces both internal and external communication costs, so the impact on the firm size is conclusive. But the technology surely has had an impact on streamlining bargaining and decision processes, even though they still require the presence of managers and lawyers. The biggest impact is probably on policing and enforcing costs. But some critical and strategic functions may not be open to outsourcing anytime soon.

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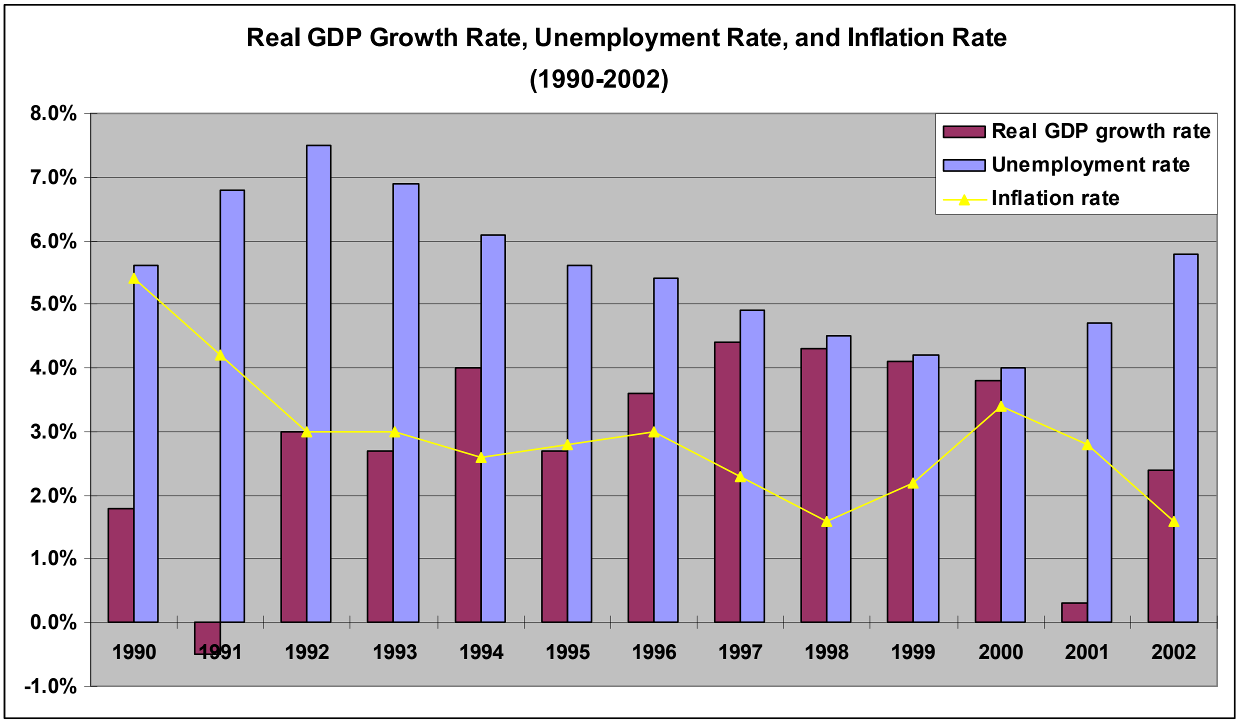
## Appendix A: Real GDP Growth Rate, Unemployment Rate, and Inflation Rate

