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The U.S. Information Economy: Value, Employment, Industry Structure, and Trade

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Abstract

This study examines the evolution of the United States (U.S.) economy after 1999, extending our previous studies [4, 8] up to 2007. The U.S. economy has moved steadily toward services and information-intensive sectors in terms of Gross National Product (GNP), employment, and wage distribution. Information-intensive services, the nexus of these two major trends, now compose the largest portion of the U.S. economy in terms of GNP value, jobs, and wages. In addition, we study the growth of international trade in services and information sectors, which is likely to become increasingly important in the future. Finally, we examine the factors underlying the shifts observable in the economy and the impact on competition, strategy, and sector structure.

An online technical appendix that discusses the definitions and conceptual framework, and describes the data sources and the detailed calculations used to measure the size and structure of the U.S. information economy in 2002 is available at http://dx.doi.org/10.1561/0200000013_app.

1

Introduction

Most of the large economies in the world are already dominated by services, in that services compose more than 50% of national income. We are now in the midst of another major evolutionary trend: that from a material or physical to an information economy. This change is most visible in developed economies, but is occurring in all economies. Some of the research studies that have examined, established, and measured this trend for the United States (U.S.) are those by Machlup [60], Porat [73], Apte and Nath [8], and Apte et al. [4]. Choi et al. [32], following the same methodology as Apte and Nath, demonstrate that a similar evolution has taken place in South Korea, which, while having a relatively larger manufacturing sector than the U.S., was also effectively an information economy by 2000 and has continued to trend in that direction until 2005.

In this monograph, we explore the confluence of these two trends by examining the double dichotomy of products versus services and information versus material (noninformation), which divides the economy into four supersectors. Figure 1.1 provides some illustrative examples of industries in the four supersectors. Note that certain physical manufacturing and service examples (e.g., computers, telecom) fall in the

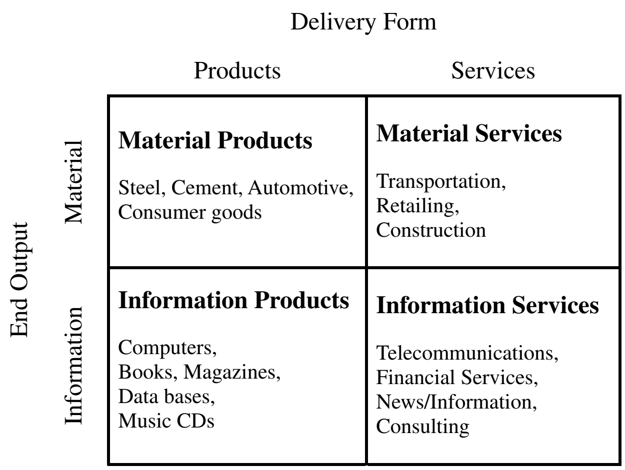


Fig. 1.1 A 2×2 decomposition of the U.S. economy with sector examples.

information sector following the definition by Porat [73]. It also should be pointed out that many industries do not really lie entirely inside one cell. For example, both Machlup and Porat arrived at nearly identical conclusions about the health care industry: It breaks down just about evenly across the material and information sectors.

In previous articles, we have examined the way in which Gross National Product (GNP) in the U.S. divides across these sectors using data on U.S. GNP from 1967, 1992, and 1997 [4]. The current article revisits the earlier estimates and extends them to 2007. Since we examine data across several years, we are also able to look at the changes during that period. Our analysis of the broad changes in the U.S. economy uses sector-level data organized by the Standard Industrial Classification (SIC) and North American Industrial Classification System (NAICS) codes.

We also examine the evolution of jobs and wages in the U.S. This is different from the GNP studies and gives a more detailed perspective. Wages are a major part of GNP but are not exactly the same. Also, the number of jobs can and do distribute differently across the economy, since average wage rates differ substantially across sectors. Furthermore, the GNP data are aggregated at the level of SIC/NAICS codes. But in fact, companies and jobs often cut across the boundaries of the supersectors we are examining. The data on jobs and wages thus present a different perspective and at a finer level of resolution. We analyze data on the U.S. job market (employment and wages by more than 800 occupational categories) since 1999 and extended up to 2007. One major finding is that information workers in services now account for the largest share of total U.S. jobs. This is a significant change from the historical pattern, where noninformation workers in services were the largest segment of the labor market. This shift occurred around 2000. In addition, information workers in services had already captured the largest share of the total wage bill by 1999, and this pattern has continued. Interestingly, the highest average wage rate is for information workers in products, and that has been the case for more than a decade, although the total wage bill is much larger for other segments of the labor market.

In short, it is fair to say that the U.S. economy is now an "information economy" in terms of GNP, jobs, and wages. What is more, the largest component of the U.S. economy is now "information-intensive services." While the economic crises in the last decade have resulted in some moderation of these trends, we can expect continued movement in the same direction in the near future.

This transformation to information and information-intensive services has a wide array of consequences. In this study, we examine some of these consequences to indicate the substantial implications for both management and policy decisions. First, the economics of information-intensive sectors are different in certain specific ways that affect competition. Entry barriers are low, and simple economies of scale are less pronounced. Physical location is less of a differentiator. All of these tend to make competition more intense. On the other hand, barriers like network externalities can have the opposite effect. Furthermore, there may be opportunities for finding niche audiences. While trade in services is generally difficult due to their intangibility, trade in content-based services and even transactional services is now feasible. There are many other structural implications for economies. One systematic phenomenon is the de-integration occurring in many verticals such as music and publishing. Another is the appearance of mechanisms such as open sourcing and of direct exchange and barter, which can create a kind of "demonetization" effect. Finally, the structural changes extend below the sector level down to organizations and even jobs and tasks.

In the next section, we review research on the information economy in the U.S. and survey the literature on related topics. In Sections 3 and 4, we present the main results of our study, in terms of the two-way breakdown of the U.S. economy based on GNP data (as in Figure 1.1) and labor statistics. In Section 5, we present the changing patterns of international trade in information services. The GNP data over a 40-year period show the significant trends noted above. In Section 6, we discuss possible reasons for these trends. Productivity increases have long been recognized as a cause for the growth of services relative to manufacturing. We suggest that they are also the reason for the growth of information-intensive services relative to physical services. Underlying productivity changes are a range of management actions that we describe collectively as a process of "industrialization," having a close analogy to the historical industrialization process associated with manufacturing. We analyze the consequences of industrialization for information-intensive services in Section 7. The monograph concludes in Section 8, with a summary and a description of our ongoing research on these topics.

2

The Information Economy: Literature and History of Research

There is a substantial amount of research covering a wide range of disciplines that examine various aspects of the information economy.[1] These are mostly microlevel studies. Most recent macrolevel studies on the information economy or the so-called "new economy" (for example, [14, 41, 44, 78]) seem to have focused on the contribution of information and communications technologies (ICT) to faster labor productivity growth in the late 1990s. However, the number of studies that attempt to present a macro profile by quantifying the size, structure, and growth of the information economy in the U.S. has been relatively small. Understandably, there are formidable issues in measuring the information economy. Nevertheless, it is important to have an idea of its approximate size relative to the overall economy because of the way the role of information in modern economies has been described. For example, Martin [64] argues that, in developed economies, information

[1] The ways that information is conceptualized vary across disciplines. Even within a discipline, there are differences among scholars about how information is conceived and, as a result, how its larger impact in society has been analyzed. Schement and Curtis [76] discuss various conceptualizations from across disciplines to examine the ascendance of the idea of information throughout history and to discuss its role in the emergence of the so-called information society.

holds "the key to growth, output, and employment," a role that was played in the past by traditional factors of production like land, labor, and capital in the industrial society.

The most formidable challenge in obtaining a comprehensive measure of the information economy is to separate "information" from the "material" component of the economy. The seminal contributions of Machlup [60, 61] and Porat [73] describe methods for measuring the information or knowledge component of the total value generated in the economy. Fritz Machlup's 1962 study is one of the first attempts to assess what he calls the "knowledge industry" and to present a comprehensive statistical profile of this industry. His study provides a conceptual framework for research into quantitative as well as qualitative aspects of knowledge-based information activities. It identifies the components of the "knowledge industry" and measures its contribution to the GNP. According to Machlup, 29% of the U.S. GNP was generated by the knowledge industry in 1958. Subsequently, in the three published volumes of his unfinished series *Knowledge: Its Creation, Distribution and Economic Significance*, Machlup further explains his concepts and presents quantitative accounts of various aspects of the U.S. knowledge economy.[2]

In 1977, Marc Porat undertook an extensive study of information-based activities in the U.S. economy on behalf of the U.S. Department of Commerce.[3] Porat uses a conceptual framework similar to that of Machlup. However, to define and measure the information economy, Porat adopts an approach that is quite distinct from the one used by Machlup. He follows strictly the national income accounting framework. Machlup, on the other hand, includes a number of economic activities that are not part of the national income accounts. Machlup's approach would require a new system of national accounting if one wanted to analyze the information sector as the "knowledge industry" *a la* Machlup, within the broader concept of the national economy. Porat recognizes Machlup's innovation and its novelty but justifies his stance in using

[2] Machlup originally planned a series of 10 volumes highlighting different aspects of the knowledge economy. However, he could publish only three volumes before his untimely demise.

[3] This study uses data for 1967.

conventional national income accounting framework: "the concept of an information sector was sufficiently new that a simultaneous overhaul of the GNP scheme would confuse and obfuscate more than it would help" [73, vol. 1, p. 45]. Moreover, it is much easier to compile and manipulate data using Porat's method (rather than using Machlup's) since it makes use of the Bureau of Economic Analysis (BEA) National Income Accounts. However, it has its limitations. Because the BEA data are collected and published at aggregate levels of industrial classification, many of the information activities that can only be identified at a high level of disaggregation are not included in Porat's method.

Unfortunately, there have been only a few studies that implement the methods developed by Machlup and Porat. Following Machlup's methodology, and as a sequel to his unfinished work, Huber and Rubin [43] presented measurements of the knowledge industry for the years when the U.S. Census Bureau conducted economic censuses. These "census years" included 1963, 1967, 1972, 1977, and 1980. Contrary to expectations of high growth in the knowledge industry as predicted by Machlup in his 1962 study, Huber and Rubin [43] found that its contribution to the U.S. GNP increased from 29% in 1958 to only about 34% in 1980. Furthermore, the Organisation for Economic Co-operation and Development (OECD) [69, 70] used Porat's methodology to measure the size of the information economy in the U.S. along with eight other member countries. The OECD study showed that the share of the primary information sector (PRIS) (described below) in the U.S. GNP increased from 19.6% in 1958 to 24.8% in 1972 [69], while the contribution of the secondary information sector (SIS) increased from 23.1% in 1958 to 24.4% in 1972 [69]. In a more recent study, Apte and Nath [8] reported that the share of all information activities in total GNP grew from about 56% in 1992 to 63% in 1997. They found that the PRIS accounted for 33% of GNP in 1992 and about 35% in 1997. The GNP shares of the SIS were about 23% and 28% in 1992 and 1997, respectively.

Apte et al. [4] combined the material–information dichotomy with the traditional product–service dichotomy to present another perspective on the structural changes that have been taking place in the U.S. economy. This 2×2 decomposition of the economy reveals that information services are the largest segment of the U.S. economy.[4] By 1997, about 56% of total U.S. GNP was generated in this supersector. This share increased from about 36% in 1967 to 49% in 1992, and subsequently to 56% in 1997.

Among other attempts to quantify information economy, the Cisco Systems-sponsored research project on the Internet Economy, conducted at the University of Texas–Austin [81], and the study on the total value of private enterprise documents by Michael K. Bergman [20] at BrightPlanet Corporation are noteworthy. However, both studies lack a comprehensive conceptual framework that would make their estimates comparable with conventional macroeconomic data. Recently, the U.S. Census Bureau and the BEA have introduced a new definition of a separate information sector that includes selected publishing activities, telecommunications, data processing services, radio, television, motion pictures, and video, for which they collect and report data. But this definition of information sector or economy is too restrictive, does not match the Porat definition, and, in our opinion, does not adequately reveal the importance of information in the economy today.[5]

As mentioned above, the more recent macro literature has focused on the impact of ICT on the productivity growth in the U.S. After a period of productivity slowdown since the 1970s, the rapid productivity growth of the late 1990s in the U.S. — often referred to as "the U.S. productivity revival" — attracted much attention from the researchers. Most studies (for example, [14, 41, 44, 45, 46, 71, 78]) concluded that the unprecedented advances in ICT explained a significant part of the resurgence of U.S. productivity growth.[6] Wolff [83] further showed that, while computerization has a significant positive effect on total factor

[4] Apte and Nath [7] give a brief account of the shift of the U.S. economy toward information services in the early 1990s.

[5] As Brynjolfsson and Saunders [26] argue, the GDP contributions of these industries do not reflect their "oversized influence" on innovation. They argue that the effect of ICT "on the economy goes far beyond its production. Indeed, the innovative use of technology by individuals, firms, and industries makes far more of a difference to the economy." (pp. 15–16). It is difficult to measure these outside effects. Furthermore, "technology is having another large influence … in transactions that take place outside traditional markets." (p. 21). The conventional GDP measures exclude these transactions.

[6] However, there are differences among these studies as to the effects of ICT on productivity at the sectoral level as well as to the sustainability of these effects.

productivity, it was also strongly linked to occupational restructuring. While these studies correctly documented the importance of ICT, they failed to fully capture the effects of complementary innovations facilitated by "general purpose technologies" such as ICT.[7] As Brynjolfsson and Hitt [25] emphasized, "the economic contributions of general purpose technologies are substantially larger than would be predicted by simply multiplying the quantity of capital investment devoted to them by a normal rate of return." These complementary innovations came in the form of organizational innovations such as new business processes, new skills, and new organizational and industry structures. Although the microeconomic studies of firms (for example, [23, 24] documented the larger impact of ICT while taking into account these complementary innovations, the difficulty in quantifying and aggregating has made it almost impossible to capture their impact at the macro level.

There are a few studies that examined employment patterns along the information versus material (noninformation) dichotomy. Osberg et al. [72] identified three broad occupational sectors within modern advanced economies such as those of the U.S. and Canada: the goods sector composed of occupations that directly involve the manipulation or transformation of goods; the personal service sector consisting of occupations that involve service to other individuals; and the information sector involving the production or manipulation of symbolic information. The information sector is further subdivided into two types of occupations: the "data processors," who are engaged in routine manipulation, storage, and transfer of information within previously defined categories (e.g., clerical work); and the "knowledge producers," who are engaged in the establishment of original categories or analyses (e.g., engineering or computer programming). They argued that the growth of these three sectors could be explained by the inherent unbalanced growth of the economy.[8] According to them, labor productivity in goods and data production grew steadily over time due to increasing capital

[7] Basu and Fernald [16] examine the productivity effects specific to the general-purpose technology nature of ICT at the sectoral level for the U.S. economy.

[8] In his seminal contribution to the growth literature, Baumol [17] first explains the concept of unbalanced growth. Baumol [18] and Baumol et al. [19] further apply this concept to explain low productivity growth and higher employment in services.

intensity of production and the impact of ICT advances. In contrast, labor productivity in the personal services and knowledge sectors did not tend to increase over time, as labor time was the output in personal services occupations, and the human creativity essential to knowledge production demonstrated little tendency to increase over time. These differences in productivity growth explained the relative increase in the employment of personal service and knowledge workers. They analyzed occupational data between 1960 and 1980 in the U.S. to demonstrate a relative shift in employment toward knowledge-based occupations.

Using decennial census data on employment by detailed occupations and industries between 1950 and 2000, Wolff [84] extended this analysis and found that information workers (knowledge producers and data processors) increased from 37% of the workforce in 1950 to 59% in 2000 in the U.S. His analysis further showed that the growth of information workers was not attributable to a change in tastes for information-intensive goods and services, but partially to changes in production technologies that made it possible to substitute goods and service workers for information workers, and partly to differential rates of productivity movements among the industries of the economy, thus fitting the framework of unbalanced growth. Apte et al. [4] also examined employment and wages among information and noninformation workers in the product and service sectors; however, their analysis was based on data for 1999 only. Their classifications of information worker and noninformation worker were different from those proposed by Porat [73] or Osberg et al. [72] and were more akin to the classifications used in the current study.

