Information Services in the US Economy:
Value, Jobs and Management Implications

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Abstract

It is well known that almost all of the largest economies in the world are already dominated by services. What may be less well known is that many are also evolving towards becoming information economies in the sense of both value added (GNP) and jobs. Of course, this evolution is less advanced in some countries, but the US is already well past the 60% mark in terms of value added. We further explore the confluence of these two trends, by examining the double dichotomy of products versus services and information versus material (non-information) which divides the economy into four super-sectors. We do this by analyzing data on US GNP in 1992 and 1997 and the US job market (employment and wage rates by 821 occupational categories) in 1999. The main conclusions are that the US job market is also dominated by information work, that the largest part of the US economy in terms of GNP value added (in 1997) is the “information services” super-sector, that the largest job share in terms of the number of jobs is in the “physical or non-information” jobs in services but the largest share of the wage bill (in 1999) is in information related jobs in services. Interestingly, the highest level of wages per worker is in information intensive tasks in products. We discuss some plausible reasons behind these trends, identify major differences between information and non-information sectors, and share our preliminary thoughts on the implications for management strategy in the information economy.

Keywords: Information Economy, Information Services, Information Intensive Services.
Introduction

Most of the large economies in the world are dominated by services, in that services comprise more than 50% of the GDP. This is even true of countries like India, where although most of the employment (60%) is in agriculture, services contributed just over 60% of the GDP in 2005. A seeming exception is China, where “industry” is still larger than “services”. But it could be conjectured that this is a matter of reporting conventions; for example, construction is not included in the service sector in the Chinese figures. For developed economies, the trend to services is very far along with many of them past the 70% mark, and every other economy out of the largest 25 is either past 50% mark, or has services as the largest sector. It seems that even when manufacturing or agriculture play large roles for a country, no economy of any size can really function without a large service sector and the overall trend is inexorable.

Today it is essential to recognize another significant and general evolutionary trend: that from a material or physical, to an information economy. Apte and Nath (2007), following the methodology used by Porat and Rubin (1977), establish that the US in 1997 was already an information economy, with 63% of GNP attributable to primary and secondary information sectors. We provide more details in the next section. Choi, Rhim and Park (2006) following the same methodology, conclude that Korea in 2000, while having a relatively larger manufacturing sector than the US, was also effectively an information economy. While it remains to be established, it is likely that this trend will also hold true for all major economies.

In this paper we explore the confluence of these two trends by examining the double dichotomy of products versus services and information versus material (non-information) which divides the economy into four super-sectors. We examine the way in which GNP in the US divides across these sectors using data on US GNP from 1967, 1992 and 1997. This analysis revisits the earlier rough estimates made by Karmarkar (2002, 2004) and Apte and Karmarkar (2007) using the 1997 data from Apte and Nath (2007). The results
are similar, but not quite the same. Since we examine data across three years, we are also able to look at the changes in that period.

One issue with using sector level data is that firms are lumped into industry sectors (as identified by the SIC and NAIC codes), whereas in reality, individual companies can and do fall across sector codes. A different and more detailed perspective is obtained by going to the level of job categories. We do this by analyzing data on the US job market (employment and wage rates by 821 job categories) in 1999. The main conclusions are that the US job market is also dominated by information work, that the largest part of the US economy in terms of GNP value added (in 1997) and the wage bill (in 1999), is in information jobs in services, and that the largest job share in terms of the number of jobs is in the “physical or non-information” jobs in services. We also find that the highest average wage rate is in information intensive jobs in product firms.

In the next section we review research on the Information Economy in the US. We briefly survey the literature on related topics. Next we present the main results of our study, in terms of a two way breakdown of the US economy based on GNP data and based on labor statistics. The GNP data over a 20 year period show certain significant trends. The reasons for these trends are not completely clear, but we conjecture what they might be, and what might lie in the future. This also brings us to the implications of these results for management strategy. We end with a description of our ongoing research on this and related topics.

The Information Economy in the US: Prior Research

There exist two well-known early studies that have tried to define and measure the so-called information economy. In his pioneering work, Fritz Machlup (1962) conceptualized what he called the “knowledge industry”. He identified the components of the knowledge industry and measured its contribution to Gross National Product (GNP). According to Machlup, 29 percent of the US GNP in 1958 was generated by the knowledge industry. Subsequently, using an approach that is quite distinct from the one
used by Machlup, Porat (Porat and Rubin 1977) measured the size and structure of the US information economy in 1967. Porat strictly followed the national income accounting framework. Machlup, on the other hand, had included a number of economic activities that were not part of the national income accounts.

The approach followed by Porat is systematic, but not perfect. Companies get lumped into sectors as though they do only one thing while in reality, a firm’s activities can cut across multiple industry sectors. Nevertheless, one of the major advantages of this approach is that the definitions are (reasonably) clear, data is available for many countries, and the results are reproducible and repeatable. Porat divides the information economy into two sectors: the “primary information sector” and the “secondary information sector”. The primary sector is defined as including all industries that produce goods and services that intrinsically convey information or are directly used in producing, processing or distributing information for an established market. Thus the primary sector includes “information goods” such as computers, as well as services such as telecommunications. The secondary sector is defined to “include all information services produced for internal consumption by government and non-information firms.”