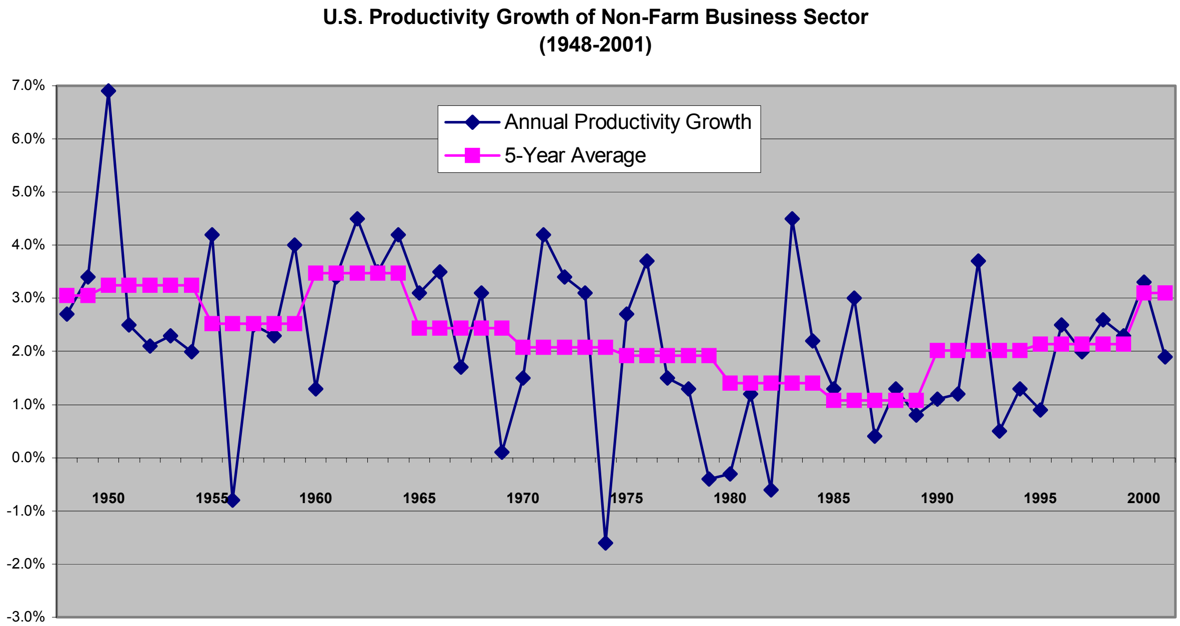



Source: BEA (real GDP growth rate), BLS (unemployment rate, inflation rate)

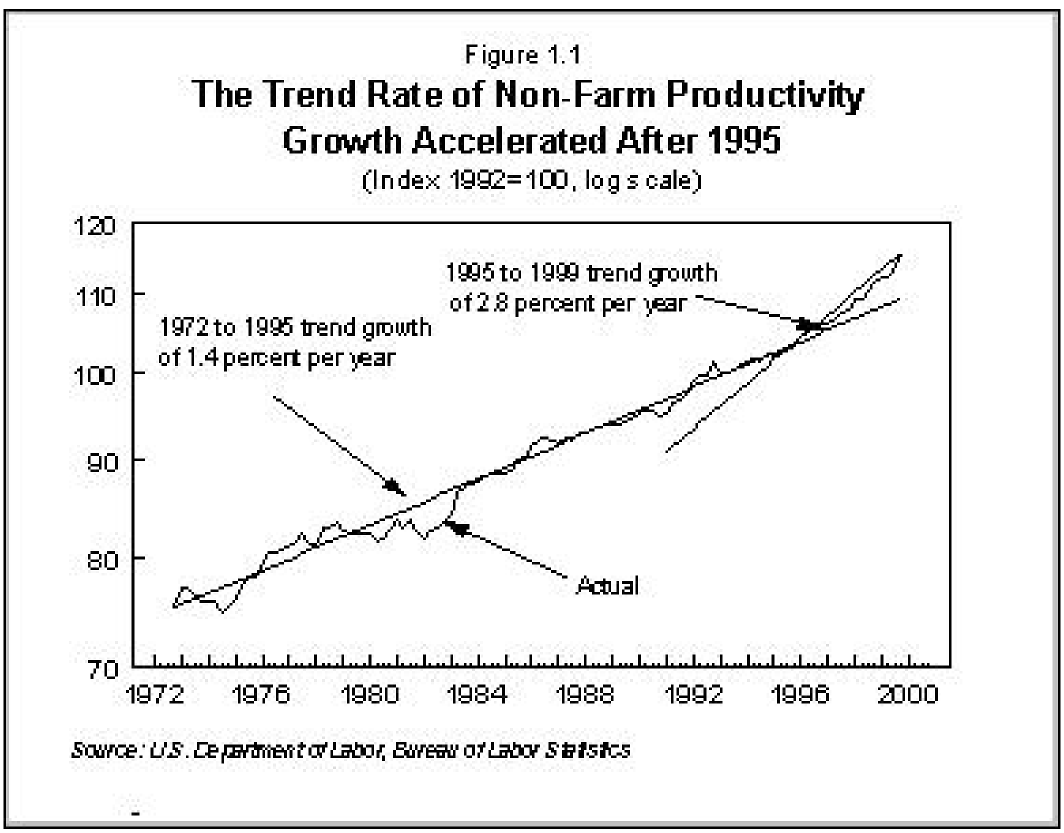
**Appendix B: Stock Market Returns in 1990's**