The articles included in Cortada [36] present a broader account by combining historical, economic, and sociological perspectives on the rise of the "knowledge workers" — the fastest growing segment of the workforce in the world today.[9] This volume made some very interesting observations. For example, knowledge workers first and foremost came into being where technologies were most advanced. Further, the shift to knowledge work began in earnest before World War I and, by the end of the 1920s, became a major trend. They noted that the ability of

[9] A knowledge worker is defined as a person who deals in data and ideas.

women to work in professional careers was made possible mainly by the rise of knowledge work, rather than through any altruistic change in the attitude of male managers. Freeman [38] further discussed various labor market outcomes of ICT extension to economic activity.

Studies on the employment of information or knowledge workers can also be related to a recent literature that focused on the increasing wage gap between low-skilled and high-skilled workers. Skill-biased technological innovation has been shown to be the most plausible explanation of this development. For example, Autor et al. [11, 12] argued that the increased use of computers (which is used as a proxy for skill-biased technological change) and skill upgrading accounted for growth in demand for and wages of skilled workers. Autor et al. [11, 12, 13], Autor [10], and Acemoglu and Autor [1] further explored the relationship between technological change and employment and earnings of skilled (information) workers. Berman et al. [21] and Machin and Reenen [59] examined empirical evidence for skill-biased technological change for several advanced countries, including the U.S., and established that skill-biased technological progress had increased the demand for skilled workers. Focusing on IT professionals, Mithas and Krishnan [66] further documented that investment in human capital and IT intensity of firms led to substantially higher compensation for these workers.

Related to this literature but considered from the operations management perspective, Apte and Mason [6] and recently Mithas and Whitaker [67] focused on global disaggregation of information-intensive services. Apte and Mason [6] developed a classification framework to identify the services and jobs that were most amenable to service disaggregation. Building on this classification scheme, Mithas and Whitaker [67] proposed and empirically validated a theory of service disaggregation, which argued that a service with high information-intensity jobs was relatively more amenable for disaggregation. They also found that high information-intensity occupations that required higher skill levels had experienced higher employment growth but a decline in salary growth. Furthermore, occupations with a higher need for physical presence also had experienced higher employment growth and lower wage growth. However, the scope of these changes in production and delivery of services (particularly information-intensive services) was far greater than just spatial disaggregation of the supply chain, as noted by Karmarkar [47].[10] This line of research created a burgeoning literature on so-called "service industrialization." Karmarkar [48, 49] discussed the link between the global information economy and service industrialization.

It is apparent that the structural shift toward an information or knowledge economy requires a new policy framework. Although ICT advances have facilitated this structural shift, it is ICT- enabled innovations that have had and will continue to have the greatest impact on the evolving nature of the broad changes. For sustained economic growth and development, countries will have to pay attention to formulating and implementing effective innovation policies. Ezell and Atkinson [37] discussed various aspects of innovation policies for the U.S. to gain competitive advantage in the twenty-first century. In the information economy, the emerging occupation and employment structures also will necessitate new policies on education and employment. Kay and Greenhill [54] discussed the need for education policies that will help build skills for the emerging labor market in the twenty-first century. However, the need for a new policy paradigm may go beyond the conventional realms of economics. The recognition of the fact that a broadly defined concept of information or/and knowledge has come to play a critical role, not only in our everyday economic life but also in shaping the current and future paths of our social, political, and cultural life, extends the scope of this policy framework to a more comprehensive paradigm. A series of articles included in Hearn and Rooney [42] discussed the concept and discourse on knowledge beyond science and technology and thus argued that there was a need for a much broader knowledge policy framework that covered a wide range of issues relevant for the twenty-first century.

[10] Chase and Apte [31] discuss the evolution of service operations from a historical perspective and identify the big ideas around which major changes have taken place.

3

The U.S. Information Economy

In this section, we present empirical evidence to document a long-run structural change that has taken place in the U.S. The share of information services in the overall economy has been growing for over four decades and now are the largest segment of the U.S. economy. Despite a dearth of detailed evidence, there are strong indications that this shift has already been taking place in other advanced economies as well.[1] Even some emerging market economies are likely to experience a similar long-run structural shift in the near future.

It should be noted that since we have documented this trend in the U.S. until the late 1990s in our earlier work [4], we will first focus on the quantitative measures of these changes for the most recent years and discuss them in the context of the long-term trends.

3.1 Data and Methodology

The main sources of data for measuring the size and structure of the U.S. information economy in this article are: (1) 2002 Benchmark

[1] Using the same methodology as Apte and Nath [8], Choi et al. [32] conclude that, while having a relatively larger manufacturing sector than the U.S., Korea was effectively an information economy by 2000.

Input–Output (I–O) Accounts, for value-added data at the six-digit level of industrial classification; (2) Annual Industry Accounts, for data on value added by three-digit industries for 2002 and 2007; (3) Fixed Assets in the National Economic Accounts for data on depreciation of private nonresidential fixed assets — all compiled and maintained by the BEA; and (4) Occupational Employment Statistics (OES), compiled and maintained by the Bureau of Labor Statistics (BLS) [28]. Most data are available online at the BEA and BLS websites [27, 29].[2]

In order to measure the size and structure of the material and information domain of the U.S. economy, we closely followed the framework and methodology developed by Porat [73].[3] Under his scheme, the U.S. economy is divided into two distinct but inseparable domains: one is "involved in the transformation of matter and energy from one form into another" and the other is involved "in transforming information from one pattern into another," where information is defined as the "data that have been organized and communicated." The term "material" refers to the first domain and "information" refers to the second domain. An operational definition of "information" encompasses "all workers, machinery, goods, and services that are employed in processing, manipulating, and transmitting information."[4]

The information sector is further subdivided into: (1) the PRIS, which produces information goods and services; and (2) the SIS, which represents the part of the value created by information workers, information capital, and information activity of the proprietor in the process of production of a "material" good or a "material" service. The total value added of an industry belonging to the PRIS is counted as a part of the information domain of the economy. For example, the total value added generated by the semiconductor industry (semiconductor is an information product) and the telecommunication industry (telecommunication is an information service) is a part of the information economy value added. In case of an industry belonging to the SIS, only a part of the value added is counted toward the information

[2] See the Technical Appendix [3, 5] for a detailed discussion of the data and data sources.
[3] Depending on the availability of data and the changes in definitions, we made certain modifications. See the Technical Appendix.
[4] Porat [73, vol. 1, p. 2].

economy. Thus, information value added of an SIS industry includes (1) employee compensation of information workers, (2) a part of proprietors' income and corporate profits earned for performing informational tasks, and (3) capital consumption allowances (depreciation) on information machines. For example, for the textile industry (textile is a material product) or the transportation industry (transportation is a material service), only the value-added contributions of the information workers (e.g., managers, accountants), the information capital (e.g., computers) employed in those industries — measured by wages and capital consumption allowances of information capital goods, respectively — *plus* a part of the proprietors' income and corporate profits, are counted as a part of the information economy. Thus, for these two industries, the total value added is decomposed into a material component and an information component.

Using the detailed Benchmark I–O tables compiled and published by the BEA, the industries at the six-digit level of industrial classification belonging to the PRIS were identified, and their value-added figures were aggregated at the three-digit level of aggregation that roughly matched the level of disaggregation at which SIS value-added data were obtained. For the SIS, the OES data compiled by the BLS were used to construct matrices of employment and wages by occupations and industries. The occupational employment data for industries belonging to the PRIS were excluded.[5] For the remainder, the occupations were classified as belonging either to information or noninformation categories according to the scheme described in Porat [73]. The information workers were broadly defined as those who were primarily engaged in the production, processing, or distribution of information.

The data on depreciation of information capital assets were obtained from the Fixed Assets dataset of the BEA. The list of information capital assets was slightly different from Porat's.[6] It included computer and peripheral equipment, software, communications equipment, photocopy and related equipment, and office buildings, communication,

[5] Some three-digit industries belong entirely to the PRIS while, for others, only a part belongs to it. See the Technical Appendix [3, 5].

[6] Note that some of the information-capital assets either did not exist or were not previously considered as capital assets.

religious, and educational structures. We further used data on net operating surplus from Annual Industry Accounts to add a portion of the proprietors' income accrued for performing information activities. Although the proportion of time allocated by proprietors toward information activities may have changed over the years due to the changing nature of economic activities, in the absence of relevant information, we used the same time allocation ratios as Porat's. The online technical appendix to this monograph provides a detailed description of how these data were incorporated in the calculation of SIS value added.

By combining this material–information dichotomy with the product–service dichotomy, we gained useful insights into the structural changes that had taken place in the U.S. economy. At the aggregate level, this exercise decomposed the economy into four supersectors, as shown in Figure 1.1. This study used a product–service classification scheme that was slightly different from the conventional "goods-services" classification used in economics, but was the same as the one used by Apte et al. [4]. Note that because of the switch from the old product-based SIC system to the new process-based NAICS in 1997, there have been some changes even in the conventional product–service classification used in economic data (see Lawson et al., [58]). The classification scheme used in this research reflected some of the important changes that had taken place in production and consumption due to technological changes. Nevertheless, the difference in terms of aggregate value added was expected to be minimal because most industries belonging to the product and services category under these two classifications were the same.

The proposed classification scheme is based on three distinct criteria.

(1) *Market transaction or delivery mode*: Products are in standard units, not differentiated by customer, priced by unit, and preproduced while services are processed, produced, and customized on demand, and priced by process rather than by unit.
(2) *Form*: Products are tangible, while services are intangible or experiential.

(3) *Production process*: Products are produced entirely by suppliers, while services are often co-produced with the customer present.

After the industries were classified into the product and services category, the material and information value-added data were aggregated separately to construct a 2×2 matrix similar to Figure 1.1 for each year. Two different versions of this matrix were created to display (1) actual value in current prices and (2) percentage distribution of shares in total GNP.

Ideally, we wanted to compute value added at constant dollars for these four supersectors of the U.S. economy so that we could consider their growth over the years. However, there were some formidable constraints to be faced. Since 1996, the BEA began using an "ideal chain index" to construct real value-added series. This step purported to eliminate some of the problematic issues associated with the fixed-weight index that was in common use until then. Although this new method of constructing real series in chained dollars improved the quality of the data, it introduced certain other limitations. One of them was the nonadditivity of disaggregate series: Unlike with fixed-weight series, the chained dollar series could not simply be added to construct aggregate series.[7] Furthermore, there could be significant differences in price changes between the material and information components of value added and, as such, one would use different deflators for these two components. Unfortunately, separate price indices were not available and it was not straightforward to construct such indices from available data.

Note that the detailed benchmark I–O tables were available at 5-year intervals, and the most recent tables that were publicly available were for 2002. The detailed benchmark I–O tables for 2007 were not available yet. However, value-added data were available at roughly the three-digit level of industrial classification for 2007. In the absence of detailed (more disaggregated) industry-level data, we applied PRIS value-added ratios at the three-digit level of industries for 2002 to the

[7] For a detailed discussion, see Landefeld and Parker [57] and Whelan [82].

2007 value-added data to arrive at some approximate measures of the PRIS in 2007. Since most of the relevant data for SIS were available, the SIS measures for 2007 were consistent with 2002 and the earlier years.

3.2 Main Findings

3.2.1 Size and Structure of the U.S. Information Economy from 1967 to 2007

Tables 3.1 and 3.2 present the value-added contributions — both in current dollar value and percentages — of primary and secondary information sectors to the U.S. GNP in 2002 and 2007, respectively.[8] As we

Table 3.1. Size and structure of the U.S. information economy, 2002.

Description	Value-added (billions of current USD) 1	Percentage share in GNP (%) 2
Primary information sector (PRIS)	4,132.5	38.65
Secondary information sector (SIS)	2,481.2	23.21
Total information	6,613.6	61.86
Total material	4,077.8	38.14
Gross national product (GNP)	10,691.4	100.00

Note: See Technical Appendix [3] for detailed calculations.

Table 3.2. Size and structure of the U.S. information economy, 2007.

Description	Value-added (billions of current USD) 1	Percentage share in GNP (%) 2
Primary information sector (PRIS)	5,534.6	38.99
Secondary information sector (SIS)	3,014.0	21.24
Total information	8,548.5	60.23
Total material	5,644.9	39.77
Gross national product (GNP)	14,193.3	100.00

Note: See Technical Appendix [3] for detailed calculations.

[8] Since the beginning of the 1990s, GDP, instead of GNP, is used as a measure of national income in the U.S. Whereas GDP measures all income generated in the U.S., GNP measures all income earned by U.S. nationals. Numerically, the difference between GDP and GNP in the U.S. has been insignificant. We use GNP to make our calculations comparable with those of Porat [73].

Table 3.3. Size and structure of the U.S. information economy, 1967–2002.

	1967	1992	1997	2002	2007
Description	1	2	3	4	5
Primary information sector (PRIS)	25.1	33.0	35.2	38.7	39.0
Secondary information sector (SIS)	21.1	22.9	27.8	23.2	21.2
Total information	46.3	55.9	63.0	61.9	60.2
Total material	53.7	44.1	37.0	38.1	39.8
Gross national product (GNP)	100.0	100.0	100.0	100.0	100.0

Note: This table is compiled from various sources: Porat [73] for 1967; Apte and Nath [8] for 1992 and 1997; and Technical Appendix [3].

can see from column 1 of Table 3.1, about 6.6 trillion USD or about 62% of the total GNP in 2002 was generated in the information sector. The PRIS accounted for about 39% of the GNP and the SIS accounted for about 23%. Less than two-fifths of the GNP was generated in the material sector of the U.S. economy. In contrast, the value-added contributions of the information sector in 2007, which was of the magnitude of 8.5 trillion USD, accounted for about 60% of the GNP. While the PRIS share in GNP went up slightly from 38.65% to 38.99%, there was a drop in the GNP share of SIS between 2002 and 2007.

In Table 3.3, we present percentage share contributions of PRIS, SIS, total information, and material sectors to the GNP for different years. In addition to our calculations for 2002 and 2007, we included those of Porat [73] and Apte and Nath [8].[9] We observed steady growth (in terms of percentage share in GNP) of the PRIS between 1967 and 2007. The SIS experienced a significantly large increase between 1992 and 1997 and a steady decline thereafter. Considering the fact that the 1990s were a period of unprecedented advances in ICT, it is not surprising that the PRIS, the SIS, and the total information share increased significantly between 1992 and 1997. The remarkable growth

[9] Ideally, we would like to include the results of the OECD [69] study that included the U.S. information economy measures for 1958, 1967, and 1972 (1974). Although the OECD study followed Porat's methodology, it makes a few modifications to make the measurements comparable across 10 OECD member countries. *First*, instead of using GNP, it uses GDP. *Second*, it uses value added at factor cost to avoid potential distortions caused by differential tax rates across the countries. Because of these modifications, the numbers presented in the OECD study are not quite comparable with the ones reported by other studies and cited in this monograph.

of the SIS seemed to be partly a reflection of the fact that industries not producing information goods and services (non-PRIS sector) were investing in information capital and hiring information workers at a significantly higher rate in the process of adopting the new ICT.[10] Furthermore, as Apte and Nath [8] discussed, the SIS measures for 1997 were based on employment and wage data for 1998 with reasonable adjustments back to the previous year. This may have introduced an upward bias in measuring the SIS. However, it is unlikely that this upward bias explained the entire growth in percentage share of the SIS in GNP between 1992 and 1997.

In contrast, there are several factors that may have contributed to the decline of the SIS, and therefore the size of the information economy, in terms of their share in GNP since 1997. First, the IT bust and the recession of the early 2000s may have had an impact on the decline of the SIS. Second, as new IC technologies took hold, a series of complementary innovations such as restructuring and reorganization (of which outsourcing — both onshore and offshore – is a part) took place. These innovations led to greater specialization, particularly of information activities. It is not hard to see that one of the consequences would be an enlargement of the PRIS. Although it needs further investigation, the increase in the share of the PRIS was an indication that it may have been the case. Note that the growth of PRIS between 2002 and 2007 seemed to have been insignificant. Offshore outsourcing of information services could have been one of the reasons for the slowdown.[11] Third, decreases in the relative prices of information goods and services also explained the slowing down of the growth of the PRIS share and the decline in the share of the SIS and of the overall information economy.[12]

[10] Tevlin and Whelan [80] discuss the special behavior of investment in computers that contributed to the investment boom of the 1990s. Further, Wolff [84] finds that there were significant increases in the employment of information workers over the years and argues that this increase is attributed to changes in production technology, Nevertheless, these studies provide only indirect support to this conjecture and it needs further investigation.