It comprises most of the public bureaucracy and all of the private bureaucracy. The public bureaucracy comprises all the informational functions of the federal, state and local governments. The private bureaucracy is that portion of every non-information firm that engages in purely informational activities. It produces information services similar to those in the primary sector, such as data processing and library services, but which are not transacted in markets. See Porat and Rubin (1977) or Apte and Nath (2007) for detailed definitions of these sectors.

Porat estimated the “information sector” to be 46% of the GNP in 1967. An OECD study (1981) using Porat’s methodology, estimated the U.S. information sector to be 49% of the GNP in 1972. A study by Huber and Rubin (1986) that followed Machlup’s methodology, estimated that the knowledge industry had only grown to about 34% in 1980, suggesting substantial differences in the Machlup and Porat approaches. Finally, following Porat’s approach, Apte and Nath (2007) estimated that the information sector
contributed 63% to the GNP in 1997. These numbers suggest that the information or knowledge economy, variously defined, has been a large part of the U.S. economy for many years -- long before the advent of computers, the Internet, mobile phones and the dot.com boom-bust, and that the share of this sector in the economy has continued to grow steadily.

Autor et al. (2003) develop a theoretical framework to show the effects of computerization on growth in demand for types of occupations in the economy. They find that computers substitute for those skills that involve routine or repetitive cognitive and manual tasks but complement skills that involve non-routine problem solving and interactive tasks. Using data on job skill requirements from the Department of Labor Dictionary of Occupational Titles over the period from 1960 to 1998, they find evidence of a positive correlation between the degree of computerization and the relative shift in skill demand within industries, occupations, and educational groups towards more skilled jobs and away from less skilled.

Using decennial census data on employment by occupations and industries between 1950 and 2000, Wolff (2006) finds that information workers increased from 37% of the workforce in 1950 to 59% in 2000 in the United States. This number is higher than our estimate of 54% for 1999 data, though we note that Wolff’s classification of information and non-information workers is different from ours. His analysis shows that this increase is not attributable to a change in tastes for information-intensive goods and services but partly to changes in production technology that make it possible to substitute goods and service workers by information workers, and partly to differential rates of productivity movements among the industries of the economy.

**Research Framework**

In this section we develop a simple conceptual framework that captures the essence of the emerging patterns of industrialization. This is based on the observation by Karmarkar (2002) that a two-way breakdown of the economy, with the product-service dichotomy
superimposed on the material-information dichotomy, provides important insights into past evolutionary trends of the economy and its future prospects. The objective is to decompose the economy into four super-sectors so that this classification can then be related to the implications for public policy and management strategy. As a first step in that direction, a product-service classification scheme provides a useful framework for highlighting the differences in process characteristics and management requirements across sectors. The classification scheme used in this study is slightly different from the conventional ‘goods-services’ classification used in economics, and is motivated by the strategic importance of the structural changes taking place in the economy. Our classification scheme is based on three distinct criteria.

1. **Market transaction or delivery form**: products are in standard units, not differentiated by customer, priced by unit and pre-produced while services are processes, produced and customized on demand, and priced by process. For example, books are products whereas newspaper subscription is a service.

2. **Form**: products are tangible while services are intangible or experiential.

3. **Production process**: products are produced entirely by supplier while services are co-produced with customer input.

A material vs. information decomposition is then superimposed on top of this classification of industries. For this decomposition, two alternative approaches are used: one for value added decomposition and the other for labor market decomposition.

Following the approach described by Porat and Rubin (1977), the U.S. economy is divided into two distinct but inseparable domains: the material domain ‘involved in the transformation of matter and energy from one form into another’ and the information domain involved ‘in transforming information from one pattern into another’ where information is defined as the 'data that have been organized and communicated'. An operational definition of ‘information’ encompasses ‘all workers, machinery, goods and services that are employed in processing, manipulating and transmitting information’ (please refer to the Appendix for further discussion). When we combine these material-information decompositions with product-service classification we get a $2 \times 2$ decomposition of the economy. Figure 1 illustrates this decomposition.
A different perspective on the decomposition of Figure 1 can be obtained by looking at the level of individual occupations, rather than industry sectors. This is closer in spirit to the work of Wolff (2006) rather than Porat, or Apte and Nath. By looking at occupations, it is possible to get a much finer view of the nature of work and jobs. It is also possible to examine the distribution of wages across different sectors in the economy. We wish to point out that the distribution of wages is of course not the same as the distribution of GNP, and hence, the two analyses will not be directly comparable. Also the methodology we use for studying occupational data is different. Instead of breaking down occupations according to industry sector (SIC/NAIC codes), and then looking at the information to non-information split, we directly estimate the information intensity of each occupational category. Following Apte and Mason (1995) we define the information intensity of an occupation as the fraction of time spent in dealing with informational actions. For the occupational data, the decomposition we obtain will be as in Figure 2.