Source: Varian (2001)

## Appendix C: Productivity Growth




Source: Bureau of Labor Statistics




Source: Bureau of Labor Statistics

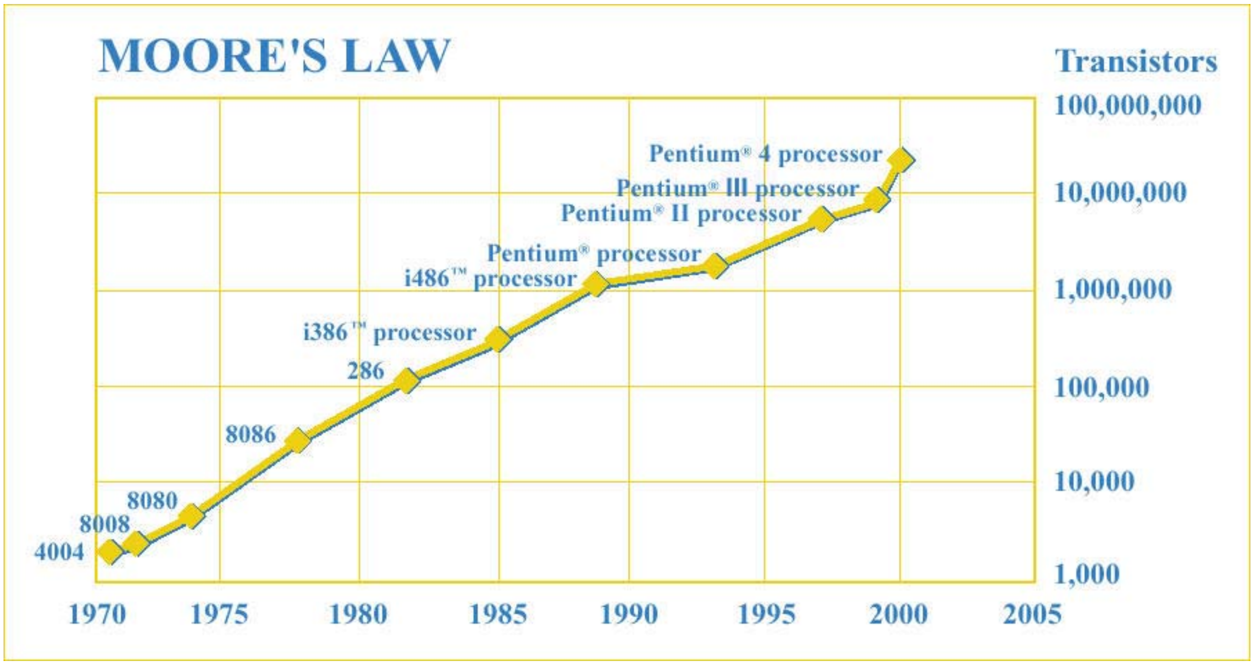
## Appendix D: Information Technology Producing Industries

| **Hardware Industries** | **Software / Services Industries** |
|---|---|
| Computers and equipment | Computer programming services |
| Wholesale trade of computers and equipment | Prepackaged software |
| Retail trade of computers and equipment | Wholesale trade of software |
| Calculating and office machines | Retail trade of software |
| Magnetic and optical recording media | Computer-integrated systems design |
| Electron tubes | Computer processing, data preparation |
| Printed circuit boards | Information retrieval services |
| Semiconductors | Computer service management |
| Passive electronic components | Computer rental and leasing |
| Industrial instruments for measurement | Computer maintenance and repair |
| Instruments for measuring electricity | Computer related services, nec. |
| Laboratory analytical instruments | |
| **Communications Equipment Industries** | **Communications Services Industries** |
| Household audio and video equipment | Telephone and telegraph communications |
| Telephone and telegraph equipment | Cable and other pay TV services |
| Radio and TV communications equipment | |

Source: Digital Economy 2002, U.S. Department of Commerce, February 2002.

Note: Industries represented here are consistent with 1987 SIC categories, rather than the newly implemented 1997 NAICS categories.

