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The Diffusion of Electronic Business in the U.S.*

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Abstract

We provide a recent account of the diffusion of electronic business in the U.S. economy using new data from the U.S. Bureau of the Census. We document the extent of the diffusion in three main sectors of the economy: retail, services, and manufacturing. For manufacturing, we also analyze plants' patterns of adoption of several Internet-based processes. We conclude with a look at the future of the Internet's diffusion and a prospect for further data collection by the U.S. Census Bureau.

1 Introduction

The commercial use of the Internet has been diffusing rapidly among consumers and businesses in the United States. As the dust of the shakeout in Internet-based industries settled, both firms and consumers started to have a better understanding of what the Internet is capable of, and which Internet business types are likely to be viable. Partly due to the much publicized mass exit of firms in Internet retailing during most of 2000 and 2001, the effect of the Internet on retail industries has been the focus of both the popular press and academic research. Internet retailing, however, still represents only a very small fraction of the online economic activity. In fact, business-to-business electronic commerce, representing online transactions within and across firms, is far ahead of business-to-consumer electronic commerce in volume, and it has been transforming the way many business transactions are carried out inside and outside of the firm.

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The uses of the Internet in retail, services, and manufacturing industries are diverse and increasing, ranging from applications at the early stages of production, such as communicating and making transactions with suppliers, to post-sales applications, such as providing online customer service and support. Despite the growing volume of electronic commerce in these sectors, little is known about the extent to which the Internet is facilitating several transactions and processes at the individual plant and firm levels. This lack of knowledge can in turn be attributed to a lack of systematic establishment-level data on Internet usage. Earlier reviews of the diffusion of electronic business, e.g., Bakos (2001) and Lucking-Reiley and Spulber (2001), have provided excellent accounts of the initial stages of the diffusion. Nevertheless, they are devoid of a systematic analysis of data and mostly rely on anecdotal evidence. A more detailed and updated look is required, as changes took place rapidly in recent years and several new considerations have become relevant.

In this article, we provide a recent account of the diffusion of the Internet in manufacturing, retail, and services. The data we use comes from the U.S. Census Bureau's *E-stats Program* (available online at *www.census.gov/estats*), which provides the first systematic, albeit limited, coverage of the e-commerce activity in various sectors of the economy. For many industries, the data include the industry sales accounted by e-commerce, making it feasible to quantify the extent of diffusion across sectors. In addition, the dataset includes a large sample of plants from various manufacturing industries for which adoption of several Internet-based processes is documented, allowing us to have a first look at the Internet adoption patterns in U.S. manufacturing at the micro-level. In particular, we explore the role of plant size in adoption, in view of the discussion surrounding the role of the Internet in small versus large businesses and the Internet's potential to reduce firm size.

We start with an assessment of the evolution of e-retailing, the sector which has drawn the greatest attention in the literature. We first provide some background on the general response and reorganization of industries in the wake of inventions and innovations in order to put into perspective the evolution of this sector. We also present recent statistics on the growth rate of retail e-commerce and discuss the factors enhancing and impeding the adoption of e-commerce across retail industries. We then consider the services sector and document the extent of the diffusion of electronic commerce in this sector. Finally, we investigate the adoption patterns in manufacturing.

We rank manufacturing industries according to their tendencies to adopt Internet-based processes at the plant level. We also highlight the relationship between firm size and adoption rate. Earlier studies have invariably found that firm size is a significant factor in the adoption of new technologies, with larger plants typically adopting at a higher rate than smaller ones.[1] This finding appears to apply broadly to the case of Internet-based processes, although there

[1]See, e.g., Karshenas and Stoneman (1993), Rose and Joskow (1990), Oster (1982), Sommers (1980).

are some important exceptions. We conclude with a look at the future of the Internet's diffusion and a prospect for further data collection by the U.S. Census Bureau.

2 Retail e-commerce

During the last decade, a large number of firms entered retail markets on the Internet and then went out of business. While much has been written in the popular media regarding this mass entry and exit and the path that Internet retailing may follow in its aftermath, more work remains to be done to relate these patterns to the impact of other major innovations on retailing. Looking at this broader picture will help us assess the future prospects of retail activity on the Internet. Some guidance in this direction comes from what we already know about the growth patterns of industries following technological innovations. Many of the possibilities the Internet opens up for retailing are new, but some are only improvements over those that were once provided by other major inventions. In evaluating the Internet's impact, it is important to keep in mind that it is only part of a stream of technological breakthroughs that gradually transformed retail industries.

2.1 Industry life-cycles and technological revolutions

According to the industry life-cycle view, industries are like living organisms: they are born, they grow and then reach maturity. Figure 1 traces the typical time pattern of the number of firms in an industry, from the commercial introduction of a product to the eventual stable state of the number of firms in the industry.[2] An initial period during which only a few firms are active is followed by an episode of escalating, and then peaking, number of firms that leads to a period of mass exit called the shakeout. Eventually, the number of firms stabilizes. This pattern is remarkably regular, and it applies to the evolution of many manufacturing industries as initially observed by Gort and Klepper (1982) and later confirmed by Agarwal (1998) for additional industries and longer time periods. Industry life-cycles have also been well recognized in the theoretical literature and several models have been offered to explain the non-monotonic path the number of firms follows.[3]

What initiates the pattern in Figure 1 is a business opportunity, usually the innovation of a new product or a technological breakthrough that can be exploited commercially. Therefore, the life-cycle pattern is not necessarily confined to new manufactured products and also

[2]There are exceptions to the pattern in Figure 1, as observed by Gort and Klepper (1982). Some industries do not experience a shakeout.

[3]For instance, Jovanovic and MacDonald (1994) consider a model where the shakeout is triggered by an innovation that alters the scale of production.

occurs in other industries which experience such breakthroughs.[4]

Following a few first-movers, many firms enter the industry and the number of firms increases (Phase I). It is, however, uncertain whether an entrepreneur has the skills to be successful in the new industry, whether the new opportunity is indeed suitable for him, or whether the new product or process will be welcomed by consumers. This uncertainty gradually resolves over time often when some entrepreneurs realize that the environment is tougher than they expected, or that they overestimated their capabilities. This realization almost invariably triggers the shakeout phase of the life cycle, during which failing entrepreneurs are weeded out and the number of firms declines sharply (Phase II). The shakeout ends with the emergence of a set of surviving successful firms, as the number of firms stabilizes (Phase III). It is also observed that, at least for manufactured products, total industry output grows throughout the life-cycle, even during the shakeout, and the product price falls over time.[5]

In the next subsection, we discuss the diffusion of FM radio as an example of the patterns of industry evolution in the wake of technological inventions. For an example of a shakeout that took place on the Internet, see Day, Fein and Ruppersberger (2003), who consider the case of the shakeout in business-to-business electronic exchanges. As another example, Barbarino and Jovanovic (2003) consider the evolution of the Telecom sector in recent years and propose a model of shakeout that embeds the idea of entrepreneurs overshooting the demand in the market by investing in capacity excessively.

2.2 The Diffusion of FM Radio

As an example of industry life-cycles generated by technological improvements, consider the commercial diffusion of FM radio broadcasting shown in Figure 2. Much like the Internet, the FM technology provided a new medium for broadcasting and opened up a business opportunity for both new and existing radio stations, which could make profits by airing advertisements.

In 1941, the year of the first authorization for commercial FM stations, only 5 stations were in operation. But the number of stations increased steeply after World-War II, peaking in 1950, as the business opportunity was aggressively pursued by both new FM stations and the established AM stations diversifying into FM broadcasting. By 1949, about 85% of the FM stations were owned by existing AM stations. The AM stations used FM stations frequently as an insurance against a possible demise of the AM technology and at the same time to deter entry by independent FM broadcasters. A shakeout followed between 1950 and 1957 during which 203 stations, about 28% of all stations at the peak, shut down. Thereafter,

[4] An example of life-cycle patterns in wholesale trade is given by Fein (1998). More recently, Mazzucato (2002) compares the experience of the PC industry to the shakeout episode in the automobile industry.

[5] See, again, Gort and Klepper (1982) and Agarwal (1998).

the number of stations rebounded and continued to grow steadily.[6]

A similar pattern of early mass entry and shakeout was observed in the diffusion of AM radio and TV stations, but the extents of the entry and the shakeout, their duration, and the reasons driving them were not the same. For example, in the case of AM broadcasting, the main force behind the shakeout was the regulation placed on broadcasting frequencies. In the case of FM stations, the reasons were uncertainty about the future of FM technology, less than expected interest in the new medium from advertisers, competition from AM and TV stations, and some conflicts arising from joint ownership of AM and FM stations. Such conflicts were also pertinent in the early experience of the Internet. The fact that AM stations embraced FM technology to take advantage of synergies as well as to deter entry by independent FM stations is similar to the clash between entirely Internet-based retailers and traditional retailers adopting Internet as a sales channel.