[11] Bardhan and Kroll [15] give an account of a new wave of offshore outsourcing in the early 2000s.

[12] There is a literature that investigates productivity growth and falling prices of ICT goods and services. See, for example, Gordon [41].

The fourth factor that may have contributed to the decline in the size of the information economy since 1997 was the increasing amount of "shadow work," the unpaid work done in a wage-based economy, being performed by the customers. The growth of information technology, coupled with the increasing use of the "self service" strategy by many businesses, led to a situation in which the customers were increasingly engaging in shadow work. For example, consider the airline industry. Airports have self-service check-in kiosks that allow travelers to perform the job previously performed by airline counter personnel. Similarly, not too long ago, travel agents helped travelers purchase airline tickets with suitable fare and itinerary. Today, the same travelers spend their own time searching the Internet for flights and fares to create their own itinerary and purchase their tickets online. To the extent that travelers were not compensated for the shadow work they performed, this work and its associated value was not captured in the formal economy. Hence, even if the real share of information economy in GNP were on the rise, its share in the formal economy could decline, as seen in the data in Table 3.3.

3.2.2 Decomposition of the U.S. GNP

Table 3.4 presents 2×2 decompositions of the U.S. GNP for 1967, 1992, 1997, 2002, and 2007. The decompositions for the first 3 years were taken from Apte et al. [4]. For both 2002 and 2007, information services were the largest segment of the economy, with more than half of total value added generated in that supersector. In contrast, information products were the smallest sector with slightly more than 5% value-added contributions to the U.S. economy in both 2002 and 2007. When we compared the percentage shares of these four supersectors in 2002 and 2007 with those in previous years, we made two important observations. *First*, the shares of information products and information services continuously declined from 1997 through 2007. *Second*, while the GNP share of material products declined continuously until 2002, there was a slight increase between 2002 and 2007. In contrast, the share of material services declined until 1997, and then rose steadily.

Table 3.4. 2 × 2 decomposition of the U.S. GNP, 1967–2007.

Percentage shares in GNP				Value in millions of current US dollar			
1967				**1967**			
	Products	Services	Total		Products	Services	Total
Material	19.2	34.5	53.72	Material	152514	274775	427289
Information	10.5	35.8	46.28	Information	83370	284730	368100
Total	29.66	70.34	100.00	Total	235884	559505	795389
1992				**1992**			
	Products	Services	Total		Products	Services	Total
Material	12.7	31.5	44.13	Material	788844	1961990	2750834
Information	6.5	49.4	55.87	Information	402520	3080551	3483071
Total	19.11	80.89	100.00	Total	1191364	5042541	6233905
1997				**1997**			
	Products	Services	Total		Products	Services	Total
Material	10.5	26.5	37.00	Material	877051	2211055	3088106
Information	6.9	56.1	63.00	Information	577631	4679908	5257539
Total	17.40	82.60	100.00	Total	1454682	6890963	8345645
2002				**2002**			
	Products	Services	Total		Products	Services	Total
Material	9.5	28.7	38.1	Material	1012160	3065612	4077772
Information	5.9	56.0	61.9	Information	626982	5986665	6613647
Total	15.3	84.7	100.00	Total	1639142	9052277	10691419
2007				**2007**			
	Products	Services	Total		Products	Services	Total
Material	10.2	29.6	39.8	Material	1450469	4194413	5644882
Information	5.3	54.9	60.2	Information	750487	7798062	8548548
Total	15.5	84.5	100.00	Total	2200956	11992474	14193430

Note: See Technical Appendix [3] for detailed calculations.

3.3 Information–Material Decomposition at the Industry Level

Table 3.5 presents some relevant facts about the size and structure of the information economy at the industry level for the 25 largest private industries (according to their respective shares in GNP in 2002) and the government for 2002 and 2007. Note that these 25 industries accounted for about 71% of the GNP in 2002. The GNP shares are shown in columns 1 and 3. Columns 2 and 4 present the shares of information

Table 3.5. Industry share, information share, changes in real value added and prices for 25 largest private industries and governments in 2002 and 2007.

		2002		2007		Percentage change in real value added		Percentage change in price index	
Ranking according to GNP shares in 2002	Industry title	Industry share in total GNP	Information share in industry value added	Industry share in total GNP	Information share in industry value added	1997–2002	2002–2007	Inflation: 1997–2002	Inflation: 2002–2007
		1	2	3	4	5	6	7	8
1	Real estate	11.33	41.18	11.17	41.36	11.56	16.15	17.75	12.73
2	Retail trade	6.84	58.76	6.29	56.61	21.06	8.40	2.39	12.64
3	Wholesale trade	5.75	59.81	5.75	60.24	38.23	19.32	−15.25	11.28
4	Construction	4.62	39.91	4.66	39.24	6.06	−7.61	34.42	44.78
5	Miscellaneous professional, scientific, and technical services	4.26	98.51	4.60	98.37	19.74	18.84	18.99	20.56
6	Federal Reserve, banks, credit intermediation, and related activities	4.08	100.00	3.40	100.00	46.16	4.47	20.34	6.04
7	Ambulatory health care services	3.14	76.30	3.23	76.08	18.38	20.39	13.56	13.48
8	Hospitals and nursing and residential care facilities	2.77	57.63	2.81	56.67	8.54	10.90	26.35	21.67
9	Other services, except government	2.67	49.39	2.48	47.05	−0.11	1.81	27.50	21.55
10	Administrative and support services	2.53	87.26	2.66	86.95	17.19	28.99	20.01	8.40
11	Broadcasting and telecommunications	2.51	100.00	2.44	100.00	46.46	45.27	−11.15	−11.15
12	Insurance carriers and related activities	2.32	100.00	2.77	100.00	1.39	34.68	18.79	17.24

(*Continued*)

Table 3.5. (*Continued*)

		2002		2007		Percentage change in real value added		Percentage change in price index	
Ranking according to GNP shares in 2002	Industry title	Industry share in total GNP	Information share in industry value added	Industry share in total GNP	Information share in industry value added	1997–2002	2002–2007	Inflation: 1997–2002	Inflation: 2002–2007
		1	2	3	4	5	6	7	8
13	Food services and drinking places	2.02	17.18	2.00	13.29	19.03	14.54	20.95	14.88
14	Utilities	1.69	20.83	1.74	17.03	0.28	6.91	6.22	27.66
15	Management of companies and enterprises	1.67	100.00	1.80	100.00	12.79	−3.75	27.41	48.58
16	Food and beverage and tobacco products	1.65	15.26	1.30	15.70	1.26	19.34	30.27	−12.49
17	Chemical products	1.59	32.24	1.58	26.98	3.47	22.16	8.72	8.49
18	Legal services	1.44	100.00	1.49	100.00	15.69	4.84	22.10	31.02
19	Securities, commodity contracts, and investments	1.44	96.73	1.42	100.00	142.93	3.00	−46.58	27.19
20	Rental and leasing services and lessors of intangible assets	1.38	51.44	1.40	50.26	32.82	14.98	4.64	16.90
21	Computer and electronic products	1.24	100.00	1.39	99.07	233.90	163.91	−74.51	−43.51
22	Publishing industries (includes software)	1.14	99.61	1.03	99.64	28.55	22.36	15.35	−1.95
23	Motor vehicles, bodies and trailers, and parts	1.13	20.79	0.74	33.82	27.11	20.02	−0.71	−28.17
24	Computer systems design and related services	1.03	100.00	1.13	100.00	43.89	59.07	1.09	−8.30
25	Fabricated metal products	0.98	28.59	0.96	26.01	−10.54	18.99	7.68	8.54
	Government	12.65	73.87	12.42	69.59	7.36	4.18	18.74	25.03

value added for each industry. As we can see from this table, four service industries, namely real estate, retail trade, wholesale trade, and construction, accounted for about 30% of the GNP in both years. None of these four industries produce information goods or services. However, information activities contributed more than one half of total value added only in trade. Included in this list of the 25 largest industries are two financial service industries — "Federal Reserves, banks, credit intermediation, and related activities" and "Insurance carriers and related activities" — and "Broadcasting and telecommunications" with GNP shares greater than 2% that belong to the PRIS. There are four other PRIS industries and three more with an information share larger than 90% that have made it to this list of the top 25 industries.

Columns 5 and 6 present growth rates of value added in 2005 chained dollars for two 5-year periods: 1997–2002 and 2002–2007, respectively. These rates represent the growth of quantity or volume. Note that during these two periods, the U.S. economy grew by about 17% and 14%, respectively. Among these 25 industries, 11 grew faster than the overall economy in both periods. Six of them were highly information-intensive industries such as "Broadcasting and telecommunications," "Computer and electronic products," "Publishing industries," and "Computer systems design and related industries," Besides these, there were two other information-intensive industries that grew faster than the economy in one of the two periods. We present percentage changes in prices for various industries during 1997–2002 and 2002–2007, in columns 7 and 8, respectively. They give another perspective on the changes that took place during this 10-year period. Note that the industries experiencing negative price changes were mostly information-intensive industries. These decreases in prices may partially explain the decline in the share of the information economy, as shown in Table 3.3.

The governments at all levels, local, state, and federal, accounted for about 12% of GNP. Within the government, information activities contributed about 74% in 2002 and declined to 70% in 2007. Government grew slower than the economy during this period.

4

Employment and Wages in the U.S. Economy

In this section, we present and analyze the changes in the U.S. labor market that have taken place, along with the structural shifts that we have discussed above. Due to a lack of data, our empirical analysis was limited to a relatively shorter sample period that began in 1999. However, the major findings in this section are consistent with our analysis of the long-run structural shifts and contribute to the understanding of various implications for the labor market in the U.S.

4.1 Data and Methodology

The main source of data for the analysis of the labor market was the OES, compiled and published by the BLS. The data included, among other things, the number of workers and the average annual wages for more than 800 occupations, and by industries at various levels of industrial classification since 1999. The data were available for two- and three-digit-level SIC industries between 1999 and 2001, and for two-, three-, four-, and five-digit-level NAICS industries since 2002.

We classified occupations into information and noninformation categories. This classification scheme was different from the one used in Porat [73] and Apte and Nath [8], and also from those used by some other previous studies (for example, [11, 12, 84]). This scheme — based on the framework developed by Apte and Mason [6] and used by Apte et al. [4] — recognized that every occupation used information at various intensities. Following Apte and Mason, the information intensity of an occupation was defined as the fraction of time spent in dealing with information-intensive tasks (i.e., in creating, processing, and communicating information). Occupations were classified according to five levels of information intensity. If an occupation required creating, processing, and communicating information and did not require physical presence in a specific location or physical action by the worker, then it was classified as an information occupation. An occupation that required only physical action and did not involve creation, processing, and communication of information was called a noninformation occupation. Because many occupations involved creation, processing, and communication of information as well as physical action (including physical presence in a particular location), they were classified into one of the three intermediate categories based on the fraction of time spent on information actions versus noninformation actions: high (75% information and 25% noninformation), medium (50% information and 50% noninformation), and low (25% information and 75% noninformation). However, there were no clear guidelines for assessing the information intensity of various occupations. The detailed descriptions of occupations from the *Dictionary of Standard Occupational Classification (SOC) Codes*, available from the BLS, were used to determine information intensity. Then, by applying the weights: 100%, 75%, 50%, 25%, and 0% total employment was decomposed into the two broad categories: information and noninformation for each disaggregate industry.

The following equation is used for the decomposition of total employment in industry j into the information and noninformation category:

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

where IE_i and NE_i are, respectively, the full-time equivalent (FTE) information and noninformation employment in industry i; v_j is the

Non-Information Workers in Product Sectors	Non-information Workers in Service Sectors
Information Workers in Product Sectors	Information Workers in Service Sectors

Fig. 4.1 A 2 × 2 decomposition of the U.S. labor market based on information intensity at the level of occupational data.

information-intensity weight applied to the jth occupation and $v_j \in [0, 0.25, 0.50, 0.75, 1]$; and E_{ji} is the number of workers employed in occupation j in industry i.

A similar equation is used to calculate wage bills for information and noninformation categories in industry i:

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

where W_{ji} is the annual average wage for occupation j in industry i. The product–service classification is then applied to the industries, and the information and noninformation employments are aggregated for each of these two broad categories. The total wage bills are also calculated for information and noninformation workers in each industry. Then, the industries are classified into the product or service category, and the aggregate wage bills are obtained by these two broad categories.

The resulting data on employment and the total wage bill were decomposed into four major categories, as shown in Figure 4.1, for the years from 1999 to 2007. This decomposition gave another perspective on the structural changes that had taken place in the U.S. economy focusing on the labor market. Note that this decomposition is related to but not quite the same as that in Figure 1.1.

4.2 Main Findings

Table 4.1 presents the 2×2 decomposition of total employment, wage bill, and average wages in the U.S. economy for each year between 1999

Table 4.1. 2 × 2 Decomposition of employment, wage bill, and average wages in the U.S. Economy: 1999–2007.

Percentage shares of employment				Percentage shares of wage bill				Average annual wage (in current USD)			
1999											
	Products	Services	Total		Products	Services	Total		Products	Services	Total
Noninformation workers	10.00	45.15	55.15	Noninformation workers	8.63	37.46	46.09	Noninformation workers	27,061	26,039	26,224
Information workers	4.00	40.86	44.85	Information workers	6.21	47.70	53.91	Information workers	48,793	36,629	37,713
Total	14.00	86.00	100.00	Total	14.84	85.16	100.00	All workers	33,264	31,070	31,377
2000											
	Products	Services	Total		Products	Services	Total		Products	Services	Total
Noninformation workers	9.83	42.74	52.58	Noninformation workers	8.67	35.35	44.02	Noninformation workers	28,997	27,193	27,531
Information workers	3.77	43.65	47.42	Information workers	5.78	50.20	55.98	Information workers	50,465	37,813	38,818
Total	13.60	86.40	100.00	Total	14.45	85.55	100.00	All workers	34,945	32,559	32,884
2001											
	Products	Services	Total		Products	Services	Total		Products	Services	Total
Noninformation workers	9.16	43.21	52.37	Noninformation workers	8.14	35.94	44.08	Noninformation workers	30,228	28,294	28,632
Information workers	3.59	44.04	47.63	Information workers	5.53	50.39	55.92	Information workers	52,463	38,918	39,938
Total	12.75	87.25	100.00	Total	13.67	86.33	100.00	All workers	36,486	33,657	34,017

(*Continued*)

Table 4.1. (*Continued*)

Percentage shares of employment				Percentage shares of wage bill				Average annual wage (in current USD)			
2002											
	Products	Services	Total		Products	Services	Total		Products	Services	Total
Noninformation workers	8.48	43.73	52.21	Noninformation workers	7.35	36.12	43.47	Noninformation workers	30,796	29,362	29,595
Information workers	3.11	44.68	47.79	Information workers	4.76	51.77	56.53	Information workers	54,402	41,187	42,047
Total	11.59	88.41	100.00	Total	12.10	87.90	100.00	All workers	37,127	35,338	35,545
2003											
	Products	Services	Total		Products	Services	Total		Products	Services	Total
Noninformation workers	8.35	43.85	52.20	Noninformation workers	7.22	36.08	43.30	Noninformation workers	31,289	29,778	30,020
Information workers	3.12	44.68	47.80	Information workers	4.82	51.87	56.70	Information workers	55,976	42,015	42,926
Total	11.47	88.53	100.00	Total	12.04	87.96	100.00	All workers	37,999	35,954	36,189
2004											
	Products	Services	Total		Products	Services	Total		Products	Services	Total
Noninformation workers	8.03	44.31	52.34	Noninformation workers	6.93	36.49	43.42	Noninformation workers	31,928	30,479	30,702
Information workers	3.02	44.64	47.66	Information workers	4.68	51.90	56.58	Information workers	57,287	43,037	43,941
Total	11.05	88.95	100.00	Total	11.61	88.39	100.00	All workers	38,861	36,781	37,011