## Appendix E: Moore's Law

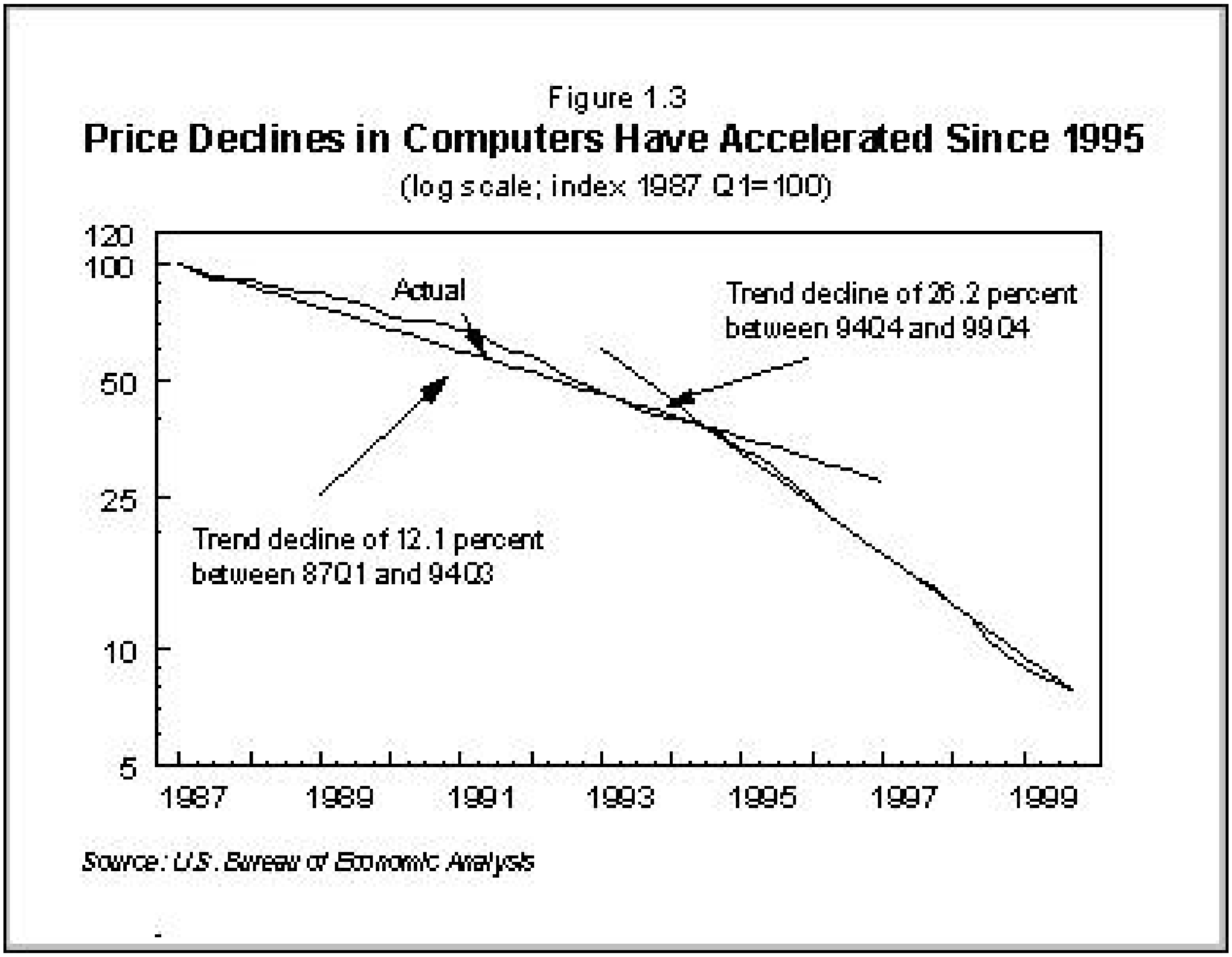



Source: Intel Corporation

(ftp://download.intel.com/intel/intelis/museum/arc_collect/history_docs/pdf/mlawgraph.pdf)