2.3 The evolution of retail e-commerce

For Internet-based retailing, the business opportunity was clearly not a new product, but rather a new medium through which business could be conducted. The main attractive features of this medium for retail business are easier communication between consumers and firms through reduced costs of advertising and search, the possibility of eliminating the traditional geographic market boundaries which allows local entrepreneurs to compete in a wider market, and the *scale* and *scope* economies made possible by a central warehousing and distribution system that reduces the need for many local facilities and a labor force dispersed across several locations.[7] All of these factors appear to be important considerations for retailing.[8]

The retail industry has benefited from many major innovations, such as railroad, telegraph, automobile, radio, television, electric elevators, computers, barcodes, and scanners. Because doing retail business requires both flow of goods and flow of information from one location to the other, any improvement in transportation or communication technologies has had an impact on the structure of retail industries. Earlier, the railroad-telegraph combination enlarged the market reach of local retailers and was crucial for the emergence of regional and national department stores and mail-order houses. Automobiles enhanced the physical connection of consumers and retailers, while radio and, later, television, further contributed

[6] In many industries, there is no such post-shakeout growth in the number of firms. The growth in number of FM stations post-shakeout is probably a consequence of the fact that FM stations are local in nature, and growth in local population over time may have led to an increase the variety and number of such stations.

[7] In a single-product firm, *economies of scale* indicate declining per-unit costs as the number of units produced increases; in a multi-product firm, *economies of scope* indicate cost-saving synergies between different product lines.

[8] Dinlersoz and Pereira (2004) provide a theoretical analysis of how these factors may affect adoption incentives for established versus new firms.

to the emergence of a national market for retailers by increasing the reach of advertising. In this sense, the Internet's effect on retailing is similar to that of other communication technologies, such as newspaper, radio, and television, which help match consumers with firms.

In Internet retailing, we have already witnessed the two phases of the industry life-cycle characterized by rising and declining number of firms, respectively. What is most interesting about these two phases is that they occurred at a much faster pace than the historical average. A shakeout that spans several years, even decades, in a typical manufacturing industry, spanned only a few months in the case of the Internet. Similarly, the initial entry of new firms was much more rapid on the Internet. This can be attributed to easy access to website-design technology that may have reduced entry costs in many, but not all, sectors, and to faster diffusion of information about firms' attributes and performance, which probably sped up the demise of inefficient firms and enhanced the dominance of efficient ones.[9]

It appears that the faster pace of these phases is not an entirely new but rather a gradual historical phenomenon. The time it takes for additional competitors to enter a new industry in the presence of a few dominant first-movers has been shrinking throughout the 20th century. Agarwal and Gort (2001) find that this time window decreased from an average of 33 years at the turn of the 20th century down to about 3.4 years for products introduced in the 1967-1986 period.[10] Even the Internet itself has been diffusing much more rapidly among the U.S. population than major innovations in the past. This appears to be part of a broader trend that the diffusion of major innovations has been increasingly faster over time.[11]

The adoption of the Internet as a marketing and sales channel proved to be challenging. In the beginning, the tendency to adopt was quite different for two groups of retailers: existing retailers with established traditional market functions and facilities versus entirely new entrepreneurs who had no traditional market presence. Even though the website design technology was available at a low cost to almost anybody who wanted to start a retail business, the cost of investing in warehousing and distribution facilities, which are required for large scale retail operations, is high in some sectors. Established retailers in such sectors seemed to have an edge with respect to the latter, so it is surprising that they were the latecomers.[12]

[9]See Dinlersoz and Yorukoglu (2004) for the effect of easier spread of information on firm and industry dynamics.

[10]See Agarwal and Gort (2001) for potential explanations for this phenomenon.

[11]For instance, it took approximately 45 years for electricity to reach 20% of American households, 35 years for the telephone, 25 years for the television, and 15 years for the personal computer.

[12]Some Internet-based firms, however, overcame this difficulty by using a method called "drop-shipping", which allowed them to use manufacturers to ship products on their behalf. This reduced the investment needed in warehousing and shipping in some cases.

The reluctance of existing retailers to diversify to the Internet market stemmed partly from the potential problems associated with harmonizing traditional and Internet retail channels, giving rise to *channel conflict*. This conflict comes in many forms, including the resistance of the firm's traditional operations and sub-units to the possibility of being replaced by the Internet, the incentives for free riding by traditional market rivals on the product information and related services provided directly on the firm's website, and the possibility that a firm's business on the Internet might compete for its own clientele in the traditional market.[13] Nevertheless, channel conflict currently appears to have lost its role as a major concern in deterring the existing retailers from diversifying. Eventually, the established names of well-known traditional retailers, their ability to raise funding to finance new ventures, and their existing warehousing and distribution facilities allowed them to enter the Internet market strongly. In some product categories, however, the largest online sales today are still made by pure online retailers and by manufacturers directly selling their products, rather than by diversified traditional retailers.[14]

During its emergence and early growth, Internet retailing was largely free of regulation. However, one important policy has been the absence of taxes. Following the practice in the case of catalog retailing, the Internet commercial activity is free of tax as a result of a moratorium initiated in 1998 that continues to apply. While there has been no other special infant industry protection program for Internet retailing, the no-tax environment clearly encouraged the growth of the industry by favoring Internet firms over local firms. Goolsbee (2000) provides preliminary estimates that imposing taxes would have reduced the sales on the Internet by 25-30%.[15] The industry evolution was therefore positively influenced by the absence of taxes. In addition to aiding the growth of Internet retail, the tax-free environment had some implications for the location of Internet retailers' sales offices and warehouses. Since the shipments within the state where the firm is physically located are subject to local taxes, there are incentives to avoid populous states. However, the tax break neither changed the main course of the industry's evolution nor prevented the shakeout. With taxes, we would have probably observed fewer sales and a smaller number of firms, but no major changes in the trends.

[13]See, for example, Carlton and Chevalier (2001), Shaffer and Zettelmeyer (2002), and Dinlersoz and Pereira (2004).

[14]For instance, in books, Amazon.com has a much higher share than the traditional retailer Barnes and Noble. See Latcovich and Smith (2001).

[15]Also see Ellison and Ellison (2003) for a smaller scale, but more recent, analysis of the effects of sales tax on Internet retailing.

2.4 Some effects of the Internet on the retail industry structure

The Internet is a hybrid medium that is capable of combining two basic ways of information exchange in a market: advertising and search. The reach of the Internet makes these two functions truly global. As a consequence, the location of demand has become less of a concern for a retailer's location. The separation between the locations of demand and supply can increase the scale and scope of a retailer.

Internet retailers that can dominate the market in a certain category of products are also able to easily expand their operations into other categories. Amazon.com is a good example. Amazon started as a book retailer but now it sells many different products. This replicability or expandability, in some cases through linkages with traditional retailers, is due to the fact that adding a new product to the existing set of products is probably much easier and cheaper on the Internet. Basically, all that needs to be done is to create digital space for the new product on the website and physical space in the warehouse. Large Internet firms, such as Amazon.com, have a much wider range of products than traditional big firms, such as Wal-Mart. In addition to the availability of lower prices, the proliferation of varieties on the Internet is a key feature that increases consumer welfare.[16]

Besides its role in enhancing search and advertising, a distinguishing feature of the Internet is its interactivity. Unlike other media, it allows for two-way information exchange between consumers and firms, and it can also be used to record and store the various steps of this exchange for future use. This latter feature of the Internet is especially useful for retailing, because it makes it possible for firms to learn about consumers' preferences by analyzing their shopping patterns. This type of information extraction works in favor of customization of goods and services to satisfy finer individual tastes. In this respect, the Internet is an advanced form of the scanner technology at the checkout counter that revolutionized retailing earlier by allowing firms to monitor what consumers bought. The Internet also enables firms to target consumers individually or in small groups, unlike other communication tools, such as radio and television, which can at best target coarsely defined, large groups of consumers.

The Internet also offers firms the possibility to monitor rival firms' strategies more closely, especially their prices and promotional efforts, making it easier for firms to respond quickly to changes in rivals' strategies. The costs of pricing products and adjusting prices, referred to as *menu costs,* appear to be much lower on the Internet.[17] This feature is likely to speed up the pace of competition in retail markets.

What will be the main characteristics of the retail industries on the Internet in the future?

[16]See Brynjolfsson, Smith, and Hu (2003) on the welfare gains to consumers from high variety in online markets.

[17]Brynjolfsson and Smith (2000) estimate that menu costs are substantially lower on the Internet compared to the traditional market. Changing prices of products on the Internet requires simply updating price listings on a website, as opposed to physically marking products on the shelves, which is costly.

Will the industry structure look more like a competitive industry or a monopolistically competitive one with many small firms each serving a particular niche in the market, or will it be more concentrated with a few large firms dominating the market for a particular product type or many product lines simultaneously? It is too early to answer this question convincingly. Clearly, there are features of the Internet that can promote entry, competition, and fragmentation. Initially, it was believed that low entry costs associated with operating a website might foster entry and competition. However, the Internet also provides an environment conducive to expanding scale and scope of operations at very low cost and to spreading information about a firm's attributes, and can give rise to firms that can quickly become large. These features can lead to high concentration.

While some early findings suggest that the Internet concentration ratios were initially much higher than their traditional market counterparts, there is no overwhelming evidence that this is the case. In one of the earlier studies, Latcovich and Smith (2001) find that industry concentration is much higher on the Internet than in the physical market in the case for book and music retailing. The authors also report that advertising and promotion efforts are more intense on the Internet compared to the traditional market. Thus, post-entry sunk costs in the form of investment in advertising and customer loyalty programs may be an important aspect of competition. Such investments have the potential to deter entry and lead to a highly concentrated market structure.[18]

In a more comprehensive study, Noam (2003) also points to high concentration, as measured by the Herfindahl-Hirschman Index (HHI), in several industries for the pre-2002 period.[19] He finds that the Internet sector's overall concentration was high, and concentration initially declined in 1980's and 1990's, but increased towards mid-1990's. For data starting in 2000, Baye and Morgan (2003) find that the average HHI for 5000 products in their sample initially increased between August 2000 and February 2002, but then exhibited a clear decline till November 2003. The average HHI in their sample, though, is much lower than those in Noam (2003). The authors conclude that the differences between the industries analyzed and the differences in the market definitions may be the cause for the discrepancy between the two studies. In some markets, such as local Internet access providers, there are many competitors in any town and concentration is low. In other markets, such as broadband providers in a city, there are only a few competitors and concentration is very high.