![Figure 1: A 2×2 decomposition of the U.S. economy](image)

Figure 1: A 2×2 decomposition of the U.S. economy

![Figure 2: A 2×2 decomposition of the U.S. economy based on information intensity at the level of occupational data](image)

Figure 2: A 2×2 decomposition of the U.S. economy based on information intensity at the level of occupational data
In taking this approach, we estimate information intensity of work for each occupation. An occupation is classified into one of five levels of information intensity. If an occupation requires creating, processing and communicating information and does not require physical presence in a specific location, or physical action by the worker then we classify it as an information occupation. An occupation that requires only physical action and does not involve creation, processing and communication of information is called a non-information (material to be consistent with the above) occupation. Because many occupations involve creation, processing and communication of information as well as physical action, they are classified into one of three intermediate categories based on the fraction of time spent on information actions versus non-information actions: high (75% information and 25% non-information), medium (50% information and 50% non-information) and low (25% information and 75% non-information). This classification scheme also helps us to break down each occupation into information and non-information components from which we estimate the full-time equivalent (FTE) number of jobs in each of the four cells of figure 2.

This approach is the same as that used by Apte and Mason (1995) and Apte and Karmarkar (2007) in previous studies addressing the information intensity of jobs, with the eventual aim of understanding the potential for technology and reengineering to affect jobs in the US.

**Data Sources and Empirical Methodology**

The data for this study have been obtained from three sources: the Benchmark Input-Output (I-O) Tables for 1992 and 1997, and the Value Added by Industry Data – both published by the Bureau of Economic Analysis (BEA), and the Occupational Employment Data for 1992, 1998 and 1999 published by the Bureau of Labor Statistics (BLS). Following the detailed methodology discussed in the Appendix, the I-O Tables are used to calculate the value added by different industries within the primary information sector and the Occupational Employment Data are used to calculate the value added by industries within the secondary information sector. These value added figures
are then aggregated to obtain total information (both primary and secondary) value added by industries at 2-digit Standard Industrial Classification (SIC) to make them comparable with Porat’s calculations for 1967. We then subtract information value added from total value added by 2-digit industries to arrive at material value added. We then classify the 2-digit industries into products and services and aggregate by these two broad classifications. We also use industry level value added implicit deflator at 1996 constant US dollar to convert the current price value added figures into constant prices so that we can calculate the growth rates of the four super-sectors.

To measure the size of these four super-sectors by employment and total wage bill, we use the occupational employment statistics for 1999. Note that 1999 is the first year for which BLS has published data on employment and wages by the new standard occupational classification (SOC) – under which there are 821 occupations – and also by SIC classification which is comparable with our value added calculations for 1997. We first classify the occupations into the five categories described above and apply the corresponding weights to total employment and total annual wage bills in each industry. Thus, for example, the occupational category ‘computer support specialists’ is classified as ‘high’ – i.e. 75% information and 25% physical. For industry ‘oil and gas extraction’, the total number of computer support specialists is 1010 and total wage bill is USD 48.7 million. By applying the weights, we take 757.5 (=1010×0.75) towards information and 252.5 towards non-information employment. Similarly, out of the total wage bill, 36.5 million is allocated to information and 12.2 million to non-information wage bill. We calculate information and non-information employment, and wage bills for all occupational categories within each of 2-digit SIC industries, and sum them up for each industry. Then we use the same product-service classification scheme to divide the industries into product and service categories, and to aggregate them by these two broad categories.

The Main Results
We used the methodology described above to analyze the data available from the Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics (BLS). The results of
our analysis are presented in the form of three sets of tables: the distribution of GDP in terms of value added (in current prices) in four sectors (Table 1), the distribution of GDP in terms of 1996 constant prices (Table 2), and the distribution of 1999 employment and wage bill. The tables present lead to some interesting observations:

- The US economy has truly become an information economy: the share of the information sector has grown from about 46% of GNP in 1967 to 63% in 1997 (See Table 1). Within the information sector, services have grown from about 36 percent of GNP to 56 percent during this period. The size of the material sector has been correspondingly declining with both products and services shrinking in their share in GNP. Share of information products in GNP declined between 1967 and 1992 and slightly increased between 1992 and 1997. This may be ascribed to large purchases of information products by households and businesses in the 1990s.

- The annual average growth rates in Table 2 indicate that information services grew at consistently high rates during the three decades between 1967 and 1997. The growth of information products accelerated between 1992 and 1997, and it is consistent with our observations about the previous table.

- One of the most interesting finding of Table 3 is that although material services grew at an average annual growth rate of 2.59% between 1967 and 1992, they experienced a small decline between 1992 and 1997. The fall in value added by material services industries can be ascribed to the increased outsourcing of information services by those industries. In terms of National Income Accounting practices, this will show up as a decrease in value added and a corresponding increase in intermediate inputs. In other words, intermediate inputs would substitute labor. To give an example, when a hotel reservation is made over the internet through Expedia.com, a reservation clerk's job at a Holiday Inn is being substituted for by the information service provided by Expedia.com. The value added of the Hotel industry goes down whereas the intermediate input of the service goes up. However, a careful investigation of changes in input requirements of services in the input-output table is required for empirical validation of this casual observation.
• We see that the economic trend in the period from 1992-97 is not a “shift to services”. While services overall grow, physical/material services do not. The growth comes from information services. Similarly, while the “product” sector shrinks, information products actually grow rapidly. This is quite different from the picture in the earlier period. This suggests that change in the economy during and after the second period, might well be better understood as a shift to the information sector, rather than a shift to services per se. This remains to be investigated as data for subsequent years after 1997 becomes available.