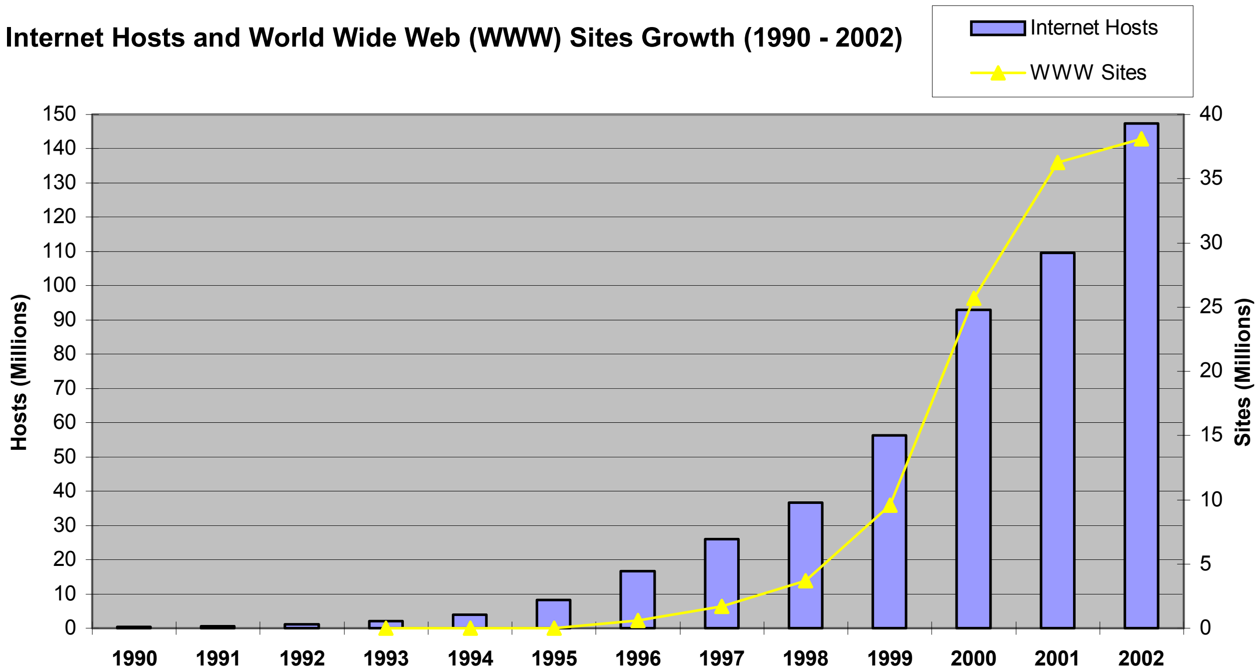
Note: The numbers of transistors per chip doubles every 18 months. This is closely equivalent to increasing by a factor of 10 every 5 years and by a factor of 100 every 10 years. Moore's Law was first noted by Gordon Moore, co-founder of Intel, in 1965.

**Appendix F: Price Declines in Computers**




Source: Digital Economy 2000, U.S. Department of Commerce, June 2000.

## Appendix G: Internet Growth




Source: Robert H Zakon (1993-2002) at http://www.zakon.org/robert/internet/timeline/