Aside from the evidence discussed so far, there is no systematic comparison of concentration levels in traditional versus Internet markets. One of the important issues in such comparison is the comparability of the industry definitions in Census Bureau data on tra-

[18]For theoretical arguments behind this, see Sutton (1991). Also see Dinlersoz and Yorukoglu (2003) for an alternative analysis of the role of lower cost of advertising in changing market structure.

[19]The Herfindahl-Hirschman concentration index is defined as the sum of the square of participant firms' output market shares.

ditional retail industries and the data collected independently by individual researchers on Internet industries. The main data source on traditional retail industries, the Census of Retail Trade, provides concentration measures at the 4-digit *industry level*, which usually consists of several products. Most of the data privately collected by researchers, on the other hand, are compiled at the *product level.* Unless such product level data are aggregated to the 4-digit industry level compatible with the Census Bureau's industry definitions, a direct comparison of the concentration ratios is not possible. A second issue is the definition of the concentration ratio itself. The Census of Retail Trade only reports *n-firm concentration ratios*, such as a 4-firm or an 8-firm concentration ratio.[20] To be comparable with these definitions, independent data collected by researchers must contain enough information to calculate similar ratios. These shortcomings point to a demand for more organized data collection by the Census Bureau, an issue we return to in the conclusion.

2.5 The growth of retail e-commerce sales

Despite the shakeout, retail e-commerce sales have been growing at a steady pace over the years, as shown in Figure 3. While the current share of retail sales accounted by electronic commerce is still very low (around 2%), its growth rate is considerably high. As total retail sales grew at an average rate of 1.3% quarterly over the sample period, e-commerce sales exhibited an average growth rate of 8.6%. The strong seasonality in e-commerce sales is also apparent from Figure 3, with 4th quarters exhibiting exceptional growth, due to the surge in online shopping during holiday seasons.

The sectoral breakdown of the share of retail e-commerce sales is shown in Table 1. In almost all sectors, the share in 2002 was less than 1%, and the differences across sectors were not highly perceptible. Table 2 presents the percentage of sales accounted by e-commerce by product category, considering only the firms classified as "electronic and mail-order houses." The electronic and mail order houses industry includes all catalog and mail order houses and other direct retailers, many of which sell in multiple channels, as well as pure Internet-based firms and brick-and-click retailers, if the e-commerce group operates as a separate unit and is not engaged in the online selling of motor vehicles. The diffusion of e-commerce sales was relatively rapid and widespread among electronic and mail-order houses compared to other retail sectors, and differences across product categories in the share of e-commerce are more visible in this industry. In 2001, the highest shares were observed in books and magazines, electronics, and music and videos. Relatively low shares were observed in food, beer and wine, clothing and apparel, and drugs.[21]

[20]The *n-firm concentration ratio* is defined as the market share accounted for by the n largest firms in the market.

[21]Part of the lack growth observed in beer and wine e-commerce sales is probably related to the restrictions

These observations make clear that the nature of the product matters for the extent of the diffusion. However, the differences across categories are expected to vanish over time as both sellers and buyers experiment with various product types and find out the products within a category that are most conveniently and cost-effectively traded online. Such convergence is already happening to some extent. Some product categories in which e-commerce had little share initially have exhibited strong growth. Examples are food, beer and wine, furniture and home furnishings, and clothing. This growth is likely to be a result of consumers and firms becoming more familiar with the Internet environment, and overcoming the concerns they initially had about the medium.

Many other sectors that were once thought of as relatively unsuitable for Internet retailing have been on the rise. A very recent example is jewelry.[22] Mullaney (2004) reports that Internet-based startups are slowly taking over this product category, especially in diamonds. The main reason for the success of Internet-based firms appears to be the substantial cost savings for online retailers in selling diamonds, for which sales traditionally involve several stages before the item reaches the customer. These layers of middlemen, experts, appraisers, and sales-force are dramatically reduced for online sellers.[23] As diamond sales on the Internet increase, some traditional retailers which specialize mostly on standard diamond types may lose their market share. On the other hand, some other traditional retailers rely more on image and brand, so that customer loyalty to their name makes them relatively less vulnerable to increasing online sales. In the meantime, many other small traditional retailers appear to be facing a choice between focusing on more specialized diamonds, instead of the standardized ones, so that they can avoid direct competition with online retailers. This behavior of traditional retailers is just one example of retail industries' re-organization in response to the emergence of e-commerce, and is reminiscent of the way local markets were once reshaped by the entry of Wal-Mart stores and other dominant chains.

3 Services and the Internet

Service industries have also been embracing the Internet rapidly, even though the overall share of e-commerce in total revenues is still below 1%, as shown in Figure 4. In some ways, the affinity between the Internet and services industries is not very surprising. Service industries in general have been quick in adopting the basic technologies such as computers and Internet access. Moreover, since many service products are essentially information goods

set on interstate shipments of alcohol by many states.

[22] Amazon.com announced in April 2004 that it was entering the jewelry market through an open letter to customers on its website signed by the founder Jeff Bezos.

[23] It is estimated that a physical chain would need 116 stores and more than 900 workers to match the sales of the leading firm in the Internet market (See Mullaney (2004)).

that come in digital form, they can be easily traded online. Examples are publishing services, information services, travel reservations, and even mortgage and stock trading. Such goods that can be traded in digital form are bound to become dominant categories in online retailing as argued by Dinlersoz and Pereira (2004), because they can be conveniently delivered and returned via e-mail, they can bypass wholesale and retail layers, they require neither physical storage space nor transportation, and online demos make product information easy to obtain and product quality easy to verify. Therefore, both firms and consumers stand to gain substantially by trading digital goods online.

Digital products, especially information goods, in general exhibit different behavior than non-digital ones in many dimensions, including pricing and distribution. For such goods, the initial fixed production cost tends to be high, but the marginal cost is generally low. For instance, a computer program may have a substantial development cost, but producing a copy of it is relatively simple and cheap. These peculiar features of digital goods have been the subject of recent research.[24]

Table 3 contains the share of electronic commerce in sales for various services. Sectors leading in the penetration of electronic commerce sales are publishing, online information services, securities and commodity contracts intermediation and brokerage, computer systems design and related services, and travel arrangement and reservation services. Many sectors still have low penetration rates. The data for certain sectors are not of high quality and awaits further development and refinement in the data collection process. Furthermore, some sectors, such as mortgages—a rising sector on the Internet—have not been included.

The travel industry is far ahead of any other industry in the service sector in terms of its share of electronic commerce. The importance of consumer search and the dynamic nature of travel arrangements make this category a very suitable one for electronic commerce. The demand, capacity, and prices are relatively more volatile and seasonal in this industry, implying that real-time price changes can be monitored by both firms and consumers more easily online than off-line. Furthermore, transaction costs are much lower for this industry online than off-line, and travel firms are able to pass these cost savings onto consumers in the form of lower prices. Another attractive feature of online travel reservations is that a consumer can select different elements and stages of a trip, such as flight, hotel, car rental, local tours, etc., in one big bundled reservation. This flexibility in bundling is a source of utility for consumers. This kind of bundling also existed in traditional markets for a long time, but the travel websites make it much easier and much more flexible. Considering all the benefits of online shopping, the travel industry is a candidate for becoming the first big industry with the majority of its sales online.

[24]See, e.g. Varian (1995, 2000, 2001)

4 Manufacturing and Electronic Commerce

The Census Bureau's survey of electronic commerce activity indicates that the penetration of the Internet in e-commerce sales has been highest in manufacturing sector, followed by wholesale, services, and retail. Not surprisingly, manufacturing also leads in terms of the Internet's impact on business-to-business transactions. In fact, the Internet's biggest and most immediate impact has been on reducing transaction costs and enhancing efficiency in many ordinary business exchanges between firms and within a firm, rather than between firms and consumers. In the next two sections, we document the diffusion of several important Internet-based processes used by manufacturing plants in facilitating stages of production.

4.1 Leading sectors and processes

To understand the extent and prevalence of usage of Internet-based processes in manufacturing industries, we present two simple rankings. Shown in Table 4 is the ranking of industries in terms of plants' tendencies to use the Internet for various processes.[25] To generate this table, we assume that a plant in industry i adopts process j with probability p_{ij} independently of other plants. We then compute $\widehat{p}_{ij}$, an unbiased estimate of this probability, as the ratio of the number of plants in industry i that adopted process j, n_{ij}, to the total number of plants surveyed in industry i, N_i.[26]

After obtaining estimates $\widehat{p}_{ij}$ for each industry i and for each process j, we simply ranked industries according to the rate of adoption of each process, and then took the average of these ranks across all processes by industry. We then ranked industries based on this "average rank." The resulting ranking in Table 4 reveals that industries that are generally perceived to be technologically advanced, such as *machinery*, *electrical equipment*, *computer and electronic products*, and *transportation equipment*, tend to rank high. These industries are also the ones where computers have traditionally had a lot of applications. Industries that are at the bottom of the list are *wood products*, *nonmetallic mineral products*, and *furniture and related products*.