• In 1999, non-information workers in service industries constitute the largest component of the total employment with 45.1 percent whereas information workers in services are the second largest with 40.9 percent (see Table 3). Service industries employ 86 percent of the total workers employed. Total non-information workers account for about 55 percent while information workers account for the rest.

• Information workers in services account for about 48 percent of total wage bill, followed by the non-information workers in services accounting for about 38% (See Table 3).

• In terms of average wages, information workers in the product industries earned the highest wages followed by the information workers in services. There is a wage gap of more than $20,000 between information and non-information workers in the product industries, and of more than $10,000 in services. The wage gap can partly be explained by skill premiums (for example, see Jung and Choi 2006). In the product industries it may also be because of increased capital intensity for information occupations.

Economic Evolution: Trends and Mechanisms

The two trends discussed here (that to services and to an information economy) are clearly related. Information and communication technologies find their biggest applications in services activities, since information plays a fundamental role there.
Clark (1940) conjectured that the sectoral differences in productivity would lead to a situation whereby a majority of the labor force would no longer be engaged in agriculture or manufacturing, but in services. That conjecture seems to have come true. Today, agriculture represents only a small part of the labor force and the GNP in the US, not because of a reduction of per capita or total consumption of food, but because the sector has been extremely productive. Similarly, the manufacturing sector is shrinking because of relentless productivity gains in manufacturing coupled with outsourcing, and not because we are consuming less of physical products. Perhaps a more influential analysis of the topic was that by Baumol (1967, 1985), which also identified productivity differences as an underlying cause. Albeit with some sweeping assumptions, Baumol showed that service costs would rise relative to manufacturing due to lower productivity growth in services.

One might ask if this is the only mechanism underlying the trend. And do the same mechanisms explain the growth of the information economy? Finally, there is growing evidence on increasing productivity in the service sector. Some of this is attributable to information and communication technologies. What might be the consequences of this relatively new development?

It seems apparent that the decline of manufacturing relative to services, is partly also due to declines in the relative costs of transportation and trade of physical goods, which have led to the globalization of manufacturing in the latter half of the 20th century. This in turn has fueled the development of those economies around the world that have been able to export to foreign markets. Countries like Germany, Switzerland, Singapore, Japan and Korea are examples. In other words, outsourcing and off-shoring of manufacturing has been a major reason for the relative decline of manufacturing industries in the US in terms of GNP share and jobs.

There is potentially a third factor that could be at play: limits on the consumption of certain goods. It could be that the demand for certain products or services saturates or plateaus due to satiation, so that the growth of some sectors may be limited relative to
others. Of course, there is no a priori reason to assume that this will act in favor of services. Essentially, this is an empirical question for which there is no easy answer since quantification of volume for services is much more difficult than for products; and even with products, adjustments have to be made for increases in quality and features. For example, a car in 2000 is very different from a car in 1960. Nevertheless, this is at least a plausible mechanism.

A fourth factor could be a drop in prices of certain goods and services due to improvements in technology, which then causes a shift in consumption patterns in their favor. In some cases, technology can enable entirely new types of products and services. Cell phones (the products), mobile phone services, personal computers, gaming platforms and MP3 players are all examples.

A fifth factor is a matter of simple demographics. The baby boom undoubtedly led to an increase in the demand for educational services after the 1950’s. The aging of the baby boom will certainly lead to an increase in the demand for health care services and assisted living facilities in the near future.

Finally, where jobs are concerned, a decline in the number of jobs in a sector could come from changes in processes as a result of reengineering, redesign, automation, or moving jobs and operations to other points in the process (self-service is one example). But again, this is not necessarily true for traditional services, where transportation of outputs is not always possible.

Considering the relative growth of the information economy, we have to look separately at the information product, and information service sectors. With information products, one part of the story is the distribution of information processing capacity to the level of individuals together with the increase in the use of information appliances. This has happened in the workplace and with individual consumers. Technology improvements have lowered prices and improved performance and functionality, leading to huge sales growth. Correspondingly, information products such as packaged software have also
shown large increases in sales. A question for the future is: has a point of satiation been reached for some of these products, or is there still room for growth? Could it even be that with convergence of functions, the number of appliances per person will actually decrease?

For information services, one likely reason is the same as the explanation for services in general – low productivity. This could be part of the reason for growth in the education sector. However, in some cases, it may also be a reduction in costs creating greater demand. This could be the case for mobile telecommunications.

The future pattern of evolution is difficult to predict. A major issue is the process of “industrialization” of information services, which is having effects not unlike those seen in manufacturing (Karmarkar 2004). In addition to productivity increases, there is increased outsourcing, offshoring, and reengineering visible in this sector. We conjecture that by and large, industrialization will lead to a decrease in the number of jobs which are routine, such as bank tellers. However, there may well be larger returns to higher levels of skills, capital for labor substitution (e.g., automation), and higher returns to capital.