(*Continued*)

Table 4.1. (*Continued*)

Percentage shares of employment				Percentage shares of wage bill				Average annual wage (in current USD)			
2005											
	Products	Services	Total		Products	Services	Total		Products	Services	Total
Noninformation workers	7.94	44.50	52.44	Noninformation workers	6.82	36.71	43.53	Noninformation workers	32,554	31,244	31,442
Information workers	2.92	44.64	47.56	Information workers	4.51	51.96	56.47	Information workers	58,436	44,091	44,973
Total	10.86	89.14	100.00	Total	11.33	88.67	100.00	All workers	39,521	37,678	37,878
2006											
	Products	Services	Total		Products	Services	Total		Products	Services	Total
Noninformation workers	7.77	44.65	52.42	Noninformation workers	6.63	36.88	43.51	Noninformation workers	33,388	32,345	32,500
Information workers	2.87	44.71	47.58	Information workers	4.40	52.09	56.49	Information workers	60,100	45,624	46,496
Total	10.64	89.36	100.00	Total	11.03	88.97	100.00	All workers	40,584	38,989	39,159
2007											
	Products	Services	Total		Products	Services	Total		Products	Services	Total
Noninformation workers	7.54	44.70	52.23	Noninformation workers	6.37	36.83	43.20	Noninformation workers	34,419	33,529	33,658
Information workers	2.80	44.96	47.77	Information workers	4.31	52.49	56.80	Information workers	62,691	47,502	48,392
Total	10.34	89.66	100.00	Total	10.69	89.31	100.00	All workers	42,077	40,536	40,696

and 2007. For each year, employment and wage bill are distributed in terms of percentage shares among the four categories of workers indicated by a combination of the descriptions along the relevant rows and columns. For example, in 1999, noninformation workers in the products sector accounted for 10% of the total employment and only 8.63% of total wage bill in the U.S. economy. The table also presents the total for the categories under each dimension of the double dichotomy. Thus, workers in the products sector accounted for 14% of total employment and approximately 15% of total wage bill in 1999, while workers in the services sector accounted for the remaining 86% and 85% of employment and wages, respectively. In contrast, noninformation workers constituted about 55% of total employment and about 46% of total wage bill in that year. Correspondingly, information workers accounted for about 45% and 54% of employment and wages, respectively. The figures under the "average wage" column represent average wages (in current dollars) of the four categories of workers. For example, a noninformation worker in the products sector earned an average income of USD 27,061 in 1999. The table also presents average wages by broad categories. Thus, a worker in the products sector, on average, earned USD 33,264, while he/she earned USD 31,070 in the services sector in 1999. In contrast, a noninformation worker, on average, earned USD 26,224, while an information worker earned USD 37,713 per year in the same year.

We made the following observations from this table. *First*, a majority of all workers were employed in the services sector. The share of services employment had increased from 86% in 1999 to approximately 90% in 2007. Within services, although noninformation workers were the largest constituent, with about 45% of total employment in 1999, the employment share of information workers rose from about 41% in 1999 to about 44% in 2000 and then to about 45% in 2007, becoming the largest category of workers in the economy. In the products sector, the employment shares of both information and noninformation workers have been steadily falling. Along the information–noninformation dichotomy, the noninformation workers accounted for about 55% of total employment in 1999, and this share dropped to about 52% in 2007.

Second, services workers received the largest share of the total wage bill in the U.S., and this share increased from about 85% in 1999 to about 89% in 2007. Within services, information workers received the largest share, accounting for about 48% of total wage bill in 1999. This share rose steadily to 52.5% in 2007. The wage bill share of the products workers steadily declined, with slight fluctuations for information and noninformation workers over that period. Furthermore, the overall share of information workers in the total wage bill increased from about 54% in 1999 to 57% in 2007.

Third, the average wages were higher in the products sector. Within this sector, information workers, on average, earned about 1.8 times higher than the noninformation workers. In the services sector, information workers earned about 1.4 times higher than the noninformation workers. Overall, the average wage of information workers was one and one half times greater than that of noninformation workers. However, there are sectoral differences in the earnings of information workers. On average, they earned about 1.3 times higher in the products sector than their counterparts in the services sector. This, however, appeared to be a reflection of the fact that most information workers in the products sector were engaged in "high-end" information jobs, while a large number of information workers in the service sector were engaged in "low-end" information jobs.[1] We also found that noninformation workers generally earned more in products industries than their counterparts in services, although the difference was not large.

Another way of looking at growth of employment and wages during this period is by plotting graphs. Figure 4.2 depicts the employment growth of information and noninformation workers in the products and services sector. As we can see from the figure, employment of both types of workers in the products sector fell steadily through this period. There was a sharp decline in 2002, immediately after the recession of 2001. The services sector employment exhibited a different pattern. The

[1] By "high-end" information jobs, we refer to those jobs that require high cognitive skills and innovative ideas, such as managerial jobs, scientists, and designers; and by "low-end" information jobs, we refer to those jobs that are routine or repetitive in nature and do not require very high cognitive skills or innovative ideas, such as travel agent and customer service representative.

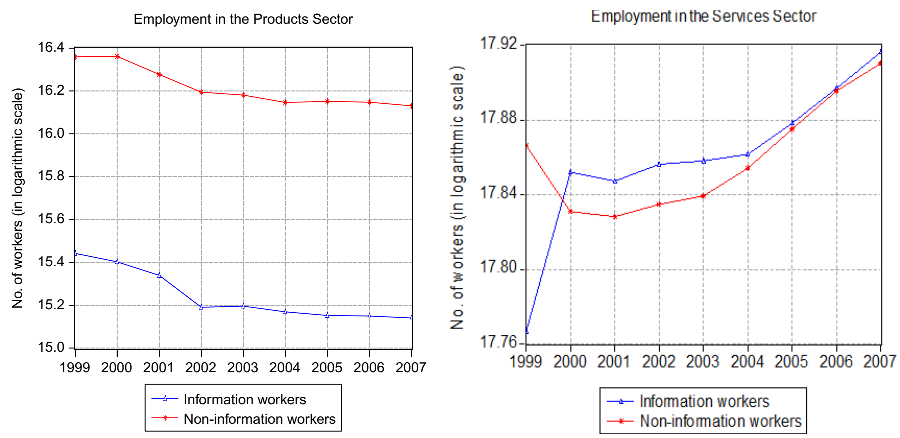


Fig. 4.2 Employment growth in the U.S.: 1999–2007.
Note: Differences in logarithmic values between successive period (×100) approximate percentage change.

employment of noninformation workers declined sharply between 1999 and 2000, while that of information workers rose significantly during the same period. Between 2000 and 2001, employment of both types of workers declined slightly, only to rise steadily thereafter. The growth of services employment accelerated after 2004.

Figure 4.3 depicts the growth of average real wages for both information and noninformation workers in the products and services sector.[2] The average real wage of information workers in the products sector rose steadily until 2002, remained almost constant until 2004, and fell for two consecutive years. Between 2006 and 2007, it grew again. The average real wage of noninformation workers, however, increased until 2002, and then steadily declined. The average real wage of information workers in the services sector rose sharply between 2001 and 2002, declined slightly until 2005, and then started rising. The average real wage of noninformation workers in services also exhibited a similar pattern of growth over this period of time.

[2] Real wage is obtained by adjusting nominal (current dollar) wage for inflation calculated from the annual U.S. city average of all urban consumer price indices (CPI) published by the BLS.

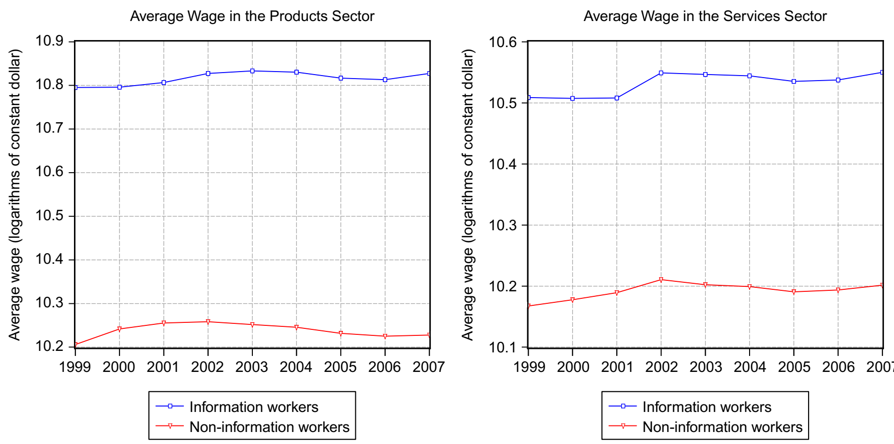


Fig. 4.3 Growth of average wages in the U.S. economy: 1999–2007.
Note: Differences in logarithmic values between successive period (×100) approximate percentage change.

4.3 Sector-wise Employment and Wage Patterns

Table 4.2 presents a list of 25 industries, ranked in descending order according to their shares in total employment between 2002 and 2007, along with their respective shares of information workers, and average annual growth rates of employment and wages. The 25 industries together accounted for about three-quarters of the total employment in the U.S. economy during the sample period. The figures that appeared in this table are annual averages over 2002–2007.[3]

As seen in column 2 of Table 4.2, for 13 of the 25 industries, information workers accounted for more than half of their employment. Column 3 indicates that 21 of these industries experienced growth in total employment. Although the employment of information workers increased for 21 industries (not necessarily the ones for which overall employment increased), it increased faster than that of noninformation

[3] The selection of the sample period 2002–2007 for the analysis at the sectoral level is dictated by two considerations. *First*, the data for 1999 through 2001 are available by SIC industry codes while, for 2002 through 2007, they are available by the new NAICS codes, which are not quite comparable at the disaggregate industry level. *Second*, the years between 2002 and 2007 represent a period of business cycle expansion between two recent recessions in the U.S.

Table 4.2. Employment share, information intensity, employment and real wage growth of 25 largest industries (in terms of their respective shares in total employment in the economy) Averages over 2002–2007.

Ranking by industry share in total employment	Industry title	Industry share in total employment	Information share in total industry employment	Annual average growth rate of employment	Average annual growth of info employment	Average annual growth of real wage	Average annual growth of information real wage
		1	2	3	4	5	6
1	Educational services	9.29	79.60	1.21	1.52	0.07	0.03
2	Federal, state, and local government (OES designation)	7.46	53.16	−1.18	−1.66	0.36	0.74
3	Food services and drinking places	6.88	6.95	2.37	−4.58	−0.81	−0.72
4	Administrative and support services	5.93	37.41	1.84	1.56	0.80	1.00
5	Professional, scientific, and technical services	5.33	77.65	2.54	2.73	0.10	−0.06
6	Hospitals	4.03	36.96	1.14	1.03	1.30	1.34
7	Ambulatory health care services	3.85	43.89	2.74	2.45	−0.47	−0.29
8	Specialty trade contractors	3.49	15.12	2.63	1.66	−1.13	−1.32
9	Merchant wholesalers, durable goods	2.30	56.67	0.90	1.00	−0.38	−0.50
10	General merchandise stores	2.23	65.83	2.52	1.82	−0.20	−0.35
11	Food and beverage stores	2.18	53.84	−0.18	0.10	−1.30	−1.63
12	Nursing and residential care facilities	2.18	29.83	1.17	0.90	0.18	0.15

(*Continued*)

Table 4.2. (*Continued*)

Ranking by industry share in total employment	Industry title	Industry share in total employment	Information share in total industry employment	Annual average growth rate of employment	Average annual growth of info employment	Average annual growth of real wage	Average annual growth of information real wage
		1	2	3	4	5	6
13	Credit intermediation and related activities	2.16	82.12	1.43	1.54	0.25	0.18
14	Insurance carriers and related activities	1.64	82.67	0.37	0.44	−0.27	−0.31
15	Social assistance	1.59	59.78	3.11	2.17	0.00	0.23
16	Merchant wholesalers, nondurable goods	1.56	53.40	0.51	0.66	−0.26	−0.29
17	Motor vehicle and parts dealers	1.46	48.62	0.31	0.15	−1.34	−1.46
18	Accommodation	1.37	24.30	0.77	1.00	0.10	−0.27
19	Transportation equipment manufacturing	1.36	26.21	−0.43	1.66	−0.68	0.21
20	Management of companies and enterprises	1.35	76.39	2.61	3.05	0.69	0.60
21	Construction of buildings	1.28	26.46	2.25	2.05	−0.54	−0.84
22	Fabricated metal product manufacturing	1.17	22.49	0.63	−0.12	−0.90	−0.88
23	Food manufacturing	1.15	18.67	−0.91	−1.75	−0.70	−0.60
24	Real estate	1.09	51.92	1.68	3.17	0.67	0.12
25	Clothing and clothing accessories stores	1.08	72.46	3.12	3.33	−1.16	−1.26

workers only for 12 industries, which mostly included those industries with relatively larger shares of information workers. Prominent among them are: "Educational Services" and "Professional, Scientific, and Technical Services." Interestingly, the employment of information workers in the government sector fell faster than that of their noninformation counterparts.

We also present the average annual growth rates of real wages for all workers and information workers between 2002 and 2007. Columns 5 and 6 indicate that real wages for all workers fell for 11 of 25 industries and real wages for information workers fell for 15 of 25 industries. For only eight industries, including governments, did real wages rise for all workers, as well as for information workers. Because both employment and wages increased for seven private sector industries, demand factors were more dominant than supply factors for the workers in those industries. These were all service industries that included "Educational Services," "Administrative and Support Services," and "Hospitals," with significant total employment shares. Of note is that, while average real wage for all workers in "Professional, Scientific, and Technical Services" increased slightly, that of information workers fell slightly.

5

International Trade in Information-Intensive Services

This section briefly discusses some of the important recent trends in international trade in the U.S.[1] In particular, as more than 80% of income and about 90% of employment are generated in services in the U.S., trade in services is of special interest. It is important to note that, although the U.S. has an overall trade deficit, it has had a surplus in services trade and, as seen below, that surplus has grown in recent years. As shown in Sections 3 and 4, because we observed a clear shift of the economy and the labor market toward information-intensive services, we will focus on information-intensive services in international trade.

5.1 Data and Definitions

The main source of data for this section was the *International Economic Accounts* of the BEA. The data are publicly available from the BEA website (http://www.bea.gov/) [27]. We primarily used annual data from between 1992 and 2009 for two reasons. First, the data with

[1] For a more detailed discussion with a special focus on the U.S. trade in information-intensive services, see Apte and Nath [9].

important details were consistently available for this period. Second, this sample period coincided with the most recent period covered in our analysis of the size and structure of the U.S. information economy.

As a note of caution, there are unresolved issues related to the concepts and definitions used in the measurement of services trade. In general, it had been recognized that "International trade and investment in services are an increasingly important part of global commerce. Advances in information and telecommunication technologies have expanded the scope of services that can be traded cross-border... trade and foreign direct investment (FDI) in services have grown faster than in goods over the past decade and a half."[2] This recognition led the World Trade Organization (WTO) to include services in the multilateral trade architecture in the form of the General Agreement on Trade in Services (GATS). Since, unlike merchandise trade, services trade needs to encompass a wide range of international transactions; the GATS takes a broad view of trade in services. Thus, the definition of trade in services that GATS uses includes four categories of transactions: cross-border trade (services supplied across borders), consumption abroad (services supplied in a country to foreigners), commercial presence (services supplied in a country by foreign business establishments), and the presence of natural persons (services supplied in a country by foreign nationals). Recently, the statistical agencies in the U.S. and other countries have tried to collect and compile data on services trade according to this definitional framework set forth by GATS.[3]

5.2 Main Observations

In Table 5.1, we present an overall account of U.S. trade in services and goods relative to GDP in 1980 and 2010. While the dollar value of merchandise trade (both exports and imports) increased about seven times from less than half a trillion USD to more than 3 trillion USD, the dollar value of services trade increased almost 10 times from barely 100 billion USD to about 1 trillion USD during this period. In 2010, services

[2] Mattoo et al. [65, p. 3]
[3] For a discussion on the efforts made by the BEA, see Koncz-Bruner and Flatness [56].