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Note:    Hosts    = a computer system with registered ip address
         Sites = # of web servers (one host may have multiple sites using different domains)
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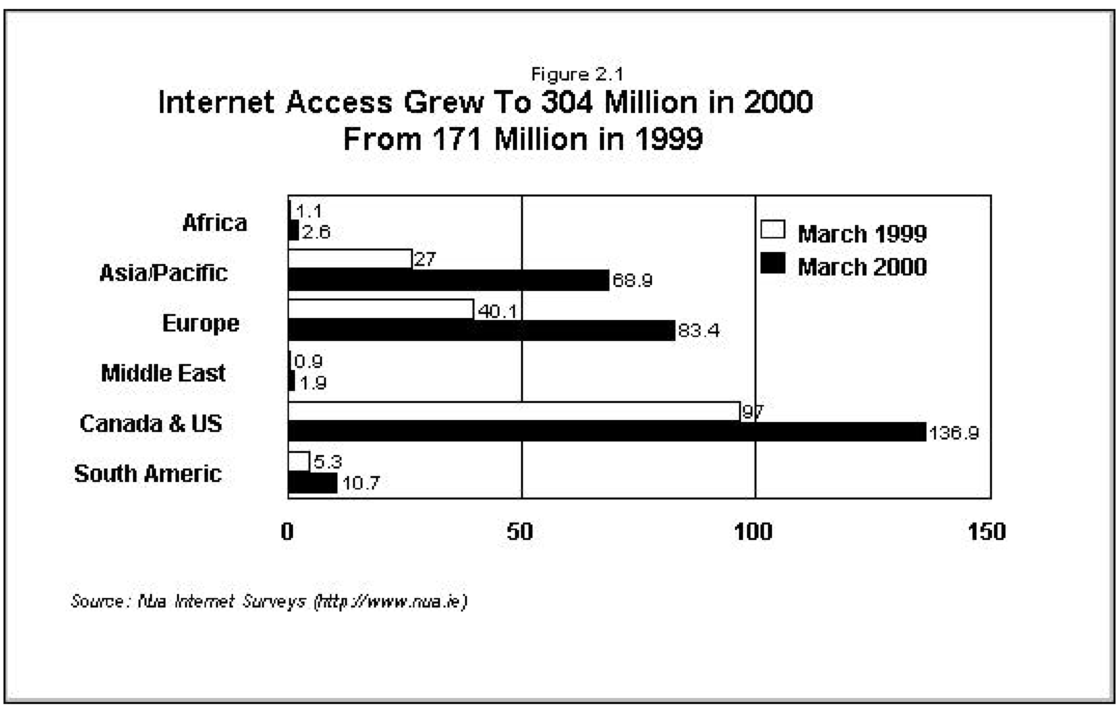
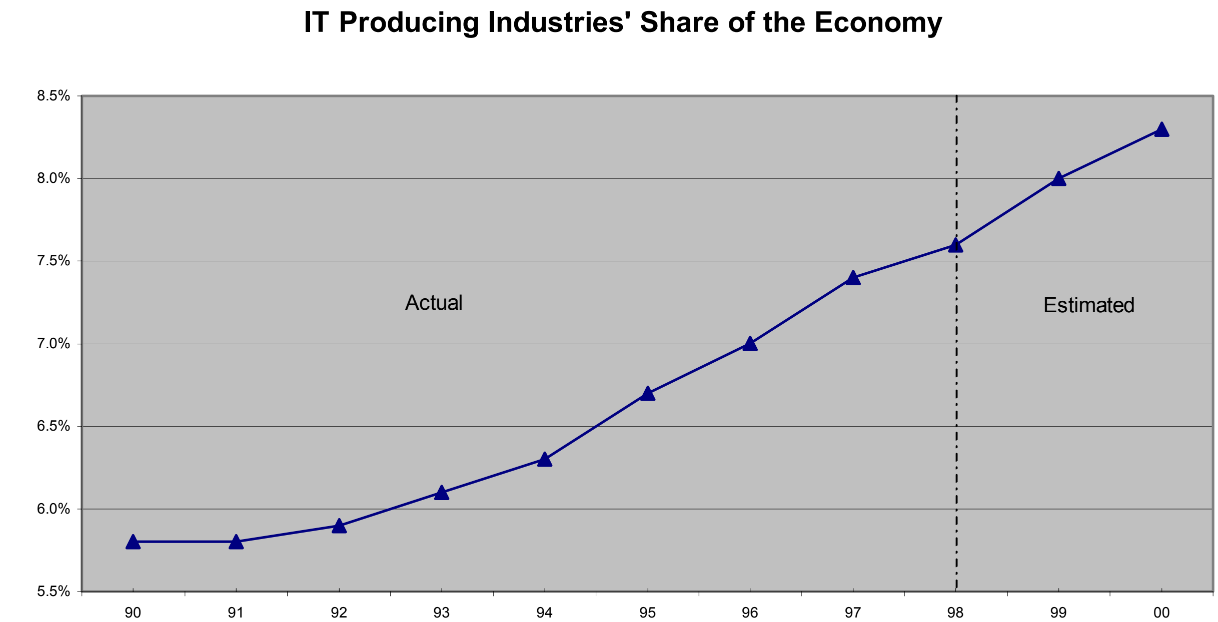