The Implications of the Material-Information Dichotomy

The implications of the economic trends described here for management in all sectors and for public sector policy, are substantial. The first point to recognize is that the information economy that we assess includes both primary and secondary segments. The primary sector is very visible since market transactions are involved. The secondary sector, being internal to firms, is less so. But it comprises well over 40% of the information economy, and some 28% of the entire economy (Apte and Nath 2007). So the information activities internal to organizations and institutions represent a very large part of the economy. This is further reinforced by the employment numbers and wage bill for information intensive jobs, which represent about 44% and 54% of the totals for the economy, respectively.
What this means is that any transformations that are possible at the industry or sector level due to the impact of technology, are also going to affect organizations internally. Nor is this just a matter of operational and tactical adjustments. Rather, the changes inside and outside organizations are linked because they are structural changes, and are potentially so large as to require significant re-thinking of company strategies, ranging from competitive positioning, to organizational design. As we note below, it is clear that substantial restructuring is already occurring and will continue to occur at the level of jobs, operations, organizations, industry chains and public institutions. We cannot hope to summarize all of the manifold issues that need to be addressed, but we present just a few observations. We emphasize the implications that arise from the dichotomy between physical and information sectors, since that is the new perspective afforded by our analysis.

At the aggregate level, the shift to information is reflected in the nature of investments in assets, equipment and technologies. This has implications for both the vendors of these technologies and for the users as well as for capital markets and investors. The value in capital markets is increasingly associated with information intensive firms and information technology intensive projects. As noted by Professor Leamer (UCLA Forecast), the recession in 2000 was the first postwar recession that was driven by business conditions rather than consumers, and that it was strongly related to declines in information asset purchases by companies.

A second major difference at the aggregate level is that in the physical world, the costs of logistics are very significant. In the information world the costs are by no means trivial, but by comparison are quite small. This rather obvious difference has been noted often with respect to the costs of information transportation (Cairncross, 1997) as well as the costs of “inventory” and storage. The speed of information transport is also obviously high. As a consequence, the rate of obsolescence of information can also be much higher since dissemination of new information is faster, and the costs of access and search may also become relatively more important (Karmarkar and Apte 2007).
A third difference is that physical goods and services are less subject to linguistic differences and associated cultural values. This leads to a topography of global information chains that is not driven by physical geography, but rather by the distribution of language and culture (Karmarkar 2004, Apte and Karmarkar 2007). The latter two are not the same; for example, the patterns for music distribution are not the same as for newspapers.

A fourth difference is that the economics of information products differ significantly from those of physical products. Some examples of these differences include

- The high ratio of fixed to variable costs in production or equivalently the high ratio of first copy to second copy costs (Shapiro and Varian 1998).
- The non-linearity and non-monotonicity of value with volume – more can be less

A fifth difference is that the economics of information processes are significantly different from material processing, due to the nature of the technologies involved. Physical production systems display substantial scale economies. However in the information sector, scale economies are less dominant. Small scale processing equipment can be quite cost effective. As a result, in information processing, we have the equivalent of local (desktop and mobile) factories. Furthermore, the special features of information logistics permits distributed processing as well as rapid remote delivery. This combination of logistics and small scale processing down to mobile appliances, allows for a level of dispersed processing and customization that is very unlike the physical world.

Management Strategies in an Information Economy

In this paper we have discussed the broad trends present in the US economy with respect to value and jobs. In the preceding sections we have outlined some of the possible underlying mechanisms for these trends, focusing especially on the material-information
dichotomy which is central to this study. In this section we discuss the implications of the trend to the information economy, for management strategy at the level of industry sectors. Of course, we cannot do more than outline a few key issues, and we will limit our discussion to the “super-sector” level of the four major quadrants.

The major changes to which firms need to respond, are occurring in the information services quadrant. This is where the industrialization and globalization trends mentioned above have had the largest recent impact. As yet it appears that many industry sectors (viewed in the aggregate) have not responded adequately to these challenges. For example, two sectors that have been quick to globalize, have been consumer banking and telecommunications. In both of these sectors, US firms appear to be lagging. Very few firms appear to have globalization as a core strategy, though American Express and Citigroup are two leading examples in the financial sector.

The degree to which “industrialization” is being pursued, varies widely. The major strategies for industrialization include:

- automation
- outsourcing
- best cost location of production (outsourced or captive)
- process reengineering (especially modularization of processes)
- rapid service design and launch
- operations shifting (including self-service)

Here we see that in some services like brokerage, US firms have indeed been market leaders. But in many other services, they appear to be lagging behind the best firms world wide.

A major issue with the information services sector is that their history has left them with legacy organizational structures and management processes that are not easy to change (Karmarkar, 2004). The changes that are needed here are substantial and have to be made top down. Such major organizational changes are not an easy task for any firm. As an example, manufacturing firms typically have a well designed process for product
development, design, and launch. However, most service firms do not. As a result, new service introduction tends to occur in a piecemeal way, often driven by chance. In the past, information technologies in this sector have had a back-room role. So indeed a substantial amount of automation occurred in sectors such as financial services, after the 1980’s. However, information technologies are now taking on a “line” role, and many sectors do not appear to have adjusted to this new reality.