Table 5.1. U.S. Trade in Services and Goods and GDP, 1980 and 2010.

	1980		2010		Average annual growth rate (1980–2010)
	Value in billions of current USD	As a percentage of GDP	Value in billions of current USD	As a percentage of GDP	
Trade in services	**100**	**3.6%**	**965**	**6.6%**	**8.0%**
Trade in goods	474	17.0%	3,227	22.0%	7.0%
GDP	2,788	100.0%	14,660	100.0%	5.7%

Note: Services include both private and government services. Growth rates represent growth in nominal value.
Source: Based on data from Table 1.1.5 of BEA's National Economic Accounts.

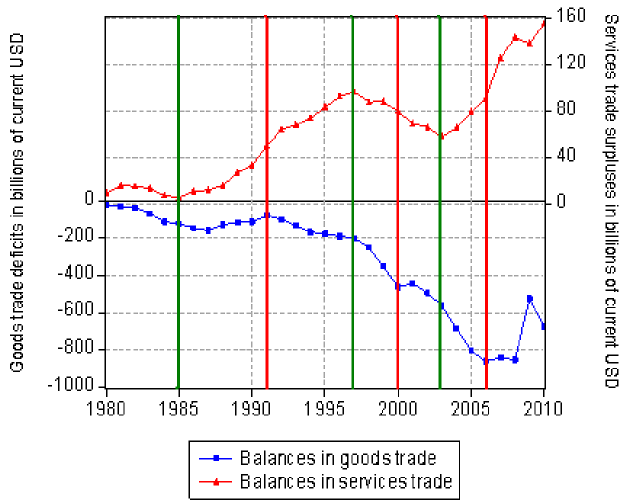


Fig. 5.1 U.S. trade balances (exports–imports) in goods and services: 1980–2010.
Note: Trade balances for goods and services are calculated using data from Table 1.1.5 of BEA's National Economic Accounts. Services include both private and government services.

trade accounted for about 7% of U.S. GDP, while merchandise trade accounted for about 22%. Thus, U.S. goods trade was more than three times larger than services trade in 2010. The last column of Table 5.1 indicates that the value of both goods and services trade has been growing faster than nominal GDP. Further, services trade has been growing faster than merchandise trade.

Figure 5.1 plots the annual dollar value of trade balances (exports *minus* imports) for both goods and services in the U.S. between 1980 and 2010. The following observations were made. First, while the U.S. has been a net importer of goods, it had been a net exporter of services throughout the sample period. In 2010, the U.S. ran a deficit of about USD 700 billion in merchandise trade. In contrast, it had a surplus of more than USD 150 billion in services trade. Second, as merchandise trade deficit grew significantly over the years, so did services trade surplus. There was a steady rapid increase in services trade surplus between 1985 and 1997 and then a steady decline between 1997 and 2003 before the surplus started rapidly rising again. In contrast, deficit in merchandise trade steadily increased between 1991 and 2006, except for a slight decline between 2000 and 2001. By 2005, merchandise trade deficit surpassed USD 800 billion and stayed there for the next 3 years before it fell drastically to about USD 500 billion in 2009. Although the deficit in goods trade increased in 2010, it did not reach the 2005–2008 level. Third, while merchandise trade balance seemed to have been sensitive to business cycle fluctuations, balance in services trade did not seem to have been sensitive to such fluctuations. For example, the steady increase in services trade surplus between 1985 and 1997 was not affected by the recession of the early 1990s. Similarly, the decline in services trade surplus during the 2001 recessionary cycle seemed to be more of a part of the downward trend between 1997 and 2003, rather than an effect of the economic slowdown of 2001. Furthermore, the drop in 2009 was moderate.

We further examine the patterns in services trade by looking at its share in total trade. Figure 5.2 presents the share of services in total trade and also the export and import shares of services separately. Trade in services accounted for about 17% of all trade in 1980. This share increased to about 24% in 1992 and then steadily decreased to about 20% in 2000, after which it increased slightly during 2000–2008, and significantly to about 25% in 2009. In 2010, trade share of services dropped to about 23%. The export and import shares of services followed similar patterns, although export shares had been much larger than import shares. The export share of services fluctuated between a minimum of 19.6% (in 1980) and a maximum of 32.7% (in 2009), while the import share fluctuated between 15.4% (in 1980) and 19.7% (in 1991).

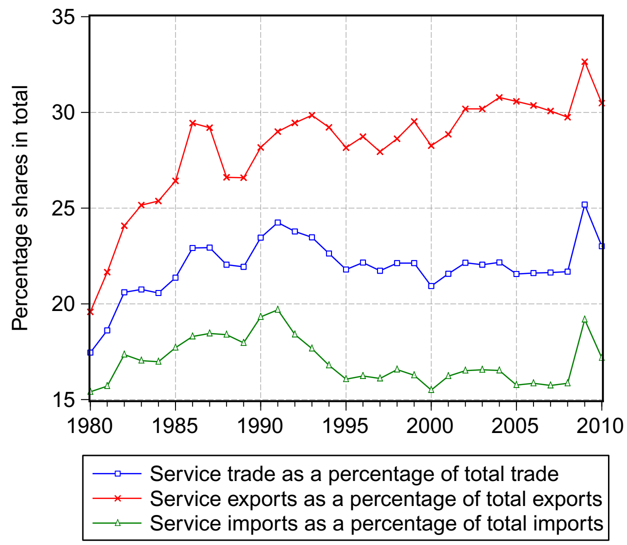


Fig. 5.2 Trade shares of services trade, services exports, and services imports: 1980–2010. *Note*: Shares of services trade, exports, and imports are calculated using data from Table 1.1.5 of BEA's National Economic Accounts. Services include both private and government services.

Further, it is interesting to observe that the role of multinational companies (MNCs) in services trade has become increasingly important. For example, the intra-industry or affiliated trade between MNCs and their affiliates accounted for 17% of total services trade in 1992, and this contribution rose to more than 27% in 2009. Figure 5.3 presents the share of affiliated trade in total services trade, and in services exports and imports separately. Exports of services by the U.S. MNCs to their foreign affiliates and by the affiliates of foreign MNCs located in the U.S. to their parent companies in other countries increased from about 20% in 1992 to more than 28% in 2009. Similarly, imports from foreign MNCs or affiliates of U.S. MNCs located outside the U.S. increased from about 13% to about 26% during the same period. The increase in affiliated services trade also indicated an increase in foreign direct investment (FDI) in services by the U.S. MNCs abroad as well as by foreign MNCs in the U.S.

We present the export and import shares of five major categories of private services during 1992–2009 in Figure 5.4(a) and (b),

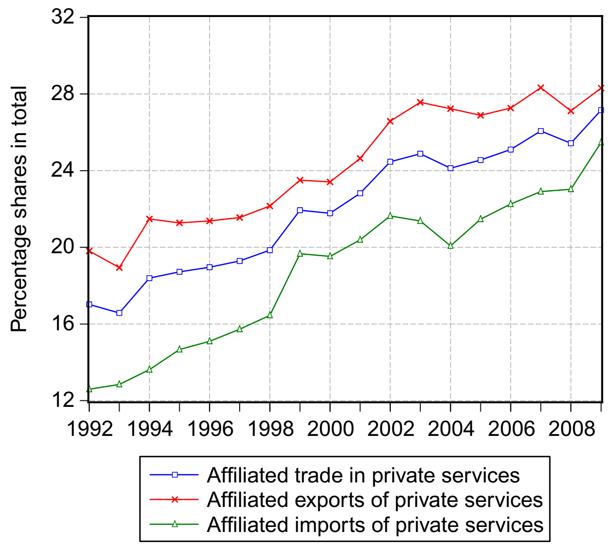
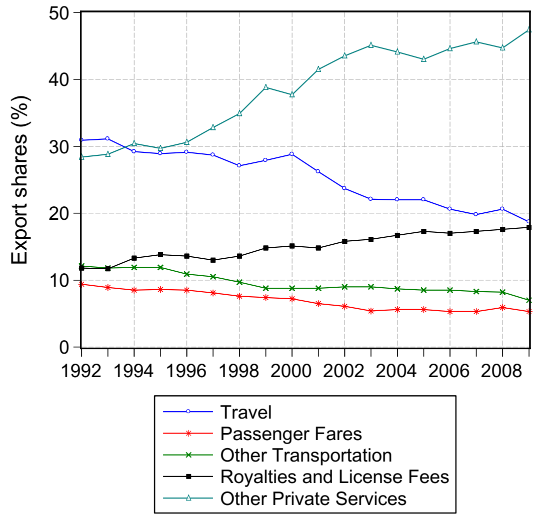


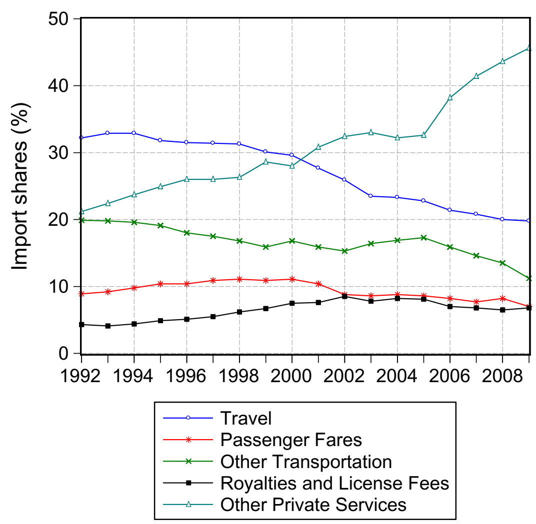
Fig. 5.3 Affiliated trade shares in total trade, exports, and imports of private services in the U.S.
Note: Shares of affiliated trade, exports, and imports are calculated using data from Table 1 (Trade in Services), Detailed Statistics for Cross-Border Trade under U.S. International Services, BEA.

respectively.[4] These categories include travel, passenger fares, other transportation, royalties and license fees, and other private services. Note that the BEA provides services trade data by seven major categories that include, in addition to the five categories above, transfer under U.S. military sales contracts and U.S. government miscellaneous services. These figures clearly indicate that "other private services" experienced the highest growth in both export share and import share. The export share of "other private services" (in total exports of private services) increased from about 31% in 1992 to about 49% in 2009, while the import share increased from about 25% to about 50% during the same time period. In contrast, travel services, which used to be the largest category with more than 30% of both exports and imports of services in 1992, declined in terms of its shares and accounted for only

[4] The data on services trade have been highly aggregated. Disaggregated data by detailed categories of services are available only for recent years.



(a)



(b)

Fig. 5.4 (a) Shares of five major categories of services in total services exports from the U.S. (b) Shares of five major categories of services in total services imports into the U.S. *Note*: Export and import shares of major categories of services are calculated using data from Table 1 (Trade in Services), Detailed Statistics for Cross-Border Trade under U.S. International Services, BEA.

about 20% in 2009. Note that "passenger fares" and "other transportation" are two subcategories within travel services, and both declined in their shares in total exports and imports of private services. A decline in the cost of travel may partially explain the decrease in these shares. The remaining major category of private services, namely "royalties and license fees," experienced growth during this period. For example, its export share increased from about 13% in 1992 to about 19% in 2009. The import share also increased from about 5% to about 8% during this period.

This discussion clearly shows that trade in two major categories of services, "other private services" and "royalties and license fees," is the largest and fastest growing segment of services trade in the U.S. As we will see in the next subsection, the services included within these two broad categories were primarily information-intensive services.

5.2.1 Trade in Information-Intensive Services

We will now focus entirely on the analysis of the U.S. trade in information-intensive services. We may categorize "royalties and license fees" as an information-intensive service.[5] This service category includes the following detailed subcategories: industrial processes; books, records, and tapes; broadcasts and recordings of live events; franchise fees; trademarks; general-use computer software; and other intangibles. Thus, exports of "royalties and license fees" are essentially the royalties and license fees received by the U.S. for the use of the intangible items listed above in foreign countries. Similarly, imports are such payments by the U.S. for the use of these intangible items developed and produced in foreign countries.

Furthermore, the services included in the category "other private services" are primarily information-intensive services.[6] This category is broadly divided into education; financial services; insurance; telecommunications; business, professional, and technical services; and

[5] Co [35] refers to this category as knowledge-intensive services.
[6] Markusen [63] modeled this category as a capital-intensive service.

a residual category called "others." The category "business, professional, and technical services" is further subdivided into advertising; computer and data processing; database and other information services; research, development, and testing services; management, consulting, and public relations services; legal services; construction, engineering, architectural, and mining services; industrial engineering; installation, maintenance, and repair of equipment; and other business, professional, and technical services. Except for "construction, engineering, architectural, and mining services" and "installation, maintenance, and repair of equipment," other categories are highly information intensive. These two categories do not entirely involve creating, processing, and communicating information and require some physical activity.

As discussed above, the export and import shares of these two major categories of information-intensive services: "royalties and license fees" and "other private services," increased significantly between 1992 and 2009. Together they accounted for about 68% of total private services exports from the U.S. in 2009. Similarly, the combined import share of "royalties and license fees" and "other private services" was about 58% of total imports of private services in 2009.

We now discuss how trade in these two categories of information-intensive services has changed by types of trade. Table 5.2 presents a decomposition of trade by two types: affiliated (intra-industry) and unaffiliated for these two broad categories in 1992 and 2009. In general, we made the following observations. First, intra-industry trade accounted for about two-thirds of exports as well as imports of "royalties and license fees," but only one-third of exports and about two-fifths of imports of "other private services." Second, within affiliated trade, the exports from the U.S. parent companies to their foreign affiliates were the largest component of intra-industry exports for both categories of services. In case of intra-industry imports, while the imports by the U.S. affiliates from their foreign parent companies were the largest component for "royalties and license fees," it was the imports by U.S. parent companies from their foreign affiliates that were the largest for "other private services."

We now examine more disaggregated data; however, total trade data for the detailed subcategories under "royalties and license fees"

Table 5.2. Affiliated and unaffiliated trade in royalties and license fees and other private services, 1992 and 2009 (values in millions of current USD).

	Royalties and license fees		Other private services	
Description	1992	2009	1992	2009
Panel A: Exports				
Total	20,841	89,791	52,854	238,332
	(100%)	(100%)	(100%)	(100%)
Affiliated	15,658	58,817	17,461	78,172
	(75.1%)	(65.5%)	(33.0%)	(32.8%)
By U.S. parent companies to their foreign affiliates	14,925	55,430	11,117	53,636
	(71.6%)	(61.7%)	(21.0%)	(22.5%)
By U.S. affiliates to their foreign parent companies	733	3,387	6,347	24,536
	(3.5%)	(3.8%)	(12.0%)	(10.3%)
Unaffiliated	5,183	30,974	35,388	160,159
	(24.9%)	(34.5%)	(67%)	(67.2%)
Panel B: Imports				
Total	5,161	25,230	25,462	168,892
	(100%)	(100%)	(100%)	(100%)
Affiliated	3,396	18,350	9,640	66,978
	(65.8%)	(72.7%)	(37.9%)	(39.7%)
By U.S. parent companies from their foreign affiliates	189	4,508	5,355	46,687
	(3.7%)	(17.9%)	(21.0%)	(27.6%)
By U.S. affiliates from their foreign parent companies	3,207	13,843	4,285	20,291
	(62.1%)	(54.9%)	(16.8%)	(12.0%)
Unaffiliated	1,766	6,880	15,816	101,913
	(34.2%)	(27.3%)	(62.1%)	(60.3%)

Note: Percentage shares in total export and import values for the respective categories are in bracket.
Source: Calculations based on data from Table 4 (Royalties and License Fees) and Table 5 (Other Private Services), Detailed Statistics for Cross-Border Trade under U.S. International Services, BEA.

are available only from 2006. Table 5.3 presents the percentage shares of seven different subcategories in total export and import values of "royalties and license fees" for 4 years between 2006 and 2009. Note that data are available only for unaffiliated trade before 2006 and, therefore, they are not comparable with the figures since 2006. This table shows that two major items, industrial processes and general-use computer software, together accounted for about 80% of total exports of "royalties and license fees" and more than 80% of total imports into the U.S. While the share of "industrial processes" declined, that of "general-use computer software" increased during this 4-year period.

