The U.S. Software Industry
As an Engine for Economic Growth and Employment

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Executive Summary

Over the last 20 years, software has become an essential input for the operations of virtually all businesses, across all industries and sectors. As a result, the software industry has had disproportionate, positive effects on American output, productivity, exports and jobs.

- From 1997 to 2012, software industry production grew from $149 billion to $425 billion; and since this growth outpaced the rest of the economy, the software industry's direct share of U.S. GDP increased from 1.7 percent to 2.6 percent, or more than 50 percent.

- The use of software also has increased the productivity of other industries, thereby contributing to the growth of their production. Analysis shows that software accounted for 12.1 percent of all U.S. labor productivity gains from 1995 to 2004 and 15.4 percent of those gains from 2004 to 2012.

- On this basis, we calculate that software accounted for 9.5 percent of all gains in U.S. output from 1995 to 2004, and 15.0 percent of those gains from 2004 to 2012. In 2012, therefore, software and the productivity gains it provides accounted for $101 billion in production by other industries.

- All told, the software industry in 2012 contributed $526 billion to GDP -- $425 billion + $101 billion – or 3.2 percent of GDP.

- About 12 percent of U.S. software production is exported, totaling some $50 billion to $57 billion in 2012. Moreover, exports of software and related services have grown by 9 percent to 10 percent per-year since 2006, nearly 50 percent faster than all U.S. exports.

- From 1990 to 2012, business investments in software grew at more than twice the rate of all fixed business investments; and from 2010 to 2012, software accounted for 12.2 percent of all fixed investment, compared to 3.5 percent for computers and peripherals.

- Direct employment in the software industry increased from 778,000 jobs in 1990 and 1,083,000 jobs in 1995, to 2,095,000 in 2010 and 2,501,000 in 2014. Since software-industry jobs grew faster than other jobs, the industry's share of all employment rose from 0.9% in 1990 and 1.1 % in 1995, to 1.9 % in 2010 and 2.2 % in 2014.

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- In addition, software companies purchased $212 billion in goods from other industries in 2012, and those purchases supported another 1,080,000 jobs in those industries. All told, therefore, the software industry was responsible for 3.42 million jobs in 2012. Using the same "employment multiplier," we estimate that software industry production is directly responsible for 3.65 million U.S. jobs in 2014.

- Like other forms of business investment, software in some instances displaces existing jobs – for example, ATM software has displaced some bank teller positions. But the use of software also creates jobs to maintain and operate its systems; and the additional wealth created by the productivity improvements tied to software also leads to more job creation, to produce the goods and services purchased with the additional wealth.

- On balance, there is no correlation between industries that invest most heavily in software and net employment losses.

- The software industry has continued to create new jobs at healthy rates throughout the current, difficult business cycle: From 2007 to 2014, as overall private-sector employment has declined at an average annual rate of 0.1 percent, software industry employment grew on average by 3.1 percent per-year.

- Five industries created large numbers of new jobs in this period – in addition to software, home health care, individual and family services, retail and restaurants. The new software workers, however, are paid, on average $86,457, or three times as much as workers in the other four industries.

I. Introduction

Innovation is a touchstone of the current American economy, exemplified by the rapid diffusion of successive new generations of information and communication technologies (ICT). For the past generation, these industries have played a disproportionate role in U.S. business investment, personal consumption, and the growth rates of productivity and GDP. This study will analyze and assess the economic role and significance of software, which provides the operating systems and applications for ICT, in these larger developments.

Dr. William Raduchel, a Harvard professor and later executive at Sun Microsystems, Xerox and AOL Time Warner, describes software as "the core of most modern organizations, most products and most services."[2] This characterization is supported by the steadily growing demand for software, defined here as computer systems design and related services, software publishing, and data processing, hosting, and information services. The total value of the software industry's product increased, for example, from 1.7 percent of GDP in 1997 to 2.6 percent in 2012, at which time the software sector directly contributed about $425 billion to U.S. GDP. Over the same period, as we will see, employment in the software industry increased even more, from 1.4 million to 2.3 million positions; and these workers on average now earn nearly three times as much as the average for all other private-sector American workers.

[2] Raduchel (2006).