Strategic changes in the physical service sector are not as wrenching. This is because the physical nature of the core service does not change very rapidly or very much. However, there are still opportunities for revisiting the information processes that accompany the service provided. In some cases, these can create substantial competitive advantage, at least for a period of time. Examples such as tracking of shipments by logistics companies are well known. The impact of on-line technologies in the B2C layer of physical services, is also creating ripple effects back into service and logistics processes, which must be understood. The impact of on-line sales on retail and wholesale sectors is a major example. The appearance of large on-line intermediaries in the leisure industry is creating substantial changes in the competitive picture in that sector. Improved searching and matching at the buyer level, is providing more opportunities for smaller players. A particularly interesting example of the competitive value of on-line technologies is the “virtual hotel” or “albergo diffuso”, where a group of small B&B providers collaborate to create a common front office to take care of promotion, sales, customer interface, registration and scheduling, while the actual physical facilities remain distributed within a town or small service area (Mandelli and La Rocca, 2005).

The impact of technologies on the information products sector has already been very substantial, and it promises to continue. There are major changes underway in music, video and film products due to the digitization of content, and the convergence of distribution and delivery methods. These will continue, and similar effects will appear in publishing and content distribution in all their forms, including books and magazines. In the software industry, a substantial growth in the marketplace for software products occurred with the move from mainframes to the desktop computer. However, the next
phase for software products may be different, and desktop computing gives way to a combination of small appliances, and server farms. In addition, it is likely that the trend to software-as-a-service (SaaS) will continue. On the other hand, the number of different software components, is likely to grow without foreseeable limits. Overall, the software market will probably be dominated by the B2B market rather than B2C.

The changes in the physical products sector are for the most part indirect. Technology driven changes in core production processes, due to automation, will continue. However, the pace of these changes, as with physical services, will be steady and not very rapid. Low labor cost solutions will continue to compete with automation at least for some decades. What is most significant for the manufacturing sector is of course, the continuing decline of the sector, with attendant job losses. However, all information and knowledge based processes in manufacturing are also subject to the same kinds of forces that affect information services. For example, certain design and control activities have the potential to be relocated or outsourced.

While our brief discussion has been at the level of industries and sectors, it is important to note that the changes that are occurring are at the level of individual tasks and operations. At this level of resolution, substantial parts of every organization consist of information services. All of these processes are subject to technology impacts and industrialization. Adapting to the potential organizational changes created at this level is a task for every company, and once again these are changes that require action from the highest levels of management.

**Conclusions and Ongoing Research**

The US economy has already undergone a shift to services in terms of both GNP and job distribution. It is presently in the middle of a shift to becoming an information economy, and for the US, the major part of the value in the economy is accruing to information intensive sectors. The information related shift may well be the more significant for the US, after 1990.
With respect to the distribution of jobs, the data for the US as of 1999 suggests that non-information related work still provided the larger number of jobs. Of course, this may not be the case now, and we are presently analyzing the changes that have occurred since 1999. With respect to the wage bill however, the major share belongs to information-intensive work even as of 1999.

The GDP data for the US in 2002 will be available in mid-2007, and it will be interesting to see how much further the US has moved to becoming an information economy. On the jobs and occupational side, data till 2007 is already available, and we are analyzing that to examine the trends since 1999. Our expectation is that the overall trend to information intensive jobs may continue, but we expect to see some short term variations due to the recessional period of 2000-2002.
References


Appendix: Definitions and Methodology

Material-Information Classification

Porat and Rubin (1977) divides the information economy into two sectors: ‘primary information sector’ and ‘secondary information sector’ (PRIS and SIS respectively hereafter). The PRIS is defined as one that includes all industries which produce goods and services which intrinsically convey information or are directly used in producing, processing or distributing information for an established market. The broad categories of PRIS industries are: (1) knowledge production and invention: private R&D and private information services; (2) information distribution and communication: education, public information services, telecommunications etc.; (3) risk management: insurance and finance industries and others; (4) search and coordination: brokerage industries, advertising etc.; (5) information processing and transmission services: computer based information processing, telecommunications infrastructure etc.; (6) information goods: calculators, semiconductors, computers; (7) selected government activities: education and postal service; (8) support facilities: buildings, office furniture etc.; (9) wholesale and retail trade in information goods and services. Following Porat, we use Benchmark I-O Detailed Tables for 19992 and 1997 to identify 6-digit industries that fit into one of the above categories. This exercise returns 87 6-digit I-O industries in 1992 and 63 in 1997 as belonging to PRIS. Note that changes in industry classification system are responsible for the differences in number of disaggregate industries belonging to PRIS.\(^1\) We obtain the value-added figures from Benchmark Detailed I-O Use Table for each of these 6-digit information industries for both years, and aggregating over 6-digit industries we obtain the PRIS value added at the corresponding 2-digit industry levels.

The SIS is defined to ‘include all information services produced for internal consumption by government and non-information firms.’ It comprises most of the public bureaucracy