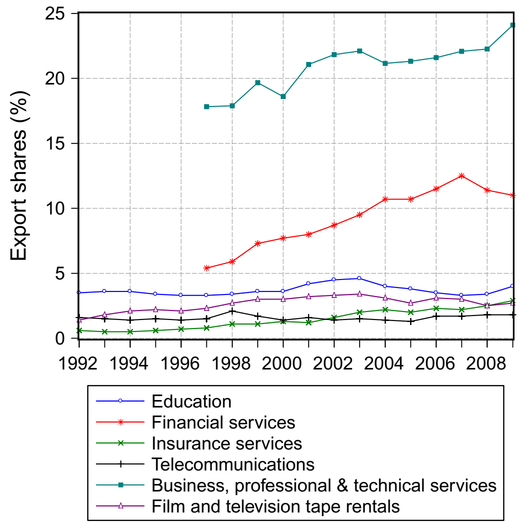
Table 5.3. Shares of various sub-categories in total exports and imports of royalties and license fees, 2006–2009 (In percentages, unless and otherwise stated).

	Exports				Imports			
	2006	2007	2008	2009	2006	2007	2008	2009
Industrial processes	45.8	43.0	42.5	39.7	70.3	66.8	63.0	65.3
Books, records, and tapes	2.1	1.8	1.6	1.6	3.2	3.0	3.1	3.2
Broadcasting and recording of live events	0.6	0.7	0.6	0.7	4.3	0.8	3.9	0.9
Franchise fees	4.6	4.7	4.8	4.8	0.8	0.7	0.9	0.8
Trademarks	14.7	13.7	13.2	13.0	8.2	9.0	9.4	9.5
General-use computer software	32.0	36.0	37.2	40.1	12.6	19.2	19.2	19.8
Other intangibles	0.1	0.1	0.1	0.1	0.5	0.4	0.7	0.5
Total value of trade in royalties and license fees (millions of current USD)	70,727	84,580	93,920	89,791	23,518	24,931	25,781	25,230

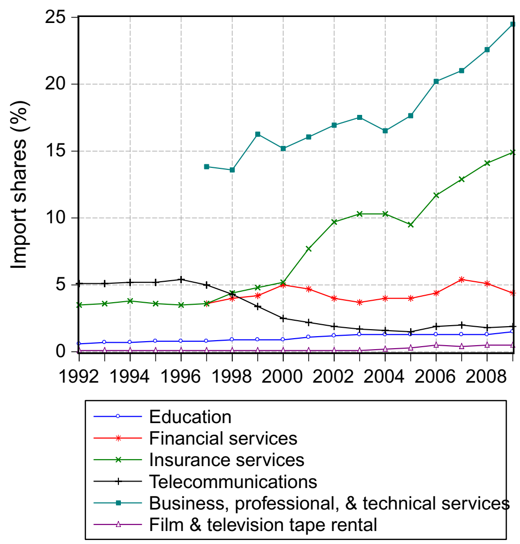
Source: Calculations based on data from Table 4 (Royalties and License Fees), Detailed Statistics for Cross-Border Trade under U.S. International Services, BEA.

Overall, the total export value of this broad category was more than three times higher than its import value.

In Figure 5.5(a) and (b), we present the shares of major subcategories of services under "other private services" in total services exports and imports, respectively. Note that for "financial services" and "business, professional, and technical services," data were available only since 1997. Among the export categories, "business, professional, and technical services" and "financial services" were the two largest subcategories with about 24% and 12% of total private services exports from the U.S., and their share rose from about 18% and 5%, respectively, in 1997. While, during the recent financial crisis, the share of "financial services" dropped since its peak in 2007, the exports of "business, professional, and technical services" continued to grow. Among the services imports, the share of "business, professional, and technical services" grew from less than 15% in 1997 to about 25%. The other service that experienced significant growth in its share, particularly since 2000, was insurance. In 2000, imports of insurance accounted for about 5% of total private services imports into the U.S. It grew to about 15% in 2009. Bermuda was the largest exporter of insurance to the U.S.



(a)



(b)

Fig. 5.5 (a) Shares of six subcategories of other private services in total exports of private services from the U.S. (b) Shares of six subcategories of other private services in total imports of private services into the U.S.

Note: Export and import shares of major categories of services are calculated using data from Table 5 (Other Private Services), Detailed Statistics for Cross-Border Trade under U.S. International Services, BEA.

Table 5.4. Shares of various sub-categories in total exports and imports of business, professional, technical services, 2006–2009 (in percentages, unless and otherwise stated).

	Exports				Imports			
	2006	2007	2008	2009	2006	2007	2008	2009
Advertising	4.37	3.94	3.57	3.40	3.07	3.07	2.67	2.85
Computer and data processing services	6.64	6.94	7.34	7.35	20.82	20.34	19.11	19.83
Database and other information services	5.03	4.58	4.25	4.12	0.95	1.12	1.24	1.12
Research and development	14.83	15.06	15.12	15.63	15.03	18.51	19.72	19.21
Management consulting and public relations services	24.80	26.18	25.25	24.17	30.09	27.65	27.08	27.14
Legal services	6.08	6.17	6.36	6.22	1.98	2.18	2.41	2.07
Construction engineering, architectural, and mining	6.30	5.78	6.17	5.82	2.26	2.15	2.30	2.19
Industrial engineering services	4.52	3.67	3.28	4.27	2.18	3.89	4.40	4.49
Installation, maintenance, and repairing services	8.88	8.44	8.24	9.59	7.43	7.40	7.15	7.52
Other business, professional, and technical services	11.40	12.39	13.70	12.80	14.53	12.37	12.80	12.26
Total value of trade in business, professional, and technical services (millions of current USD)	86,390	103,765	115,229	116,629	61,698	70,413	82,537	81,995

Source: Calculations based on data from Table 7 (Business, Professional, and Technical Services), Detailed Statistics for Cross-Border Trade under U.S. International Services, BEA.

To shed further light on this topic, we will now examine a few detailed subcategories within "business, professional, and technical services." Table 5.4 presents the percentage shares of 10 different subcategories in total export and import values of "business, professional, and technical services" for 4 years between 2006 and 2009. "Management consulting and public relations services" was the largest subcategory, accounting for about one-quarter of total exports and more than one-quarter of total imports under the broad category. This was followed by "research, development, and testing services," with about 15% of exports and more than 15% of imports. The import share has also increased over time.

Overall, dramatic increases in export and import shares of financial services and insurance seem to reflect greater global financial integration through the use of ICT. Further, the more than doubling of the import share of "computer and information services" may be a reflection of offshore outsourcing of these services. Further, a significant decline in the import share of telecommunications may be an indication of a substantial cost reduction in providing these services due to technological advances.

5.2.2 Rise of Trade in Information-Intensive Services: Potential Explanations

In this subsection, we informally discuss some of the likely and intuitively plausible explanations for the growth of cross-border trade in information-intensive services in the U.S. and globally.

First and foremost, the unprecedented advances in ICT have played (and will continue to play) a pivotal role in the expansion of trade in information-intensive services. In fact, according to some studies, ICT advances contributed positively to the growth of trade in goods as well as in services.[7] There are direct and indirect channels through which ICT advances can stimulate trade in information-intensive services. The most direct way is by lowering the cost of communicating information or transferring data. The low cost not only helps with the actual delivery of the service but also with entry into the market in another country. Further, there are indirect channels through which ICT contributes to the growth of trade in information-intensive services. For example, ICT-enabled service innovations such as geographically dispersed production

[7] Using bilateral trade data between the U.S. and 31 other countries, Freund and Weinhold [39] show that the Internet penetration in foreign countries has had a positive impact on services trade. Freund and Weinhold [40] further show that use of the Internet also contributes positively to the growth of merchandise trade. They argue that the Internet stimulates exports by lowering the costs of entering the market. However, using data for a sample of 98 countries that includes both developed and developing countries, Clarke and Wallsten [34] find that Internet penetration has a significant positive effect only on exports from developing to developed countries and not on exports to developing or from developed to other developed and developing countries.

of service components (of which service outsourcing is an example) and assembly have tremendous implications for services trade.[8] As Apte and Mason [6] argued, the information-intensive services were most susceptible to such service disaggregation and international trade.[9] They proposed a four-way classification of activities within a service process: informational actions, customer contact actions, material manipulation actions, and other indirect actions. Analyzing various services based on relative time allocated to these four actions, they hypothesized that services in which most time is spent on informational actions (called information-intensive services) with low need for physical presence and customer contact and with separable symbolic manipulation were most susceptible to globalization and, therefore, to international trade.

Second, the fact that there had been an important structural shift toward information services in the U.S. economy was also responsible for the increase in information-intensive services trade. Thus, the U.S. is not only the largest producer of information services but also the largest consumer of information services. Further, as living standards in other countries improve, demand for services, in general, and information services, in particular, in those countries increase. That also increases demand for tradable services produced in the U.S. Some studies (for example, [35, 55]) present evidence to show that standard of living, measured by per capita income, in the trading partner countries has significant positive effect on the flow of trade in information-intensive services.

Third, the economic size and growth of the trading partners also matter for trade in services, in general, and information-intensive services, in particular [35, 39, 55].[10] The range and complexity of economic activities in those economies potentially create vast demand for a number of information-intensive services. To understand this potential for demand creation, we use the illustration from Quinn [74], which shows how the size and growth of manufacturing can create demand for a

[8] These innovations are a major part of the fundamental changes in services, collectively known as service industrialization. For a discussion, see Karmarkar [49].

[9] Mithas and Whitaker [67] empirically show that information-intensive services have in fact been disaggregated globally.

[10] Freund and Weinhold [39] also find evidence of a positive impact of growth on services trade.

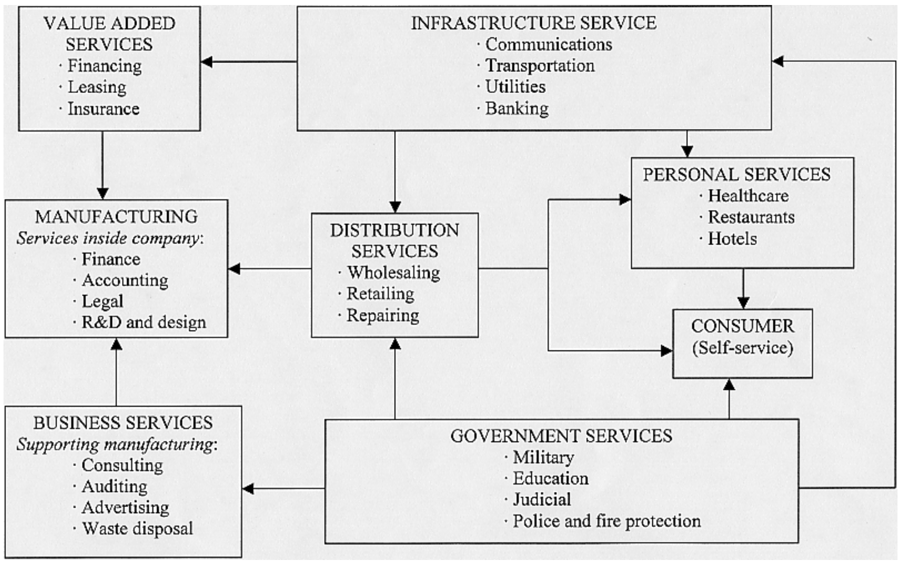


Fig. 5.6 Interactive roles of services [74].

host of services.[11] For example, as shown in Figure 5.6, manufacturing is directly supported by value-added services such as financing, leasing, and insurance; business services such as consulting, auditing, and advertising; and distribution services such as wholesaling, retailing, and repairing. These support services are further backed by infrastructure services, government services, and personal services. Many of these support services, particularly the information-intensive services, can be traded across borders.

Fourth, the deregulation of service industries at home and abroad and liberalization of foreign trade and investment regimes in many countries around the world also provide the impetus for growth in services trade. Service industries are heavily regulated and, therefore, it is often very difficult to attract foreign investment and trade. Recognizing the enhanced tradability of services due to technology, many governments around the world (including governments in many

[11] We recognize that manufacturing is not the source of demand for most services. In fact, it is quite possible to have an economy with very little manufacturing and mostly services.

emerging market economies) have deregulated a number of information-intensive services primarily to increase competition and gain efficiency. Being in the forefront of technological advances, the U.S., in fact, has already reaped the benefits by investing and trading in services with those countries. Foreign Direct Investment (FDI) also helps increase trade in services primarily through affiliated trade.[12]

Finally, unlike in merchandise trade, language and culture are very important in services trade. As Apte and Karmarkar [2] argued, for consumer services that are information intensive, the topography of the world trade and outsourcing will be strongly colored by language, culture, and colonial history. In fact, the defining feature of this topography is language and not mountains and oceans, and the language barrier may well be the hardest thing to cross. Figure 5.7 presents the

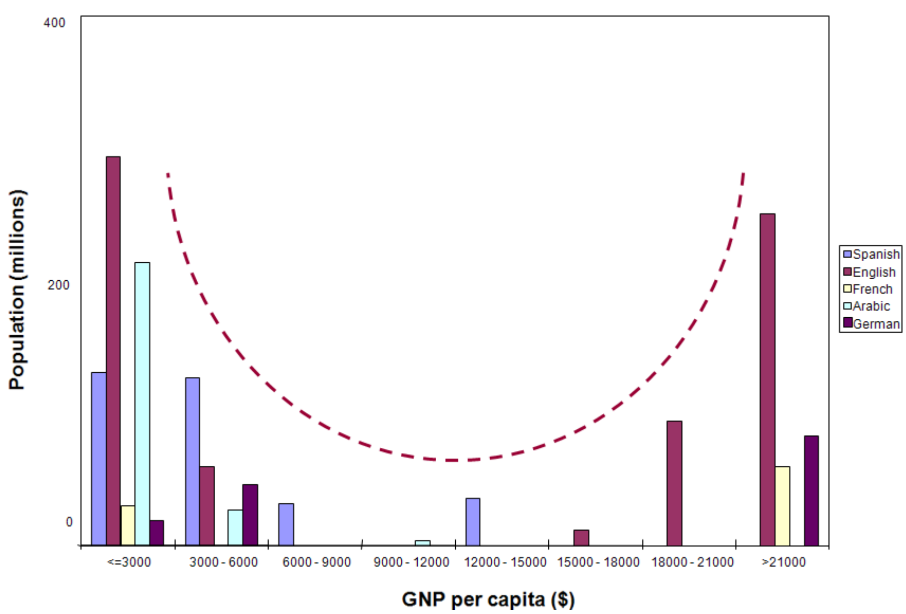


Fig. 5.7 Distribution of different language speaking population by income (Modified from Ref. [2]). Estimates of populations competent in selected languages, in categories of GNP per capita.

[12] Mann and Civril [62] provide evidence in support of this.

distribution of world population for five major languages into different income ranges, measured by GNP per capita. It shows that the world English market for services is unique in its size, geographic distribution, and, most importantly, in potential for trade. It is also one of the most open markets. Spanish shares some of these features, but the distribution being less extreme offers less opportunity for those in poorer countries. For other major language groups concentrated in one or a few countries, the potential for outsourcing and international trade would be rather limited. This might well prove to be a boon for those engaged in services in those countries, since they will not be subject to the intense competition seen due to outsourcing and off-shoring in the English-speaking and perhaps the Spanish-speaking world.

6

Drivers of Economic Evolution and Sector Growth

6.1 Productivity

Productivity in the U.S. economy has increased for decades in manufacturing, and is now showing increases in many services as well [24, 46]. It is well understood that productivity growth creates a higher standard of living in an economy (e.g., [17]). Higher productivity allows for higher levels of output for the same level of resource consumption, and results in lower prices and higher consumption levels on average. In addition, differential productivity growth rates are also a major reason for changes in economic structure and sector sizes as well as for the distribution of jobs and wages.

Productivity is itself a consequence of many decisions made in the private and public sectors. We identify technology-driven "industrialization" as a useful way of describing many of those underlying changes. We will discuss this and other issues in subsequent sections.