The second summary, shown in Table 5, is the ranking of Internet-based processes based on their rates of adoption in different industries. As in the making of Table 4, we first ranked all processes for each industry in terms of adoption rate, and then calculated the average

[25] A shortcoming of the data is that we do not have information on the intensity of usage of a process in a plant. Thus, we only summarize adoption as an all–or–nothing decision, even though firms may have different degrees of usage intensity after adoption.

[26] The estimated standard deviation of $\widehat{p}_{ij}$ can be calculated as

$$\widehat{\sigma}_{\widehat{p}_{ij}} = \sqrt{\frac{\widehat{p}_{ij}(1-\widehat{p}_{ij})}{N_i}}.$$

rank for each process across all industries. The most heavily adopted processes are *basic Internet access*, *online access to vendors' products or catalogs*, and *use of online ordering from vendors*. The least adopted processes are *supplying online inventory data to external customers* and *supplying online order status information to external customers*.

Somewhat surprisingly, the adoption rates of *online bidding* and *usage of electronic marketplaces* are relatively low. These processes are precisely the ones that were initially thought to be revolutionary. Day, Fein and Ruppersberger (2003) argue that the limited success of these applications can be attributed to the fact that online exchanges did not dramatically alter the existing way firms manage their supply chains. Firms value obtaining the right combination of products at the right time, and coordinating complex production activities is easier with a dedicated, traditional supply chain. The price savings offered by online exchanges were simply not enough to convince firms to sacrifice other aspects of production, such as timeliness and access to preferred brands.

4.2 Plant size and adoption rate

The increasing use of the Internet for transactions within and across firms also gave rise to the question of whether the rate of usage is closely associated with firm size. A related issue is how adoption affects firm size. As Varian (2002) pointed out, it is not clear in which direction firm size will move as Internet-based transactions continue to replace traditional ones. The answer depends on the relative magnitudes of competing forces. If Internet-based transactions reduce the costs of using external markets by more than they reduce internal transaction costs, then firm size can decrease. The data available are not suitable for a full analysis of the Internet's effect on firm size, but they are informative with respect to the role of plant size in adoption.

We can estimate the rates at which certain Internet-based processes are adopted by plants of different sizes. For 10 plant employment size groups, the data contain the number of plants that have adopted a certain Internet-based process at the time the survey was conducted.[27] We can again assume that the population of plants in size group k is generated by a Bernoulli distribution with parameter p_{ijk}, which can be estimated as the ratio of the number of plants in industry i that adopted process j, n_{ijk}, to the total number of plants surveyed in this size group, N_{ik}. In other words, a plant in size group k adopts the process with probability p_{ijk} independently of other plants in the size group and in other size groups.[28]

The sampling procedure used by the census is a *probability–proportional–to–size* sampling

[27] The size groups are 1-4, 5-9, 10-19, 20-49, 50-99, 100-249, 250-499, 500-999, 1000-2499, and 2500+ employees.

[28] Obviously, the assumption that a plant's adoption decision is independent of the overall adoption rate in the industry is made for simplicity. Externalities in adoption are likely to affect the probability of adoption for at least some processes.

scheme in the sense that larger plants are sampled with higher frequency, and small plants are under-represented in the sample. Therefore, the standard errors on the estimates for smaller plants are in general higher.[29] As an example, consider the estimated rate of Internet access by plant size class in Figure 5. The smallest plant size group has an estimated adoption rate of 48% compared to 98% for the largest group. The estimated values are higher for higher size groups, and the estimated standard deviations are lower, in part reflecting the sampling scheme mentioned. Consequently, the confidence intervals are narrower for higher size groups, and the differences between estimated adoption rates are usually highly significant across size classes with a few exceptions.

The pattern in Figure 5 is generally applicable to a majority of the processes. In some cases, the standard deviations of the estimates increase with firm size class, implying that there is much variation among large plants in the adoption rate, after controlling for the fact that they are represented more heavily in the sample. In the following discussion we will focus on characterizing whether the adoption rate generally exhibits a positive and statistically significant relation to firm size.

For a compact presentation of the patterns, we aggregated the 10 plant employee-size groups into three size classes: small plants (plants with 1 to 20 employees), medium plants (plants with 21 to 99 employees), and large plants (plants with 100 or more employees). Table 6 confirms that in many cases there is a statistically significant increase in the adoption rate as plant size class increases. Exceptions occur for some important processes, however. In the case of *use of the Internet to place orders for materials and supplies online*, adoption rate declines with plant size, as shown in Figure 6. A similar pattern is observed in the case of *use of the Internet to accept orders online*, as seen in Figure 7. While these exceptions deserve further exploration, lack of plant characteristics prevent us from reaching a definitive conclusion about the adoption rate/firm size relationship.[30] Since larger plants are more likely to be vertically integrated, it is quite possible that these plants rely less on the Internet to access outside suppliers. This explanation may also apply to the case of accepting orders online, albeit to a lesser extent.

Two other processes deserve attention. It appears that plant size has little effect on the

[29]The estimated standard deviation of the estimated probablity, denoted by $\widehat{p}_{ijk}$, can be obtained as

$$\widehat{\sigma}_{\widehat{p}_{ijk}} = \sqrt{\frac{\widehat{p}_{ijk}(1-\widehat{p}_{ijk})}{N_{ik}}}.$$

A 95% confidence interval for the true adoption probability, p_{ijk}, is then given as

$$[\widehat{p}_{ijk} - 1.96\widehat{\sigma}_{\widehat{p}_{ijk}}, \widehat{p}_{ijk} + 1.96\widehat{\sigma}_{\widehat{p}_{ijk}}].$$

[30]Plant characteristics are available from the U.S. Census Bureau, but only for on-site usage, as they are classified as confidential data.

adoption of *online bidding* and *trading in electronic marketplaces*, as shown in Figures 8 and 9. While sampling errors may be contributing to these two patterns, there does not appear to be a highly statistically significant increase in the adoption of these two processes as plant size increases. In fact, both processes are adopted with a rate of less than 20% by plants of all sizes. The low adoption rates of these two processes notwithstanding, virtually indistinguishable rates of adoption across a wide range of size classes suggest that large plants may be benefiting from these external market activities as much as small plants do. Obviously, without the intensity of usage of these two processes by plants, a definitive conclusion cannot be reached based only on adoption rates. Nevertheless, one might have expected a priori that small plants adopt these two processes at a higher rate than larger ones, as smaller plants may rely more on these external market activities because of a lack of several internal sub-units focusing on individual stages of production and procurement.

One of the conjectures about the Internet's impact on the organization of production was that it would lead to more vertical disintegration. Along Coase's (1937) arguments, if the cost of making transactions outside of the firm declines, firms should have higher incentives to carry out these transactions with outside specialists, rather than within the firm. While our results do not offer any direct evidence on the issue, they suggest that, at least for some stages of production, this may be happening to some extent. Most processes are adopted at a higher rate by larger plants. Some of these processes are those that can induce vertical disintegration, such as *the use of the Internet to place orders for materials and supplies online*, *online ordering from vendors*, *online payment to vendors*, *online bidding*, *use of electronic marketplaces*, and *use of computer networks to outsource research and development*. As such processes are adopted with higher frequency and intensity, plants, and firms, may reduce the size of internal units undertaking these functions, or eliminate them altogether.

5 Conclusion

In this paper we have provided a brief account of the diffusion of electronic commerce in major sectors of the economy. Electronic commerce appears to have settled on a course of promising growth, much like other industries did in the wake of technological revolutions in the past. A lot of learning has taken place both on the firms' and the consumers' side, and all parties are now better informed about what to expect in online markets and how to realize these expectations. There remain, however, still some concerns that need to be addressed for faster diffusion of electronic commerce: for example, improving online security for payments and transactions and improving the quality and speed of transactions.[31]

[31] Security is still listed as one of the top concerns by consumers. See The Economist's survey "E-commerce Takes Off" , May 15, 2004.

In summary, some of the important observations presented in this paper are as follows:

- In the retail sector, we have witnessed a rapid development of the two initial phases of the e-commerce industry life-cycle, corresponding to an initial increase in the number of firms followed by the subsequent shakeout. Although the current share of retail sales accounted for by e-commerce is still low, the sector has experienced very high growth rates in recent years.

- Internet retailers that can dominate the market in a certain category of products seem to be more capable of expanding their operations into other categories. This has generated a vast proliferation of product varieties in Internet market. The patterns observed so far suggest that the variety of goods and services offered on the Internet is bound to increase.

- In the services sector, the travel industry is far ahead of other industries in terms of the share of sales accounted for by e-commerce.

- The volume of business-to-business e-commerce transactions far exceeds that of business-to-consumer e-commerce transactions. This is particularly true in the manufacturing sector, where almost every stage of production has been affected by the use of the Internet.

- In general, manufacturing industries that are perceived to be technologically advanced tend to rank high in the adoption of Internet-based processes used to facilitate production.

- Although the most heavily adopted processes include obvious ones, such as *basic internet access* and *online access to vendors' catalogs*, other processes that were initially thought to thrive on the Internet, such as *online bidding* and *usage of electronic marketplaces* have not been widely adopted.