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1 Prior to 1996, the I-O industry classification system was different from more familiar Standard Industrial Classification System (SIC). In 1996 SIC was replaced by the new North American Industrial Classification (NAICS) system and also the new I-O classification is now based on NAICS. Under NAICS, establishments are grouped according to the similarities of their production processes rather than the similarities of their products. For detailed discussion on the changes, see Lawson et al (2002)
and all of the private bureaucracy. It includes ‘the costs of organizing firms, maintaining and regulating markets, developing and transmitting prices, monitoring the firm’s behavior and making and enforcing rules’ (Porat and Rubin (1977), vol.1). The public bureaucracy comprises all the informational functions of the federal, state and local governments. The private bureaucracy, on the other hand, is that portion of every non-information firm that engages in purely informational activities. In order to measure the SIS, non-PRIS firms and public bureaucracies are taken apart, in an accounting sense, into an information division and a non-information division. To measure the non-marketed services of the SIS, Porat uses a rather restrictive definition of value added. According to this definition, value-added of an SIS industry includes (1) employee compensation of information workers, (2) part of proprietors’ income and corporate profits earned for performing informational tasks, and (3) capital consumption allowances on information machines. To calculate compensation of information workers, Porat uses a BLS matrix (unpublished) that shows detailed occupational structure of all U.S. industries, together with wages and salaries for various occupations.² He imputes the value of proprietors’ income earned for performing informational tasks by matching them with information workers in similar occupations and using their salaries as the value of compensation for proprietors for informational activities. Similarly, he uses an unpublished BEA matrix that shows the detailed capital flows of all industries to calculate depreciation allowances on information capital goods.

Our study, however, is mainly based on published data, and hence of necessity, we make a few modifications. The most important one is that since most data are available at the 2-digit level of Standard Industrial Classification (SIC), we use those data for the subsequent quantitative calculations. In order to be consistent with the use of I-O industry classification in our calculation for the PRIS, we also make a few minor adjustments, which are discussed later in this section.

² Vol. 6 and Vol. 7 of Porat and Rubin (1977) contain two matrices showing the employee compensation paid to 422 occupations in the 108 industries by I-O classification for 1967 and 1970 respectively.
Measuring employee compensation of information workers

To calculate employee compensation of information workers in 1992 a matrix of occupations versus 2-digit SIC industries is compiled from the *Occupational Employment Statistics* for 1992. This matrix consists of 181 information occupations and 41 2-digit SIC industries in 1992. In identifying the information occupations we strictly follow the scheme developed by Porat. This matrix represents the distribution of information workers over all occupations in all industries. Average/median salaries of information workers are obtained from the *Occupational Outlook Handbook*, and then each entry in the above matrix is multiplied by the average/median salary for the corresponding occupation to calculate the total employee compensation by industry. As noted earlier, a few exceptions have been made in implementing this methodology. For ‘agriculture, forestry and fishing’, ‘finance, insurance and real estate’, 'government enterprises' (federal, state and local) and 'general governments', the data by occupational categories, unfortunately, are not available for 1992. For these industries the shares of the SIS in total employee compensation for 1967 are taken from Table 9.2 of volume I of Porat and Rubin (1977) study, and are applied to the BEA-compiled total compensation of employees in these industries in 1992.

For 1997, we create a matrix of 232 information occupations and 70 2-digit SIC industries from the *1998 Occupational Employment Statistics* that also reports the mean hourly wages in different occupations. The survey uses fourth quarter of 1998 as the reference period and adjusts the wage data for inflation accordingly. In order to make them comparable with other components, after calculating the compensation of information workers for each industry group we adjust them back to 1997 values by applying industry-wise GDP deflator calculated from the Bureau of Economic Analysis.

Measuring proprietors’ income and depreciation allowances

Data on proprietors’ income and depreciation allowances by broad industry groups for 1992 are obtained from the Bureau of Economic Analysis. We need to calculate the
shares of these two categories respectively as accounted for by the information activities and information capital. We again apply the percentage shares of the secondary information sector in total proprietors’ income, and percentage shares of the SIS in total depreciation allowances by industries, as reported in Table 9.2 of volume 1 of Porat and Rubin (1977) study, to 1992 figures.

Since these proportions are available for aggregate industries (roughly at 1-digit level of SIC), applying them to 2-digit level industry data would ignore the fact that there could be some variations among 2-digit industries within each of these aggregate industries. To get around this problem, we first calculate proprietors’ income for informational activities and depreciation allowances on information capital at aggregate levels (at 1-digit level) and they are apportioned according to the shares of corresponding 2-digit industries in aggregate (1-digit level) employee compensation of information workers, as obtained in the previous subsection. However, we want to make it clear that the procedure we use does not take into account the possibility that over the years the informational activities of the proprietors or relative use of information capital goods may have increased. However, we also want to point out that by using the above-mentioned procedure, we arrive at very conservative estimates of proprietors’ income for informational activities and for depreciation of information capital goods. In any case, these two items represent only a very small part of the total SIS, and therefore this method presumably has a negligible impact on the overall accuracy of estimation.

For 1997, however, we use a slightly different approach. The 1997 Benchmark I-O Tables report three components of gross value added for each I-O industry: ‘Compensation of Employees’, ‘Indirect Business Tax and Nontax liability’ and ‘Other Value Added’. The component ‘Other Value Added’ mainly includes proprietors’ income and depreciation allowances. We use the mapping between 1997 NAICS and 1987 SIC to calculate other value added for each of the 2-digit SIC industry. We then calculate the shares of proprietors’ income and depreciation allowances accounted for by information activities in total for 1992, and apply them to the 1997 ‘other value added’ to obtain corresponding components of SIS value added.
As we mentioned earlier, in measuring the SIS we use SIC rather than I-O classification as used by Porat. It is important to recognize that while calculating the value added contributions of different 2-digit SIC industries to the SIS using the procedure described above, we carefully make suitable adjustments for those disaggregated industries, which have already been entirely or partially allocated to the PRIS. Otherwise, it would lead to double counting of parts of value added of PRIS industries. To prevent double counting, we calculate the shares of the 6-digit I-O industries included in PRIS, in total value added of corresponding 2-digit SIC industries. We then apply these proportions to the SIS value added as calculated above, to purge out the pure contributions of the 2-digit SIC industries to the SIS.