Productivity growth differentials have long been identified as the reason for the relative decline of manufacturing and the growth of services. Baumol [17] showed how higher productivity in manufacturing and correspondingly lower productivity growth in services would lead to an increase in the costs of services, calling the phenomenon the "cost disease." The same model showed that the manufacturing sector would decline relative to services.

However, there are certain limitations to this model in terms of the assumptions made. For example, the levels of demand for products and services are assumed to stay in a fixed ratio. As a result, the model does not seem to explain the earlier growth in manufacturing as occurred during the Industrial Revolution, which would intuitively seem to correlate with increasing productivity.

A more general model [53] resolved this question. In this model, an economy consisted of heterogenous individuals (or entities) who both consumed and produced. Given prices set by a Walrasian "auctioneer," so as to clear the market, they made independent choices on what to produce and then allocated the resulting income to consumption. As might have been expected, individuals chose to produce the goods or services at which they were relatively most productive, in terms of production quantities adjusted by the prices received. Thus, the model endogenously determined employment choices, production quantities, prices, sector sizes, and wealth distribution.

The model showed that higher productivity growth in one sector resulted in larger quantities being produced and lower prices. However, the sector did not always decline in size in favor of the other (lower productivity sector), as in Baumol's model. If the market for the sector's output was at an early stage, then increased productivity caused relative growth in the sector. If, on the other hand, the market was mature and demand was satiated, then higher productivity caused a relative decline in sector size. In other words, the relative consequences of productivity growth depended on the level of demand satiation and demand elasticity.

Since the 1970s, we have seen growth for the services sector relative to manufacturing for the U.S. economy. This growth in the service sector as a whole has been attributed to low growth in service productivity. At the same time, we are seeing information-intensive services growing relative to physical services. This could again be due to higher productivity growth in information-intensive services, but now coupled with the appearance of new and emerging services for which demand is growing (i.e., elasticity). Productivity effects are one credible explanation for both the relative growth of services against manufacturing, and then within the service sector, for the growth of information-intensive services relative to material or physical services.

The same productivity growth and demand satiation mechanisms explain employment shifts. High productivity without market growth (mature satiating markets) drives employment into other sectors. However, productivity growth in emerging and growing markets can show employment gains in those sectors.

6.2 Industrialization

Productivity increases themselves are an aggregate result of many factors. It is reasonable to think of these collectively as industrialization. By industrialization, we mean changes in the underlying processes of production driven by the appearance and implementation of new technologies.[1] In the small, this refers to changes in the way tasks and processes are carried out in a firm. In the large, there can be substantial changes in the way sectors and industries are organized.

In the manufacturing sector, industrialization was driven by a set of complementary factors:

- The application of new sources of power such as water, steam, and electricity,
- The mechanization and automation of processes to leverage human ability,
- Improved precision and reliability in process operations,
- Reliable sources of inputs and materials of uniform quality,
- Increases in the efficiency of transportation and logistics using rail, roads, and shipping,
- A process of standardization starting with products, going to processes, and leading to mass production, and
- Precision of specification and measurement to support standardization.

The outcomes of industrialization included increases in productivity, mass cost-effective production, improved product quality, mass

[1] Some of the material in this section is drawn from Karmarkar [49].

markets, increased consumer welfare and wealth, and a growing "industrial" sector due to market growth.

All the driving factors for industrialization in manufacturing have now appeared in information production processes as well. Clearly there have been vast increases in basic processing capability. Correspondingly, the ability to automate and leverage human capabilities in data and information processing has increased. The increases in transportation efficiency for information that started with the radio, television, and telephone have evolved to modern data communications systems that integrate seamlessly with processing and storage resources, allowing for end-to-end integration of information chains.

The standardization process for information products and services can be thought of in stylized form as:

- Standardization of information representation in symbolic form,
- Standardization of processes of production (e.g., printing), storage (books), and processing (calculators, cash registers, and computers),
- Standardization of processing and processes at the machine level (punched cards, programmable machines, and software), and
- Standardization of products and services (books and newspapers, packaged software including operating systems, data bases and applications, websites, and server-based applications).

The standardization of information products has happened rather quickly, but standardization of services is still evolving. We are now seemingly in the middle of a new wave of standardization and productivity increases with service-oriented architectures (SOAs), syndication, mash-ups, and web (cloud) services.

6.3 Technology and Process Change

Industrialization could well be thought of in large part as the creation and application of new technologies. A basic impact of new technologies is simply increased processing power. Moore's law (actually stated in terms of the density of elements on silicon chips) projected that computer processing capability would double every 18 months, and this rate has held for over five decades. Similar improvements have applied to the transportation and storage of information.

Another aspect of technology is the management of technology development and implementation from scientific discoveries to invention, product development, and commercialization. This could be thought of as the "push" aspect of technological development and of industrialization. The impact of new technologies on service industrialization can be examined in terms of three ongoing processes:

(1) The application of new technologies to improve performance in existing processes. An example is the invention of digital cameras and their use in image capture. Another is the development of software that leverages human effort (word processing) or substitutes for it (online services).
(2) The creation of infrastructure and systems that improves existing processes or enables new ways of executing certain processes. An example would be the development of telecommunications and its application to business transactions.
(3) The reconstruction of information and service chains, enabled or even forced due to the use of new technologies.

The decisions and actions underlying these processes occur in the firms that develop, commercialize, and sell new technologies in the form of new products and processes, as well as in the firms that use these new technologies to create new businesses, ranging from infrastructure (telecommunications networks) to business services (hosting and email) to technology products and services (hardware, software, and IT services).

6.4 Design and Innovation

The designs of new services and innovations in existing services have the potential for increasing the value delivered to customers. Of course, design and innovation are highly correlated with new technological developments, but not necessarily so. For example, operational changes such as improved queue management may not involve new technology, or even any cost increase.

The result of improved service value in a sector is to cause a reallocation of consumption toward the sector and a growth in that sector. But again, once the design of the product of service stabilizes (e.g., with the emergence of a dominant design concept), this effect can become muted; or with sufficient improvement in value, demand could become satiated. This effect is likely to be most visible in new and emerging products and services.

6.5 Logistics and Distributed Production

The development of low-cost logistics allows the location of production and maintenance activities to low-cost locations and outside sources. This may or may not cause a productivity increase. In fact, it can entail productivity decreases in the fundamental sense. However, the reduced costs result in lowered price to customers, potential growth in market share for individual firms, and growth for the entire sector.

Outsourcing of processes to third party providers often results in a cost reduction for firms as well as productivity increases for the sector as a whole. Typically, an outsourcing process-providing company will have higher productivity than the buyers. Suppose a firm operates two processes, and that the productivities of these parts are previously p_1 and p_2, so that the productivity of the overall process is $p = p_1 \bullet p_2$. Now suppose that the firm outsources one process and retains the other. After outsourcing, p_1 can be expected to increase so that the overall productivity of the overall process also increases; this happens for all the firms using the outsourced supplier. Of course, the effect of such productivity gains may be either toward growth or decline of the sector, as discussed earlier.

However, as the geographical distribution of operations crosses national boundaries (off-shoring), there can be substantial reductions in sector size. Efficient information logistics provision at a global level has enabled the movement of information-intensive service processes to almost anywhere in the world. Various sources [4, 6] have suggested that the impact of off-shoring on employment in the U.S. could affect anywhere from 4% to 10% of service jobs in some way. However, it is difficult to disentangle the many causes of job losses, including factors such as automation, process reengineering, and (on-shore) outsourcing.

6.6 Demographics

The impact of demographics on economic evolution and structure is complex with multiple aspects that we cannot fully explore here. At a basic level, growth in population, absent constraints to growth, means a bigger economy. Larger economies, with larger populations, also have the potential for more complex industrial structures. For example, there can be a much higher level of specialization, and much more variety of products and services in the market. In other words, small populations cannot be "broad spectrum" economies. One reason for this is that economies of scale are not present. For example, small economies do not have large automotive or aerospace sectors. At a more detailed level, high production volumes also allow for specialized methods of mass production, and job specialization within processes. Productivity can be much higher for such processes. In addition, there may not be room in small economies to support a large variety of products, except perhaps in one or two specialized sectors (e.g., Belgium and beer). Higher product and service variety also means higher value to customers. This would generally mean an increase in the size of such a sector.

On the other hand, large economies, especially when they are diverse in terms of languages, cultures, and religions, may not be managed as well internally and may expend a lot of energy in resolving internal problems. Smaller economies, especially those that are more homogenous linguistically and culturally, have the potential for highly directed and strategic action. It is likely not accidental that the smaller, more homogenous economies in Asia (Taiwan, South Korea) made faster and earlier economic strides relative to some larger economies (India, Indonesia).

The age distribution in the population has obvious impacts on sector sizes and economic structure. An aging population means higher demands for health care and financial services. Declining numbers of children and young adults mean lower demand for educational services, a major source of jobs and employment. Specific features of the age distribution such as the baby boom in the U.S., or the one-child policy in China, can have large effects. In the case of the U.S., as baby boomers retire, there will be a loss of experienced workers and managers from the working population, and the relative proportion of experienced workers will drop. A similar pattern is visible in most developed economies.

Historically, younger Americans have always been more educated than older generations. However, that pattern is not holding[2] in recent years. For example, in 2003, the 25–29-year age group had a lower level of educational attainment, in terms of high school graduation or college graduation, than age groups up to age 50. The proportion in the 25–29-year age group with a college degree has remained flat at a level around 30% since the mid-1970s. There are complex effects related to aging and education that are not easy to unravel. On the one hand, jobs will become available as baby boomers retire. But it may not be easy to find individuals with the level of education and training that is needed to fill the open jobs. In other words, there may be a matching problem in labor markets that could become visible over the next decade. This issue could be particularly important as the job mix in the economy moves toward information-intensive and knowledge-intensive jobs.

[2] See Stoops [79].

7

The Consequences of Economic Evolution

7.1 Competition

The transition to an information-intensive economy is accompanied by changes in market mechanisms and production processes in the small and in the large. These have effects on the competitive landscape and on the structure of the global-, regional-, and industry-sector levels of the economy. The changes in the nature of competition are driven by multiple factors operating on the buy side and the sell side as well as on market mechanisms and market structures. Many of these changes are most striking in terms of services, where technology-driven industrialization is most prevalent, with the largest current and future impact.

7.1.1 Standardization and Commoditization

The automation of service processes including both backroom and front offices has contributed to the standardization of services. Backroom processes are increasingly similar for several reasons. The use of third-party suppliers for software packages and systems integration leads to similar or even identical processes. Even when customized or built in house, functions tend to be carried out in the same way, even if the lines of code are different, simply because of similar professional training, similar languages, the same databases, and the same components and libraries. With front office and customer-facing systems that are increasingly online and web enabled, there is much more rapid diffusion of design and functionality. Software is easy to reverse-engineer in terms of replicating functionality, look, and feel.

The early result is higher levels of standardization, which can help in terms of creating mass markets and reduced cost of design, construction, sales, and delivery. However, there is also the threat of design convergence becoming a slide to commoditization with a lack of differentiation. This is quite visible in websites of all stripes, in every sector from financial services to retail. Standardization and the difficulty in differentiation lead to competition being more cost driven and therefore intense.

7.1.2 Loss of Localization

Low-cost logistics and the creation of online customer interfaces accessible from anywhere are leading to a reduction of local and regional differentiation — the so-called "death of distance" (e.g., [30]). The arena of competition for services that are accessible online can expand to almost any geography. There may remain some degree of localization based on language and culture [2, 47], since the topography of information-intensive sectors is aligned to those rather than physical geography. There also may be other localizing factors such as trust, brand, relationships, and familiarity. These operate more at the customer interface than in business-to-business transactions, although they are not absent there either. In the most basic backroom or transaction-oriented processes, physical location may play no role and may in fact be unknown to the customer. With the advances in SOA methods and the increasing appearance of software-as-a-service (SaaS), application service providers (ASPs), third-party web services, and so-called cloud computing, location becomes truly irrelevant.

The distribution of service processes, as with supply chains for goods, results in lower and similar production costs for all suppliers, and also contributes to the standardization of processes addressed earlier.

The intensity of competition is increased due to a larger arena as well as cost reduction and leveling. Competition may be cost based and much more intense, with more competitors. Although costs may reduce substantially, competition results in lower prices, and savings get passed on to customers.

7.1.3 Low Entry Barriers and Low Scale Economies

Hardware and equipment costs are no longer barriers to entry into information-intensive sectors. Software can occasionally be a barrier but here, too, standardization and off-shore provision have reduced costs. Access and remote delivery are no longer cost issues. As a result, there are likely to be more entrants in a service sector, and standardization also reduces the opportunities for differentiation.

Scale economies are less of a factor in building information-intensive services in terms of hardware capacity for processing and communications. First of all, information-processing capacity is not only of low cost but is also "scalable," in that it is possible to start at a small scale and add capacity incrementally as required. To a great extent, for many firms, capacity can be rented as needed from service providers of hosting, storage, and other web or "cloud" services. This is also true of enterprise software and other functional software tools, the availability of which continues to grow.

However, software and other pure information products display economies of scale, due to the variability of production costs. Fixed costs (or first copy costs) tend to be relatively high, while variable (second copy) costs are often extremely low. There are indeed barriers to entry for vendors of large software products such as operating systems and enterprise systems.

Apart from entry, the nature of information chains also permits a firm to occupy a relatively narrow slice of the delivery chain. In dominating the early days of photography, Eastman Kodak not only made film but delivered it to the end customer in a Kodak camera, provided film development and printing services, and returned a reloaded camera to the customer. The customer just took the picture — Eastman Kodak did the rest. This was a great business model, which locked in customers but required an extreme level of vertical integration and investment. By comparison, in the modern information-intensive world, there are many examples (Kazaa, Skype, Hotmail, Google, Napster) of a relatively specialized service provided very quickly, initially by a small group with relatively low investment levels.

7.1.4 Network Externalities and Installed Base Effects

Networks are a common feature of many information-intensive sectors, starting with the underlying infrastructure of telecommunications to the network aspects of consumer sites that involve many-to-many communications and interactions. As is well known, the value of a network is theoretically proportional to the square of the number of nodes in the network. Therefore, the bigger the network, the larger is its value to users. The basis for this effect is the observation that the number of point-to-point or bilateral connections in a network with n entities or nodes is proportional to the square of n. This creates an advantage to first movers and also a barrier to entry, since a user choosing between networks will usually favor the larger incumbent over a new entrant. There is vast literature on the economics of networks and network competition (e.g., [77]).

In addition to network externalities driven by the number of connections, the installed base of users of a technology can have other positive effects for the technology. One consequence is the creation of economies of scale in support and maintenance of the software. Another is increased diffusion of information about the product through word of mouth and online communications.

7.1.5 Differentiation and Niches

While commoditization is one common consequence of industrialization, increased differentiation of certain services or the creation of niche services can also occur in certain sectors. First, lower costs of entry allow for smaller scale enterprises and niche creation. The increased reach made possible by low-cost information logistics and the Internet also allows a provider to reach a specialized narrow market that might not have been otherwise possible. Ongoing operating costs of automated service process capacity or holding information content inventories are low. The horizon over which sales occur can be stretched out, again allowing for niche markets.

Differentiating automated services can be easier in certain cases. Bundling services, customizing them, or creating different services processes (to provide variety) are made easier by information technologies, and are becoming even easier due to new technologies such as SOAs.

7.2 Services Trade and Off-Shoring

For most countries, services trade volume is relatively stable at around 15–20% of total trade. The United Kingdom, Spain, and India are exceptions, with services trade at more than 25% of total trade volume. At the other end of the spectrum, China and Mexico have less than 10% of their trade volume in services. Additionally, for most countries, services trade is dominated by physical services such as transportation, which tends to track product trade, and travel, which is driven by tourism and product trade. Two countries that are major exceptions in this respect are the U.S. and India. For the U.S., while travel and transportation are indeed large components, royalties and licenses, financial services, and other business services are also major service exports. In fact, by 2006, "business, professional, and technical services" had become the largest export item from the U.S. among private services. Its share in total exports of private services from the U.S. was 21.6%, while that of "travel and transportation" was 21.4% and "royalties and license fees" was 17.7%. By 2009, these shares were 24.1%, 19.4%, and 18.6%, respectively. On the import side, too, business services, financial services, government services, royalties and licenses, and computer and information services are all major components. The growth in these information-intensive components has been substantial for the U.S. in both absolute and relative terms. For example, financial service exports have more than tripled in the last 10 years.