- Analysis of adoption rates of several Internet-based processes across plant sizes and manufacturing industries reveals that, generally, there is a positive and statistically significant relationship between adoption rates and firms' plant size.

As always, the burden of recording the effects of the ongoing technological revolution rests on the shoulders of data collectors. The steps taken so far by the U.S. Census Bureau are encouraging, but much more remains to be done.[32] In our view, the collection of data

[32]Haltiwanger and Jarmin (2000) provide a good list of broad areas in which data collection effort can be concentrated.

pertaining to e-commerce activity should be taken to the mainstream.[33] For instance, new survey questions can be added to the Census of Manufacturers, a quinquennial dataset collected by the Census Bureau which contains information on all active manufacturing plants, to gather detailed information on various uses of the Internet by plants. This practice would allow us to understand the importance of the digital inputs in the production processes and how the intensity of usage of such inputs compare with traditional inputs of labor and capital. Any substitution among these various inputs that can take place in the medium and long-run can then also be detected.

Furthermore, data on the intensity of Internet-based processes use should also be collected, rather than just information on whether a process is adopted or not. Several processes investigated in this paper can be measured in a continuous way, rather than a discrete "adopt versus not adopt" decision. For instance, one could measure the amount of orders received on the Internet versus traditional channels. The retail trade surveys, such as Census of Retail Trade, can be amended to include data on retail electronic commerce, especially firm level data on e-commerce sales. As mentioned earlier, one of the major drawbacks is the absence of e-commerce sales data at the firm level. If such data is collected by the Census Bureau, concentration ratios for electronic markets can be constructed, as well as statistics on firm size distribution. These statistics can then be used to fill the void in our understanding of how traditional versus electronic markets compare in various dimensions. Existing data do not allow a satisfactory treatment of this issue, partly because comparable data across the two sectors are not easy to obtain, and most data do not provide a comprehensive coverage of one market or the other.

A Data

The data used in this article come from two U.S. Census Bureau reports on electronic economic activity. The first is the "E-commerce Multi-Sector Report" and the second is the "E-business Process Use by Manufacturers, Final Report on Selected Processes." Both of these reports are available online at *www.census.gov/estats/*.

A.1 E-commerce multi-sector report

The data on e-commerce economic activity for the three industries we analyze are collected in three separate Census Bureau surveys. First, data on retail e-commerce sales are collected in the "2002 Annual Retail Trade Survey (ARTS)," a survey of more than 19,000

[33]There is also some private effort to collect extensive data, especially on prices. Visit, for example, *www.nash-equilibrium.com* to see an Internet price index tracker.

retailers. More recent data on retail e-sales (such as those used in Figure 3) are available as part of a quarterly retail e-commerce series. Revenue data on selected services industries are collected in the "2002 Service Annual Survey (SAS)," a survey of more than 58,000 firms. Finally, data on the value of manufacturing e-commerce shipments are collected in the "2002 Annual Survey of Manufactures (ASM)," a survey of more than 55,000 manufacturing plants.

The estimates in Figure 3 are reproduced from the May 21, 2004 release on "Retail E-commerce Sales in First Quarter 2004" produced by the Census Bureau. Estimates are not adjusted for seasonal variation, holiday or trading-day differences, or price changes. For additional details, please see *www.census.gov/mrts/www/current.html*.

The estimates of e-commerce shares of total sales or revenues (and their standard errors) in Tables 4, 5, and 6 are reproduced from Tables 5 and 5A, 6 and 6A, and 4 and 4A, respectively, in the "E-commerce Multi-Sector Report."

A.2 E-business Process Use by Manufacturers

This report tabulates the responses of more than 38,000 manufacturing plants to 39 questions about Internet-based processes use at the plant level. These responses were collected in the "Computer Network Use Supplement (CNS)" to the "1999 Annual survey of Manufactures (ASM)."

The estimates of adoption rates of Internet processes reported in Figures 5–9 for manufacturing plants were obtained from the authors' own calculations based on the tabulations of the "E-business Process Use by Manufacturers" report. The same tabulations were used to calculate the rates of adoption of Internet processes for the calculations of the ranking of manufacturing industries in Table 4, the ranking of Internet-based processes in Table 5, and for Table 6, where we contrast the adoption rates of several processes across three aggregate manufacturing plant size classes.

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Figure 1: Evolution of Number of Firms