**Information vs. Non-information Worker Classification**

As discussed in the section on research framework, we classify the occupations into five categories: pure information, high, medium, low and pure physical or noninformation occupations. By applying weights: 100%, 75%, 50%, 25% and 0% we are able to decompose total employment and wage bill for each 2-digit SIC industry into two broad categories: information and non-information. We use the following equations for information and non-information employment in industry $i$:

$$IE_i = \sum_{j=1}^{n} v_j E_{j,i} \quad \text{and} \quad NE_i = \sum_{j=1}^{n} (1 - v_j) E_{j,i}$$

where $IE_i$ and $NE_i$ are respectively the information and non-information employment in industry $i$, $v_j$ is the weight applied to the $j$th occupation and $v_j \in [0,0.25,0.50,0.75,1]$, and $E_{j,i}$ is the number of workers employed in occupation $j$ in industry $i$. We then apply product-service classifications to the industries and sum up the information and non-information employment for each of these two broad categories. We use a similar the following equations to calculate wage bills for information and non-information categories in industry $i$:

$$IE_i = \sum_{j=1}^{n} v_j E_{j,i} W_{j,i} \quad \text{and} \quad NE_i = \sum_{j=1}^{n} (1 - v_j) E_{j,i} W_{j,i}$$
where $W$ is the annual average wage for occupation $j$ in industry $i$. We thus calculate wage bills for information and non-information workers for each industry, classify them into product or service category and obtain the aggregate wage bills by these two broad categories.
<table>
<thead>
<tr>
<th></th>
<th>Products</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>152,514</td>
<td>274,775</td>
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<tr>
<td>Information</td>
<td>83,370</td>
<td>284,730</td>
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<table>
<thead>
<tr>
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<th>Services</th>
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<tr>
<td>Material</td>
<td>788,844</td>
<td>1,961,990</td>
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<td>Information</td>
<td>402,520</td>
<td>3,080,551</td>
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<table>
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<th>Services</th>
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<tbody>
<tr>
<td>Material</td>
<td>877,051</td>
<td>2,211,055</td>
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<tr>
<td>Information</td>
<td>577,631</td>
<td>4,679,908</td>
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</table>

Source: Authors’ calculations based on data from the BEA Webpage (downloaded in February 2007), [http://bea.gov/industry/index.htm](http://bea.gov/industry/index.htm)
Table 2
Distribution of GNP:
Value Added in 1996 Constant Prices and Annual Growth Rates

<table>
<thead>
<tr>
<th></th>
<th>Products (Millions of USD)</th>
<th>Services (Millions of USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967</td>
<td>Material: 620,195</td>
<td>1,139,555</td>
</tr>
<tr>
<td></td>
<td>Information: 330,550</td>
<td>1,195,576</td>
</tr>
<tr>
<td></td>
<td>Information: 428,345</td>
<td>3,436,597</td>
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<tr>
<td>1997</td>
<td>Material: 985,014</td>
<td>1,993,230</td>
</tr>
<tr>
<td></td>
<td>Information: 562,911</td>
<td>4,586,668</td>
</tr>
</tbody>
</table>

Compound Annual Growth Rates

<table>
<thead>
<tr>
<th></th>
<th>Products 1967-92</th>
<th>Services 1967-92</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>1.31</td>
<td>2.59</td>
</tr>
<tr>
<td>Information</td>
<td>1.04</td>
<td>4.31</td>
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<tr>
<td>Material</td>
<td>2.76</td>
<td>-1.60</td>
</tr>
<tr>
<td>Information</td>
<td>5.62</td>
<td>5.94</td>
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</tbody>
</table>

Source: Authors’ calculations based on data from the BEA Webpage (downloaded in February 2007),
(http://bea.gov/industry/index.htm)
Table 3
Distribution of Employment and Wage Bill
(1999)

<table>
<thead>
<tr>
<th>Number of workers (in '000)</th>
<th>Total wage bill (in Million USD)</th>
<th>Average Wage ($/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Products</td>
<td>Services</td>
</tr>
<tr>
<td>Non-information workers</td>
<td>12,731</td>
<td>57,458</td>
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<tr>
<td>Information workers</td>
<td>5,085</td>
<td>52,000</td>
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<tr>
<td>Total</td>
<td>17,816</td>
<td>109,458</td>
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</table>

<table>
<thead>
<tr>
<th>Percentage shares in total</th>
<th>Products</th>
<th>Services</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-information workers</td>
<td>10.0</td>
<td>45.1</td>
<td>55.1</td>
</tr>
<tr>
<td>Information workers</td>
<td>4.0</td>
<td>40.9</td>
<td>44.9</td>
</tr>
<tr>
<td>Total</td>
<td>14.0</td>
<td>86.0</td>
<td>100</td>
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</table>

Source: Authors’ calculations based on data from the BEA Webpage (downloaded in February 2007) (http://www.bls.gov/oes/oes_1999.htm)