For India, the top two service trade categories are computer and information services and business services. This pattern is consistent with the growth in outsourcing and off-shoring in information-intensive industry sectors. This increase in information-intensive trade for India has been extremely rapid, with about a tenfold increase in the last decade.

The global pattern of services trade resembles that of trade in goods, since physical services dominate information-intensive services for most countries. However, the pattern for information-intensive services is different. While trade in products is affected by distance, trade in information services is not. Rather, language and culture play a significant role [47]. India's growth in information-intensive services trade is feasible due to the presence of large service markets in English-speaking countries such as the U.S. and United Kingdom.

In principle, the low cost of logistics for trade, and the ability to "modularize" information-intensive services and content production, could be expected to lead to higher volumes of trade in information-intensive services. This growth is likely to be higher in the largest information services markets. As pointed out by Karmarkar [47] and Apte and Karmarkar [2], the largest geographically distributed information services market is that composed of countries with large English-speaking populations. In fact, the English world is unique in this respect.

7.3 Wage Distribution

Apte et al. [4] showed that there were significant wage differentials across information and noninformation sectors, with the average wage in the former sectors being perhaps 40% higher than the average in the latter. In our updated analysis (Section 4), we confirmed that these differentials continue to exist. There are several possible explanations for these differences. One leading factor is that the returns to education are larger in information-intensive sectors. For example, the educational preparation required for entry-level jobs in many physical services (such as food services) is less than that required in information-intensive services (such as clerical work). Furthermore, higher levels of education do not necessarily lead to advancement in many physical services (e.g., freight, warehousing). On the other hand, advanced education has significant returns in many information-intensive services (financial services, education, professional services). Thus, a shift in employment to information-intensive jobs appears to raise the average wage level in services. It also increases inequality in income levels.

A more complex, more fundamental mechanism is that related to productivity and sector growth. Karmarkar and Rhim [53] showed that productivity growth in a sector that is also growing in terms of market size can lead to greater income inequality in an economy. This may well be the situation for the information services sector. However, we are not as yet aware of any empirical validation of this mechanism.

7.4 Convergence and Sector Restructuring[1]

The terms "convergence" and "digital convergence" are widely used to denote the blurring of boundaries between information-intensive sectors. It is useful to break down the concept of convergence further to understand its impact on different stages of information production and delivery. We can identify the following aspects of convergence, which are interrelated:

- Convergence in form (digitization),
- Convergence in logistics (storage and transportation),
- Convergence in processing (hardware),
- Convergence in work tools (desktops, laptops, workstations),
- Convergence in consumption (consumer appliances),
- Convergence in usage and behavior (in business and for consumers), and
- Convergence in content and services (blurring of product, service, and industry lines).

The first of these requires little explication. All types of information are capable of representation in digital form. This leads immediately to the reality of converged logistics, with the common means of storing and transporting all forms of information in digital form. Similarly, the tools for processing information are very much the same in terms of hardware. Software is often the same at some levels (e.g.,

[1] The material in this section is partly drawn from Karmarkar [50].

operating systems, network management, middleware, and server level industrial applications). However, it is also often specialized by the eventual use of the information (e.g., audio versus video processing on a desktop or different end uses). There, too, are often similar components and methodologies involved in its development, and the degree of specialization across sectors has reduced. For example, websites for diverse companies in different sectors can be built using similar tools and techniques.

So far, we have addressed the supply side of information. Turning to end users of information, we can see a process of convergence occurring in the tools that are used for working with information. The same desktops and laptops serve workers in many diverse industries. The differences between workstations, terminals, and desktops, which were mainly a matter of processing power, have almost disappeared. Those between desktops, laptops, and notebooks are disappearing. The differences now have more to do with the work environment and mobility, rather than differences across job types and industry sectors. In service delivery to consumers, there is likely to be some specialization. So it may be that kiosks at airports will always be different from ATMs or automated vending machines, often due to different physical requirements. Even here, the core technologies are very similar.

Finally, at the level of the end consumer of information, there is an increasing degree of convergence in the appliances used. There are indeed things that will not converge, in the sense that an appliance needs to deliver analog information in the form of vision and sound, and to provide an input mechanism to capture speech, gestures, or digital inputs (fingers in this case). However, all of these can now be bundled into one small box. In 2009, the Apple iPhone was the leading example of this convergence, with many other devices close behind.

Looking a bit more closely at this phenomenon, we can identify a sequence of different kinds of convergence. The first is, of course "digital," or convergence in form and representation. This, in turn, leads to the convergence in logistics and processing methods mentioned earlier. This convergence includes software and hardware assets, since the same methods and tools can be used in different sectors. The commonality and convergence in equipment and appliances extend to the user and the consumption of information, not just their production and delivery. As a result, there is a form of convergence on the supply side of information sectors, where the same companies now play the same role across sectors. An obvious example is the use of telecommunications for transportation of digital material. As a result of convergence in the appliances used in consumption, there is a kind of convergence in behavior, where formerly distinct use patterns start to overlap.

7.4.1 Vertical De-integration and Lateral Dominance

On the supply side, information-intensive industry sectors, whether products or services, were separated and often dominated by the media used for storage and distribution. This effectively separated the music business more or less completely from the publishing business. Even the frequency of distribution of different types of media led to different industry sectors, so that newspapers were very distinct from weekly news magazines or books, as examples. The economics of storage, distribution, and transportation were highly scale dependent. As a result, many information-intensive sectors were dominated vertically by a few companies. This was the case with newspapers, television, and telephone service. However, such structures cannot survive "convergence." The general consequence is a shift from vertical dominance and integration driven by distribution economics to lateral dominance and integration based on technologies and assets.

While lateral strength and integration are a general trend, there is considerable variation in the strategies that we see. Firms like Google, Yahoo, Amazon, Microsoft, and NTT DoCoMo have exploited their positions to expand laterally, although to varying degrees and with differing models and strategies. On the other hand, many telecommunication companies seem to be slower in recognizing the opportunities that were, and still are, open to them.

It remains to be seen as to what mix of lateral and vertical structures will eventually survive, and which firms will be the dominant players. However, the strongest contenders appear to be the server-based, consumer-oriented companies that have built successful platform models and strong brands.

7.4.2 Direct-to-Customer and Open Marketplaces

One of the models permitted by the economics of information logistics is the enhanced ability to go directly to the customer, bypassing traditional intermediaries. An example of this would be a writer or novelist who decides to publish his or her work online, rather than take the usual route through an editor, publisher, and distribution channel. An extreme version of this would be an author who, for whatever reason, is able to connect to a large portion of the market for his or her work, who could then simply inform their readers about a new work, with instructions on how to access (download) it from a dedicated website. This could work with some combination of a loyal audience, a large audience, and a sufficiently large flow of new material. A small modification is the use of a third party site that does not raise the cost of distribution much and is focused on certain types of content. For example, many software packages are sold through such sites. A further variation is the use of a web-based distributor, although, in this case, the cost penalty (the portion captured by the intermediary) can rise quite sharply. An example is publication through Amazon's Kindle platform. Today, this is still a proprietary and relatively closed, controlled channel, which takes a substantial portion of the gross revenue. Yet, the actual cost of the channel is low, the channel's capacity is high, and the speed at which the product reaches the market is high. Such models can clearly work with almost any kind of good or service, as long as it can be searched effectively on the web, purchased online, and delivered remotely. The ability to reach even small market segments using the low-cost search and delivery modes available with the Internet is sometimes called the "long tail" phenomenon.

One of the most effective routes to access markets directly has been through the open auctions and "classified" marketplaces, such as eBay and Craigslist. These platforms have high fixed costs but low operating costs, and can scale up to very high capacities, so that the cost per transaction is also very low, and the search and match capabilities are very high. Here, the market maker (e.g., eBay) has several alternative ways to earn revenues on the transactions that are carried out. The revenue sources could include some or all listing fees, transaction fees (fixed or proportional), and advertising.

A more business-oriented version of the same concept is the online mall, where the customer accesses and orders goods through one branded website, but the inventories are with another supplier. Actual order fulfillment may be done by the site or by the other supplier. Amazon is a leading example of this model.

7.4.3 Barter and Community Sites

One of the exchange modes enabled by technology is barter and exchange of goods and services without any monetary exchange. Some of this activity is illegal, as when information goods are shared without the right to do so. Some of the sites that used to facilitate this kind of sharing have been significantly curtailed in operation (Kazaa) or shut down (Napster). However, technologies that can be used for file sharing such as Bit Torrent will continue to survive, although sites facilitating such sharing continue to be shut down (e.g., Pirate Bay). In other cases, there are many content-sharing sites, which limit themselves to legal downloads of nonprotected content. YouTube is probably one of the best known of these. The barter mode here is not a unit-for-unit exchange. However, it is, in effect, a pool of shared content to which many contribute and from which many more consume.

Social networking and community sites like Facebook and Twitter are similar in a way, in that they provide entertaining and appealing ways for individuals to spend time in communication and social transactions that substitute for other forms of media, entertainment, and social activity. For example, it is entirely plausible that online social networking will reduce the number of people joining traditional clubs.

Such sites represent a dangerous direction for a broad spectrum of commercial interests, since the value in these transactions is not easily captured. It appears that advertising revenue is one way to "monetize" the activity, but it is clearly not directly related to the value of the transactions. The threat to commercial activity is quite substantial, since the time spent on such sites takes away from other fee-based and revenue-producing consumption. It is likely that many traditional businesses have been affected in terms of time being shifted from them to these sites and activities. The pattern of allocation of time by consumers to different forms of entertainment and social activity is changing rapidly.

7.5 Organizational Restructuring

Organizational changes arise from two directions. First, changes at the industry level also require corresponding changes in organizations. For example, as online channels start to substitute for traditional channels, a new internal structure is required to manage the new channels. Over time, it is possible that the traditional channels shrink and perhaps disappear completely — this is likely to happen in some publishing sectors. For example, it has largely happened in legal publishing. There may be several concurrent changes in the nature of the published product itself. In legal publishing, the shift has been marked, as the product has gone from (for example) publication in a paper-and-book form to a searchable database. Apart from the change in the nature of the core document, there can also be changes in supporting information. Instead of legal notes being added to the base document, the end customer can use a search engine to identify related cases and legal precedents. As a result, the core processes of publication shift from being knowledge based to being oriented toward electronic capture, collection, and delivery. The resulting changes in organizational structure are quite substantial. In the legal publishing sector, the paper-based printing processes have completely disappeared in certain firms, along with the people, the printing presses, inventories of books, and the physical warehousing and transportation systems. In addition, many legal professionals who worked on the enhancement of published content are now gone, while the expertise related to electronic publishing processes has been added.

The second driving force behind organization change arises internally. The same kinds of forces that cause changes in the larger industry sectors also apply inside organizations. For example, information-intensive processes inside organizations are subject to change, and these changes are reflected in organizational structure. For example, in the U.S., organizations across a wide range of industries are changing toward having fewer layers of hierarchy, wider spans of control, and reduced colocation of workers [52]. Many more changes are occurring due to restructuring of processes and operations down to the most atomic levels of work.

7.6 Continuing Evolution and New Developments

The shift to the information economy will continue for decades and at a very deep level, extending to tasks, jobs, and processes as well as organizations, sectors, and economies. Many sectors have already been transformed by these shifts, others are in the process of change, while some are yet to see major changes, although they are inevitable. In some cases, sectors have grown in size and importance. Telecommunications is a leading example in information logistics; web and infrastructure services, including cloud computing, are others. So-called "big data" and the business analytics sector continue to show growth. Some other sectors have mainly seen a process of substitution, or partial transformation. In retailing, search and e-commerce have had an impact on the customer choice and purchasing process, but, of course, distribution and delivery will always remain critical. Then there are some industries where the changes are not merely substitution, but substantial loss of sector size and value. Music and consumer imaging are two early examples, and there will be others, where the physical media at the core of a sector are replaced by digital logistics.

Apart from changes in existing sectors, there is also the prospect of the emergence of entirely new forms of economic activity, due to technology-driven innovation that has been labeled "nondestructive creation" [22]. One category of essentially new services is that of social networking and communications. Another is that of search; yet another category is location-based services.

In addition to these pure information service categories, we expect substantial growth at the interface of online technologies and physical automation. An early example is the use of Radio Frequency Identification (RFID) for object identification, as well as data collection and transfer. A second major category is that of sensors and sensor networks, today in applications ranging from monitoring to security. These are natural extensions of the information logistics system. The ability to address a vast universe of objects (the “internet of things”) will continue to expand the online world from screens and appliances to practically any object of value. The next step in this evolution is a much larger role for control and execution, with a combination of centralized and dispersed intelligence. There are hundreds if not thousands of such applications, ranging from large intelligent systems (smart grids, intelligent roadway systems) to local applications such as home entertainment, home security, digital environments, and intelligent personal assistants.

At the end of the day, the important consequences of these complex changes will be reflected in terms of the growth and distribution of value, jobs, and wages. There is not much room for growth for the service sector as a whole. However, we expect the shift to information-intensive activities to continue for at least a couple of decades in terms of both value and employment. In sum, information-intensive services will not only remain the dominant portion of the U.S. economy, but also will grow to occupy a larger share of the whole.

8

Summary, Conclusions, and Future Research

This work has presented a longitudinal perspective of a major trend in the U.S. economy toward becoming information intensive. This study followed and extended previous work on this subject by Machlup [60, 61], Porat [73], Huber and Rubin [43], Apte and Nath [7, 8], and Apte et al. [4]. In the last article and here, unlike the previous studies, we broke down GDP further into product- and service-related outputs. This added an important dimension toward understanding the evolution of the economy, since the trends toward services and information are not the same, but are correlated. Furthermore, we discussed not only GDP trends, but also examined the impact on jobs, employment, and wages. In addition, we looked at trends in information-related trade, which is likely to become an increasingly important issue for the U.S. in the future.

One major conclusion from our work is that the U.S. economy is now truly an "information economy." Although the share of information-intensive sectors has not increased after 2000, it has not declined substantially either, despite the shock of the 2001 recession. The U.S. can also be described as an "information service economy," with the information-intensive services sector being the largest component of GDP in the U.S. The total wage bill in information-intensive sectors has exceeded that in material-intensive sectors for a decade already. Furthermore, after 2000, the share of jobs (number of FTE) attributable to information-intensive services has overtaken that in physical and material-intensive services for the first time in recent history. While the recent back-to-back recessions in the U.S. have caused a pause in the shift of GDP to information-intensive sectors, they may well accelerate the trend in employment and wage distribution. We would conjecture that, as the U.S. economy recovers (which may happen only slowly), the trends will reestablish themselves.

There is a complex set of factors and drivers that underlie these changes. A traditional explanation has been the differential changes in productivity across sectors. While this remains valid, we noted that market maturity or newness, and the potential for growth or the lack thereof, must be factored in as well (e.g., [53]). When underlying productivity changed, we discussed technology-driven industrialization as an important microeconomic factor that creates those changes. Demographic shifts are likely to be another important factor, especially insofar as they are correlated with educational attainment.

Finally, we discussed the consequences of the evolution to an information economy. This was again a vast topic and we only summarized some of the main issues. There are substantial implications for competition, both national and global, and also for the structure of industries that are information intensive. Some of these changes are visible, as with financial services and entertainment; others are still in process and may take many years — but they are inexorable. In other recent research, we had investigated several other closely related topics, including the link between capital investment in information technology and employment [68], international trade in services [9], service industrialization [49], globalization [2], operations in the information economy [51], and the effect of productivity changes on sector growth and decline [53]. We also are continuing to work on topics related to this study, including its extension beyond 2007 and the study of sector-level changes in terms of GNP, employment, and business structure. The opportunities for research on these topics are unlimited, ranging from improved modeling of information-intensive processes [3, 5] to analysis of sector structure and competition.

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