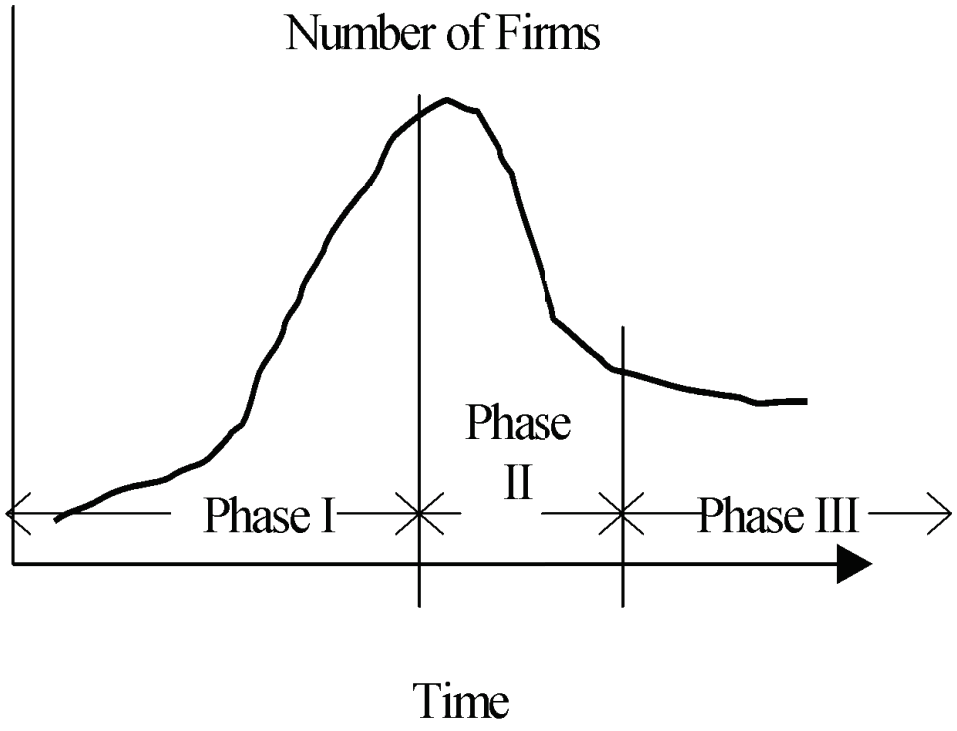

Figure 2: Number of FM radio stations over time

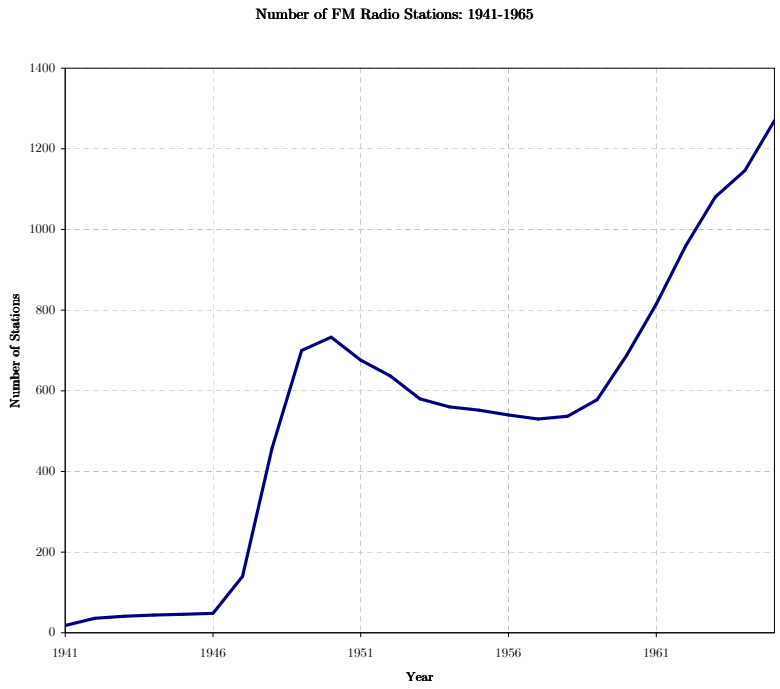

Figure 3: The growth of retail e-commerce

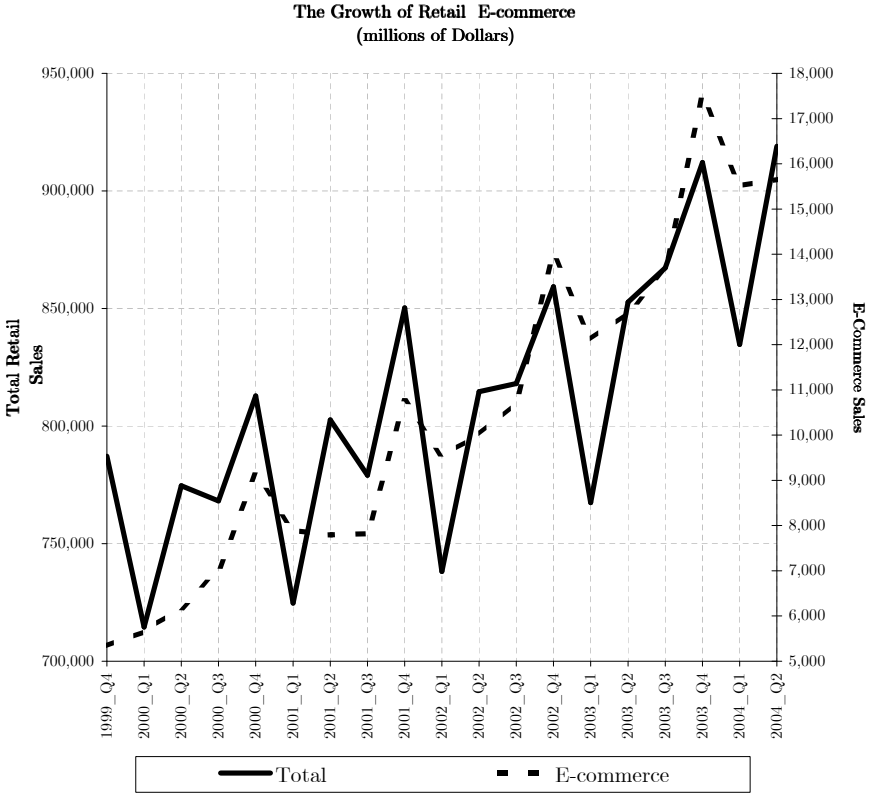

Figure 4: The revenue share of e-commerce in manufacturing, Services, and Retail

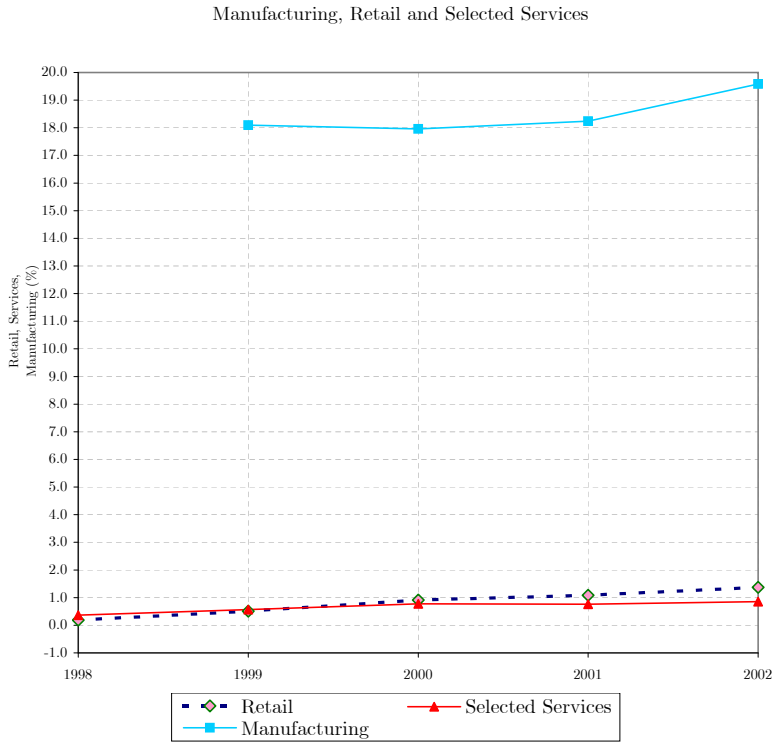

Figure 5: The adoption rates of Internet access by manufacturing plant size classes