The rapid growth of demand for software reflects its character as a genuine "general purpose" or enabling technology that has been adopted and adapted by virtually every other industry and sector. For more than twenty years – from 1990 to 2012 – business investments in software have increased at more than twice the rate of all fixed business investment. Since the mid-to-late 1990s, economists have tried to analyze and assess the impact of these software and other ICT investments. Two early studies, for example, found that the use of all forms of ICT by other industries contributed about one-sixth of annual GDP growth from 1990 to 1995/96.[3] Estimates of ICT's impact on U.S. productivity in the later-1990s are even larger: Studies traced half or more of U.S. productivity growth in those years to ICT.[4] Analysis of the most recent period has found similarly large effects, with 41 percent of productivity gains over the years 2004 to 2012 attributed to ICT investments.[5]

This study is part of this line of analyses in assessing the direct and indirect economic benefits of these technologies, focused here on the software industry rather than the overall ICT sector. To assess the software industry's general economic impact, we use the Input-Output tables of the Bureau of Economic Analysis (BEA) to track both the direct value created by the industry in any year and the flows of goods and services between the software industry and other industries. In 2012, for example, the software industry purchased $212 billion in goods and services from other industries and, in this way, indirectly supported that level of demand across the economy in addition to satisfying business and consumer demand for software. This analysis highlights both the industries on which the software industry depends and the industries that depend on software. For example, the industries that sell the most products and services to software providers include professional, scientific and technical services, real estate and rental and licensing, and manufacturing. And the industries that consume the most software and related services include, in addition to the information industry, finance and insurance, professional, scientific and technical services, and the management of companies and enterprises.

In addition, this study assesses how software affects the operations of other industries by tracking and estimating the share and value of the output of other industries that can be attributed to productivity gains produced by their use of new software. Recent research by economists at the Federal Reserve Board has traced about 15 percent of U.S. labor productivity growth from 2004 to 2012 to the use of software, an increase from the 12 percent share estimated for the period from 1995 to 2004.[6] By applying this analysis to the growth of nonfarm business output over these periods, we estimate that software accounted for about 9.5 percent of gains in output between 1995 and 2004 and about 15 percent of that output growth for the years from 2004 and 2012. On this basis, we estimate that $101 billion in output in 2012 can be attributed to the use of software and related services by other industries.

All told, therefore, the software industry and its related services were responsible, directly or indirectly, for $526 billion of U.S. GDP in 2012 ($425 billion + $101 billion), or 3.2 percent of GDP in that year.

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[3] Jorgenson and Stiroh (1999); Oliner and Sichel (2000).
[4] Corrado et al. (2006); Basu et al. (2004).
[5] Byrne et al. (2013).
[6] *Ibid.*

This study also assesses the common view and concerns that the spread of ICT and the increased use of software impair job gains in the United States. These concerns do not involve direct employment by the software industry, which has increased steadily: From 2002 to 2014, software-related jobs increased from 1.8 million to 2.5 million positions, accounting for 12 percent of all net U.S. private sector job gains over those years. Since the software industry directly accounts for 2.6 percent of GDP, employment in the industry grew at more than six times (6.3) the rate of the rest of the economy. Instead, concerns about the impact of software on employment focus on how the use of software has affected employment in other industries. Most business investments in software and ICT generally do involve, unavoidably, some "substitution of capital for labor." The use of word processing may displace secretarial positions, as the use of sophisticated engineering software can reduce the need for junior engineers. In fact, most business investments displace existing jobs to some degree, and this effect is often larger when the investments involve disruptive technologies.

That is only half of the story, however, because the same dynamics are associated with new job creation as well. To begin, all capital investments involve employing people to design, produce, promote and transport the new equipment that others invest in. In addition, when capital investments are directed to disruptive technologies such as software or the Internet, businesses often also undertake changes in their organizations and ways of doing business, so they can take better advantage of the new technologies. Many of these changes involve the creation of new positions, as well as the destruction of obsolete ones. Furthermore, once in place, most business technologies have to be serviced and maintained as well as operated, tasks which all require employment. The interplay of the job creation and job losses that accompanies most business investment is one of the reasons why the American economy manifests so much "job churn."[7]

Most business investments, including those in software, are intended to increase a firm's productivity; and the productivity gains associated with the efficient and effective use of software also create jobs by generating additional wealth and income. Whether these benefits go mainly to workers in higher wages or mainly to shareholders in larger dividends and capital gains, the macroeconomic result is the same: The additional income and wealth produce additional demand for goods and services, which in turn leads to additional employment to produce them.