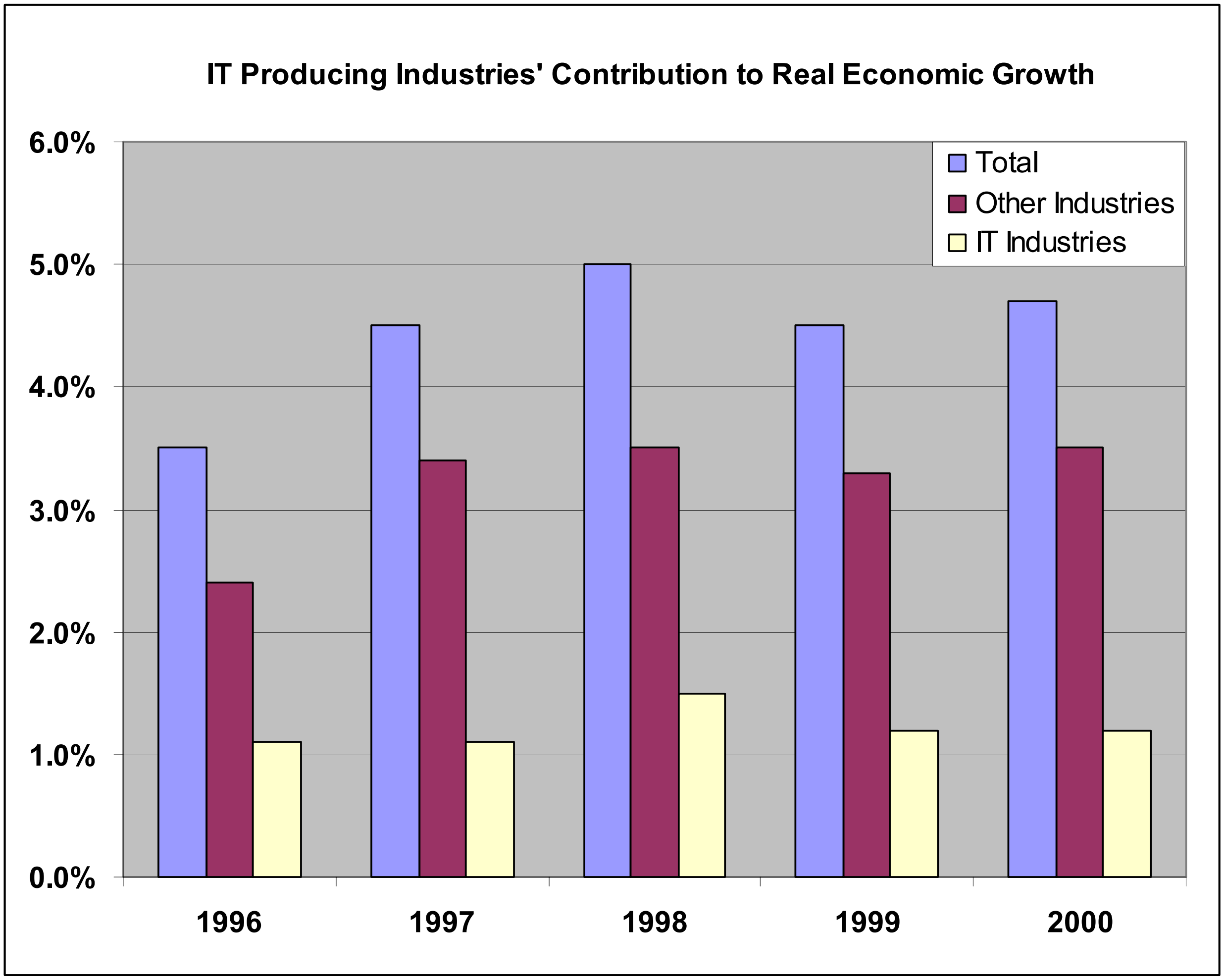

Source: Digital Economy 2000, U.S. Department of Commerce, June 2000.

## Appendix H: IT Producing Industries' Share of the Economy




Source: Digital Economy 2000, U.S. Department of Commerce, June 2000.
(Based on BEA and Census data)