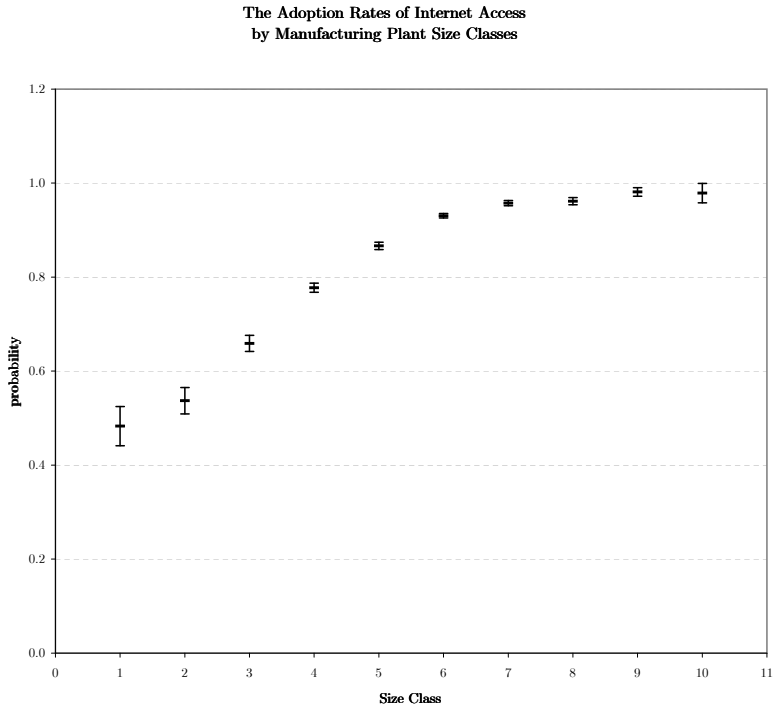

Figure 6: Use of the Internet to place orders for materials and supplies online

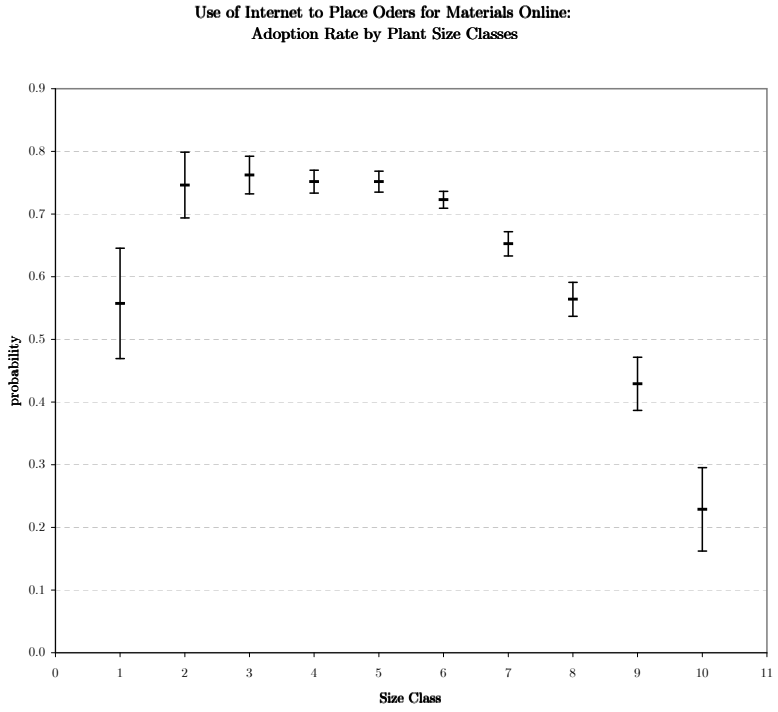

Figure 7: Use of the Internet to accept orders online

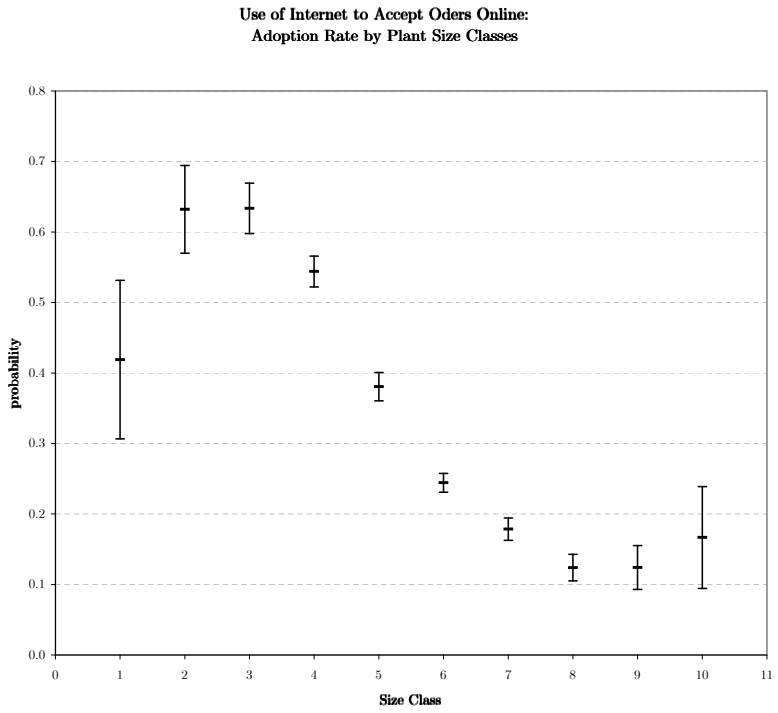

Figure 8: Use of the Internet for online bidding

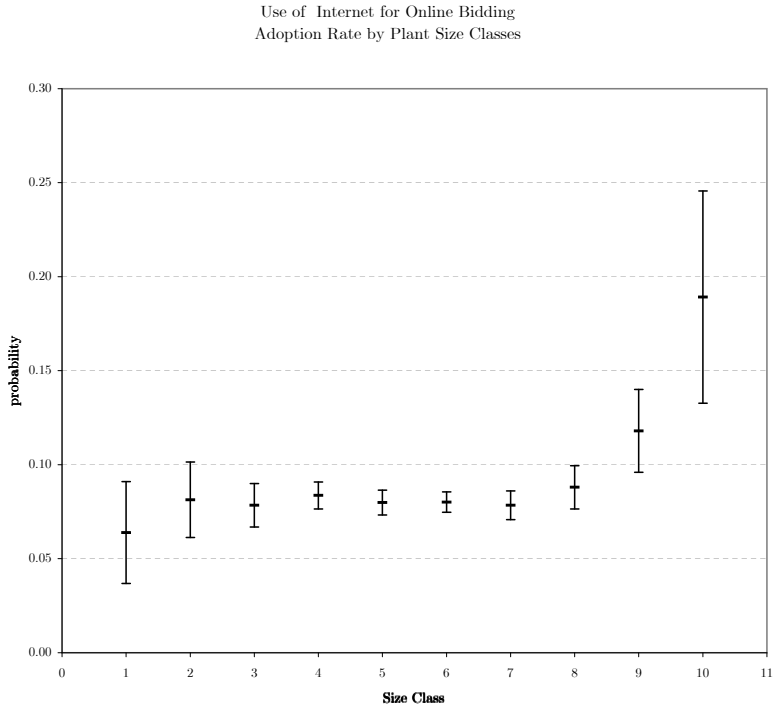

Figure 9: Use of the Internet for access to electronic marketplaces

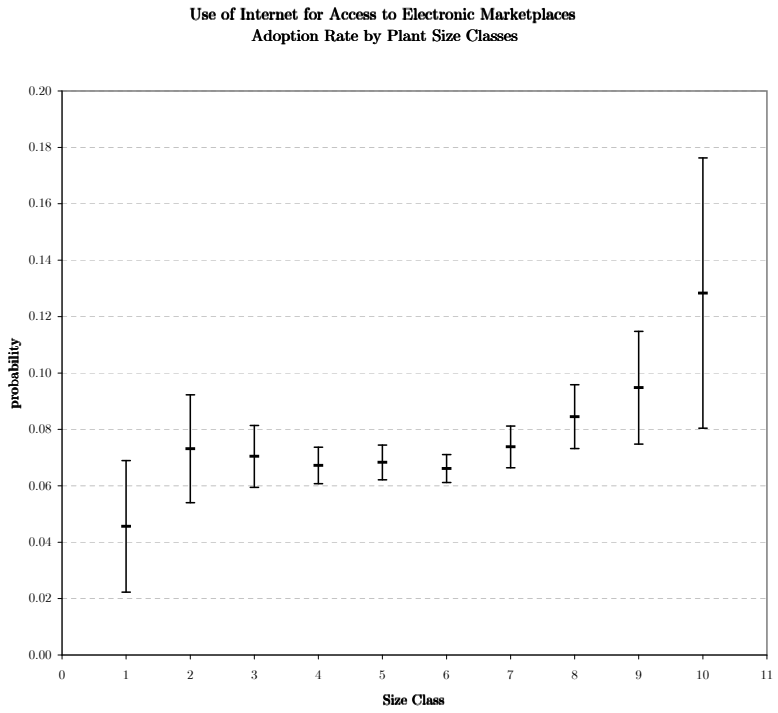

Table 1: U.S. Retail Trade Sales[1] – Total and E-commerce:[2] 2002 and 2001

		E-commerce as % of Total Sales				% Distribution of Sales	
		Percentage[3]		Standard Errors		E-commerce	Total
NAICS Code	**Description**	**2002**	**2001**	**2002**	**2001**	**2002**	**2002**
	Total Retail Trade	**1.4**	**1.1**	**(Z)**	**(Z)**	**100.0**	**100.0**
441	Motor vehicles and parts dealers	0.9	0.6	(Z)	(Z)	16.3	26.2
442	Furniture and home furnishings stores	(S)	(S)	(S)	(S)	(S)	2.9
443	Electronics and appliance stores	0.9	0.8	0.2	0.1	1.8	2.8
444	Building materials, garden equip. and supplies stores	0.2	0.2	(Z)	(Z)	1.4	9.3
445	Food and beverage stores	(S)	(S)	(S)	(S)	(S)	15.2
446	Health and personal care stores	(S)	(S)	(S)	(S)	(S)	5.6
447	Gasoline stations	(Z)	(Z)	(Z)	(Z)	(Z)	7.6
448	Clothing and clothing accessories stores	0.3	0.2	(Z)	(Z)	1.1	5.3
451	Sporting goods, hobby, book, and music stores	0.8	0.6	0.1	0.1	1.5	2.5
452	General merchandise stores	(S)	(S)	(S)	(S)	(S)	14.0
453	Miscellaneous store retailers	0.7	0.5	0.1	0.1	1.5	3.2
454	Nonstore retailers	18.7	15.0	0.3	0.2	74.8	5.5
454110	Electronic shopping and mail-order houses	28.1	23.0	0.3	0.3	72.7	3.5

[1] Estimates are based on data from the U.S. Census Bureau 2002 Annual Retail Trade Survey. Sales estimates are shown in millions of dollars, consequently industry group estimates may not be additive.
[2] Estimates include data for businesses with or without paid employees and are subject to revision.
[3] Estimates are not adjusted for price changes. For information on confidentiality protection, sampling error, nonsampling error, sample design, and definitions, visit www.census.gov/eos/www/restats.html.
(S): Estimate does not meet publication standards because of high sampling variability or poor response quality. Unpublished estimates derived from this table by subtraction are subject to these same limitations and should not be attributed to the U.S. Census Bureau.
(Z): Sales estimate is less than $500,000 or percent estimate is less than 0.05%.

Table 2: U.S. Electronic Shopping and Mail-Order Houses[1] – Total and E-commerce Sales by Merchandise Line[2]

	E-commerce as % of Total Sales				**% Distribution of Sales**	
	Percentage[3]		**Standard Errors**		**E-commerce**	**Total**
Merchandise Lines	**2002**	**2001**	**2002**	**2001**	**2002**	**2002**
Total Electronic Shopping and Mail-Order Houses (NAICS 454110)	**28.1**	**23.5**	**0.3**	**0.3**	**100.0**	**100.0**
Books and magazines	46.0	44.9	1.6	1.6	3.5	5.7
Clothing and clothing accessories (includes footwear)	30.5	21.2	0.5	0.5	12.2	13.3
Computer hardware	27.7	25.7	0.5	0.5	18.5	18.2
Computer software	32.8	30.4	1.2	1.4	3.9	4.5
Drugs, health aids, and beauty aids	7.0	5.9	0.8	0.8	18.1	4.5
Electronics and appliances	45.9	39.3	1.4	1.5	3.9	6.3
Food, beer, and wine	34.2	24.2	1.6	1.2	1.6	2.0
Furniture and home furnishings	34.4	25.4	1.3	1.4	6.2	7.6
Music and videos	37.6	32.9	0.9	1.2	3.4	4.5
Office equipment and supplies	40.1	30.0	0.9	0.9	5.3	7.6
Sporting goods	33.9	28.3	3.2	3.1	2.3	2.8
Toys, hobby goods, and games	36.1	31.0	2.0	1.9	3.0	3.9
Other merchandise[4]	24.7	18.4	0.7	0.7	13.7	12.0
Nonmerchandise receipts[5]	45.9	38.2	0.8	0.9	4.3	7.0

[1] Estimates are based on data from the U.S. Census Bureau 2002 Annual Retail Trade Survey. Sales estimates are shown in millions of dollars, consequently merchandise line estimates may not be additive.
[2] Estimates include data for businesses with or without paid employees, are grouped according to merchandise categories used in the Annual Retail Trade Survey, and are subject to revision.
[3] Estimates are not adjusted for price changes. For information on confidentiality protection, sampling error, nonsampling error, sample design, and definitions, visit www.census.gov/eos/www/restats.html.
[4] Includes other merchandise such as collectibles, souvenirs, auto parts and accessories, hardware, lawn and garden equipment and supplies and jewelry.
[5] Includes non-merchandise receipts such as auction commissions, customer training, customer support, advertising, and shipping and handling.

Table 3: U.S. Selected Services Revenue[1] – Total and E-commerce:[2] 2002 and 2001

		E-commerce as Percentage of Total Sales				Percent Distribution of Sales	
		Percentage[3]		Standard Errors		E-commerce	Total
NAICS Code	Description	2002	2001	2002	2001	2002	2002
	Total for Selected Service Industries	**0.9**	**0.8**	**(Z)**	**(Z)**	**100.0**	**100.0**
	Selected Transportation and Warehousing[4]	**1.4**	**1.2**	**0.1**	**0.1**	**8.3**	**4.9**
484	Truck transportation	1.4	0.9	0.2	0.1	5.8	3.5
492	Couriers and messengers	1.7	2.2	0.1	(Z)	2.2	1.1
493	Warehousing and storage	(S)	(S)	(S)	(S)	(S)	0.3
51	**Information**	**1.3**	**1.2**	**(Z)**	**(Z)**	**26.6**	**18.0**
511	Publishing industries	2.3	2.1	0.1	0.1	12.9	4.7
513	Broadcasting and telecommunications	0.5	0.5	(Z)	(Z)	6.1	10.0
51419	Online information services	5.7	5.7	0.5	0.6	4.4	0.7
	Selected Finance[5]	**1.6**	**1.3**	**0.1**	**(Z)**	**10.1**	**5.3**
5231	Securities and commodity contracts intermediation and brokerage	2.5	1.9	0.1	(Z)	9.8	3.4
532	**Rental and Leasing Services**	**(S)**	**(S)**	**(S)**	**(S)**	**(S)**	**2.1**
	Selected Professional, Scientific, and Technical Services[6]	**0.8**	**0.6**	**0.1**	**(Z)**	**15.6**	**17.4**
5415	Computer systems design and related services	2.6	2.0	0.4	0.1	10.3	3.3
	Selected Administrative and Support, Waste Management and Remediation Services[7]	**2.5**	**2.3**	**0.1**	**0.1**	**25.2**	**8.7**
5615	Travel arrangement and reservation services	24.1	23.7	0.8	0.9	15.4	0.5
62	**Health Care and Social Assistance Services**	**(S)**	**(S)**	**(S)**	**(S)**	**(S)**	**24.7**
71	**Arts, Entertainment, and Recreation Services**	**(S)**	**(S)**	**(S)**	**(S)**	**(S)**	**2.8**
72	**Accommodation and Food Services[8]**	**(S)**	**(S)**	**(S)**	**(S)**	**(S)**	**9.4**
	Selected Other Services[9]	**0.3**	**0.2**	**(Z)**	**(Z)**	**2.6**	**6.7**
811	Repair and maintenance	0.2	0.2	(Z)	(Z)	0.6	2.7
813	Religious, grantmaking, civic, professional, and similar organizations	0.5	0.3	(Z)	(Z)	1.5	2.5

[1] Except where indicated, estimates are based on data from the U.S. Census Bureau 2002 Service Annual Survey. Revenue estimates are shown in millions of dollars, consequently industry group estimates may not be additive.

[2] Estimates are subject to revision and include data only for businesses with paid employees except for Accommodation and Food Services, which also includes businesses without paid employees.

[3] Estimates are not adjusted for price changes. For information on confidentiality protection, sampling error, nonsampling error, sample design, and definitions, visit www.census.gov/eos/www/sestats.html.

[4] Excludes NAICS 481 (air transportation), 482 (rail transportation), 483 (water transportation), 485 (transit and ground passenger transportation), 486 (pipeline transportation), 487 (scenic and sightseeing transportation), 488 (support activities for transportation), and 491 (postal service).

[5] Excludes NAICS 521 (monetary authorities-central bank), 522 (credit intermediation and related activities), 5232 (securities and commodity exchanges), 52391 (miscellaneous intermediation), 52399 (all other financial investment activities), 524 (insurance carriers and related activities), and 525 (funds, trusts, and other financial vehicles).

[6] Excludes NAICS 54112 (offices of notaries) and 54132 (landscape architectural services).

[7] Excludes NAICS 56173 (landscaping services).

[8] Estimates are based on data from the 2002 Annual Retail Trade Survey.

[9] Excludes NAICS 81311 (religious organizations), 81393 (labor and similar organizations), 81394 (political organizations), and 814 (private households).
(S): Estimate does not meet publication standards because of high sampling variability or poor response quality. Unpublished estimates derived from this table by subtraction are subject to these same limitations and should not be attributed to the U.S. Census Bureau.
(Z): Estimate is less than 0.05%.

Table 4: Ranking of Manufacturing Industries by Rate of Adoption of Internet-Based Processes

NAICS Code	Description	Average Rank	Average Adoption Rate
334	Computer and electronic products	1	0.33
336	Transportation equipment	2	0.29
335	Electrical equipment, appliances, and components	4	0.30
333	Machinery	5	0.26
331	Primary metals	5	0.24
326	Plastics and rubber products	6	0.24
325	Chemicals	7	0.25
323	Printing and related support activities	8	0.27
322	Paper	9	0.23
339	Miscellaneous	10	0.23
332	Fabricated metal products	12	0.22
314	Textile product mills	12	0.21
312	Beverage and tobacco	13	0.21
316	Leather and allied products	14	0.20
324	Petroleum and coal products	14	0.19
315	Apparel	16	0.18
313	Textile mills	18	0.18
311	Food products	18	0.18
337	Furniture and related products	18	0.18
327	Nonmetallic mineral products	19	0.16
321	Wood products	21	0.15

Table 5: Ranking of Internet-based processes by their rates of adoption in manufacturing industries

Process	Average Rank	Average Adoption Rate
Internet Access and Degree of Access	1	0.84
Use of Online Access to Vendors' Products or Catalogs	2	0.48
Most Frequently Used Network to Place Online Orders for Materials and Supplies	4	0.41
Manufacturing Plants that Provide Product Descriptions or Catalog Online , External Suppliers	5	0.35
Use of Online Ordering from Vendors	5	0.31
Manufacturing Plants that Provide Inventory Data Online , Other Company Units	6	0.30
Use of Online Ordering by Customers	7	0.25
Manufacturing Plants that Provide Order Status Online , Other Company Units	8	0.24
Use of Online Customer Support	9	0.22
Manufacturing Plants that Provide Product Descriptions or Catalog Online , Other Company Units	10	0.20
Manufacturing Plants that Provide Order Status Online , External Suppliers	12	0.17
Most Frequently Used Network to Accept Orders Online for Manufactured Products	12	0.17
Use of Online Payment by Customers	13	0.14
Manufacturing Plants that Provide Product Descriptions or Catalog Online , External Customers	14	0.12
Use of Online Payment to Vendors	14	0.11
Use of Computer Networks in the Outsourcing of Research and Development	16	0.09
Use of Online Bidding	18	0.07
Manufacturing Plants that Provide Inventory Data Online , External Suppliers	18	0.07
Use of Electronic Marketplaces Linking Specialized Business Buyers and Suppliers	18	0.07
Manufacturing Plants that Provide Order Status Online , External Customers	19	0.06
Manufacturing Plants that Provide Inventory Data Online , External Customers	21	0.04

Table 6: Adoption Rates of Internet-based Processes by Plant Size Class[1]

Process	**Plant Size[2]**		
	Small	**Medium**	**Large**
Internet Access and Degree of Access	0.6072	0.9585	0.9406
	(0.0071)	(0.0017)	(0.0017)
Manufacturing Plants that Provide Product Descriptions or Catalog Online, Other Company Units	0.0759	0.1368	0.2717
	(0.0039)	(0.0029)	(0.0033)
Manufacturing Plants that Provide Product Descriptions or Catalog Online, External Customers	0.0620	0.1147	0.1540
	(0.0036)	(0.0027)	(0.0027)
Manufacturing Plants that Provide Product Descriptions or Catalog Online, External Suppliers	0.2117	0.3496	0.4108
	(0.0061)	(0.0041)	(0.0036)
Manufacturing Plants that Provide Order Status Online, Other Company Units	0.0927	0.1622	0.3127
	(0.0043)	(0.0031)	(0.0034)
Manufacturing Plants that Provide Order Status Online, External Customers	0.0304	0.0467	0.0779
	(0.0026)	(0.0018)	(0.0020)
Manufacturing Plants that Provide Order Status Online, External Suppliers	0.0896	0.1410	0.2192
	(0.0043)	(0.0030)	(0.0030)
Manufacturing Plants that Provide Inventory Data Online, Other Company Units	0.1314	0.2064	0.3782
	(0.0050)	(0.0035)	(0.0036)
Manufacturing Plants that Provide Inventory Data Online, External Customers	0.0115	0.0217	0.0595
	(0.0016)	(0.0012)	(0.0017)
Manufacturing Plants that Provide Inventory Data Online, External Suppliers	0.0244	0.0484	0.0926
	(0.0023)	(0.0018)	(0.0021)
Use of Online Access to Vendors' Products or Catalogs	0.6620	0.8565	0.9502
	(0.0068)	(0.0029)	(0.0016)
Use of Online Ordering from Vendors	0.2491	0.2724	0.3714
	(0.0077)	(0.0040)	(0.0035)
Use of Online Payment to Vendors	0.0558	0.0666	0.1292
	(0.0041)	(0.0022)	(0.0025)
Use of Online Bidding	0.0776	0.0816	0.0833
	(0.0048)	(0.0025)	(0.0020)
Use of Electronic Marketplaces Linking Specialized Business Buyers and Sellers	0.1862	0.2090	0.2846
	(0.0069)	(0.0037)	(0.0033)
Use of Online Ordering by Customers	0.0640	0.0919	0.1639
	(0.0044)	(0.0026)	(0.0027)
Use of Online Payment by Customers	0.1663	0.2021	0.2443
	(0.0067)	(0.0036)	(0.0032)
Use of Online Customer Support	0.0686	0.0678	0.0724
	(0.0045)	(0.0023)	(0.0019)
Use of Computer Networks in the Outsourcing of Research and Development	0.0658	0.0818	0.1159
	(0.0044)	(0.0025)	(0.0024)
Most Frequently Used Networkto Place Online Orders for Materials and Supplies	0.7371	0.7517	0.6551
	(0.0129)	(0.0063)	(0.0051)
Most Frequently Used Networkto Accept Orders Online for Manufactured Products	0.6174	0.4572	0.2036
	(0.0154)	(0.0077)	(0.0045)

[1] Standard errors in parentheses.
[2] Small: 1 to 20 employees; Medium : 21 to 99 employees; Large: 100 or more employees.