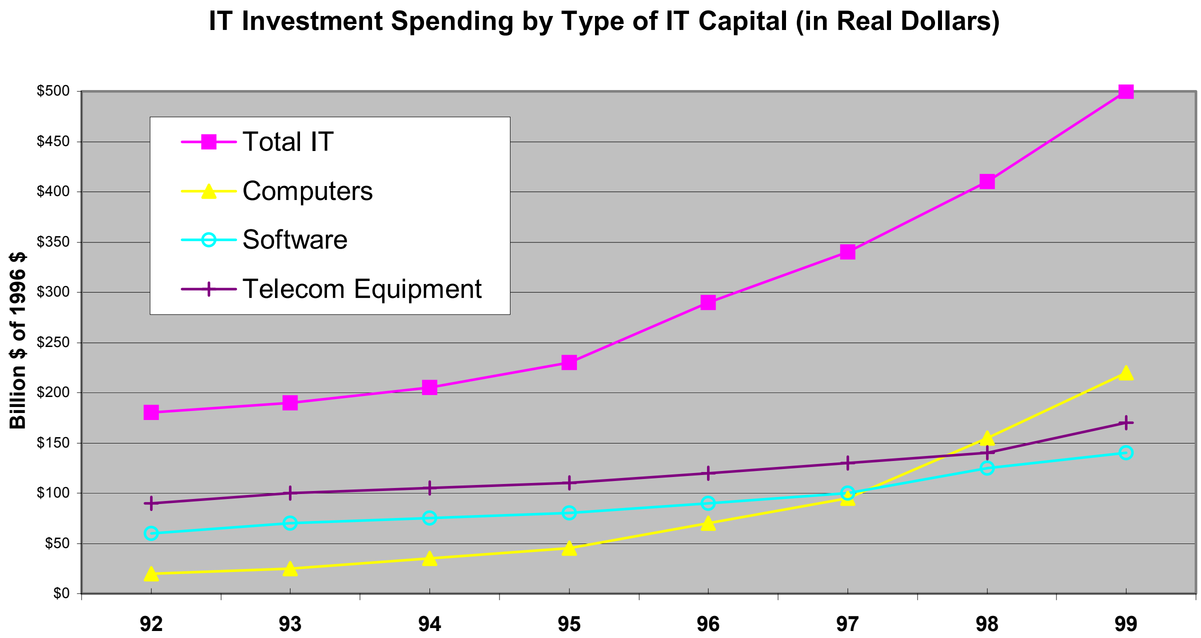
**Appendix I: IT Producing Industries' Contribution to Real Economic Growth***




Note: * Real economic growth here is changes in real Gross Domestic Income (GDI)

Source: Digital Economy 2002, U.S. Department of Commerce, February 2002.
(Based on BEA and Census data)

## Appendix J: IT Investment Spending by Type of IT Capital in Real Dollars




Source: Digital Economy 2000, U.S. Department of Commerce, June 2000.
(Based on BEA data)

## Appendix K: Contribution of IT Capital to Acceleration of Labor Productivity Growth in U.S. Private Non-Farm Business Sector

| Studies * | Capital Deepening | Technical Advance | Total IT Contribution | Productivity Acceleration | IT Share of Acceleration |
|---|---|---|---|---|---|
| | (% Point) | (% Point) | (% Point) | (% Point) | (%) |
| | (1) | (2) | (a) = (1) + (2) | (b) | (a/b) x 100 |
| **Oliner and Sichel**<br>1996-99 over 1991-95 | 0.45 | 0.26 | 0.71 | 1.04 | 68.3 |
| **Congressional Budget Office**<br>1996-99 over 1974-99 | 0.4 | 0.2 | 0.6 | 1.1 | 54.5 |
| **Economic Report of the President**<br>1995-99 over 1973-95 | 0.47 | 0.23 | 0.7 | 1.47 | 47.6 |
| **Jorgenson and Stiroh**<br>1995-98 over 1990-95 | 0.31 | 0.19 | 0.5 | 1 | 50 |
| **Whelan**<br>1996-98 over 1974-95 | 0.46 | 0.27 | 0.73 | 0.99 | 73.7 |

Source: Digital Economy 2000, U.S. Department of Commerce, June 2000.

* The studies summarized are not strictly comparable because they use different definitions of IT capital and examine different time periods:

- *Oliner and Sichel* define IT capital to include "computer hardware, software, and communication equipment."
- *Congressional Budget Office* talks about "computers," distinguishing between computer "use" (capital deepening) and computer "production" (technical advance).
- *Economic Report of the President* refers to "computers and software."
- *Jorgenson and Stiroh* include in IT "capital services" those from computer, software, and communications capital.
- *Whelan*'s "computing equipment" includes mainframes, terminals, storage devices, printers, and personal computers.

Note:

*IT capital deepening* means increase in IT capital per labor hour.
*IT Technical advance* covers capital quality improvements and multifactor productivity growth from IT and other sources.