The heart of many current concerns about the impact of software on jobs involves the extent to which the diffusion of software and IT across the economy imposes wrenching costs on workers whose skills better matched the needs of pre-IT-based businesses. Many such workers have seen their jobs disappear and found that the new positions available to them pay less, from retail and administrative workers displaced by automatic systems to taxi drivers forced out by software-enabled competition from Uber and Lyft. Any disruptive development, including the spread of a disruptive technology, will leave some people worse off, and sometimes, a large

[7] In 1997, for example, when U.S. employment increased by more than 2.8 million jobs, it involved the creation of some 18.5 million new positions and the destruction of some 15.7 million existing positions. More generally, the Census Bureau reports that from 2000 to 2009, gross job creation averaged 15.8 million positions per-year and gross job destruction averaged 14.9 million per-year, for annual job gains averaging some 900,000 net new jobs. See Kane (2000) and Haltiwqanger *et al.* (2001).

number of people bear significant costs. The early, disruptive stages of modern globalization in the late-1970s and 1980s, for example, eliminated millions of manufacturing jobs as new foreign competition drove U.S. manufacturers to substitute a great deal of capital for a great deal of labor. Manufacturing productivity went up, and the economy created large numbers of new jobs in other areas; but many former manufacturing workers never found new positions that paid as well. A similar dynamic is certainly part of the diffusion of software and IT, and it justifies new programs to give many more American workers easy access to training for an IT-based economy. However, unlike the disruptive shock from foreign competition in manufacturing, this transition also involves the creation of many highly-paid new jobs within the software industry, many well-paid new jobs in the industries that support software, and many more new jobs associated with the productivity gains produced by other industries adopting and applying new software.

Economists cannot directly measure all of these effects with precision, as the National Research Council has noted, "[b]ecause of a lack of a good economic model of software."[8] Nevertheless, we find no evidence that on balance, software destroys jobs. Rather, the data strongly suggest that software is a significant source of expanded employment. To begin, the data clearly show that the software industry itself has been a significant source of new jobs. From 2000 to 2013, while total private-sector employment grew at an average annual rate of less than 0.4 percent per-year, software-related employment increased by 1.8 percent annually, from less than 2 million in 2000 to 2.5 million positions today. In addition, we found that every 10 jobs in the software industry support another five jobs in other industries that provide inputs for the software industry. This "employment multiplier" is higher for the software industry than for most sectors, including financial services, construction, transportation, agriculture, health care, retail, education, and accommodations and food services. This tells us that the 2.5 million jobs in the software industry directly support another 1.2 million jobs in other industries.

There remains the more difficult issue of measuring the indirect impact of software on employment in other industries. To begin, we will show that there is no correlation between business purchases of software by industry and net job losses; in fact, there is a modest link between those purchases and job *gains* by industry. Businesses purchase software, because its effective use can make businesses more productive. Economists have measured the impact of software on productivity and found that from 2004 to 2012, software was responsible for more than 15 percent of productivity gains over that period. Let us consider the combined impact of these dynamics in 2012. In that year, direct employment in the software sector grew by 128,000 positions. In addition, demand by software companies for goods and services produced by other industries increased by about $8.2 billion; and that additional demand supported the creation of 43,800 new jobs. Finally, increases in productivity associated with the use of software by other industries expanded the GDP produced by other industries by over $100 billion, sufficient to support 850,000 new jobs. Therefore, the production and use of software in 2012 was directly associated with the creation of more than 163,000 new jobs and indirectly with another 850,000 new jobs. While economists cannot yet model with precision the dynamics by which software renders some jobs obsolete, there is no evidence that the use of software by businesses in 2012 offset even the 163,000 new jobs associated directly with the production of software, much less the 850,000 associated indirectly with its use, through productivity gains.

[8] Raduchel (2006).

II. The Software Industry's Increasing Impact on Economic Growth and Job Gains

In a 2011 essay in the *Wall Street Journal*, software pioneer and venture capitalist Marc Andreessen famously wrote that by spurring innovations that disrupt traditional industries, "software is eating the world."[9] The data confirm that the software industry has had a substantial impact on the American economy. In 2012, U.S. software companies generated some $425 billion in GDP and employed more than 2.3 million workers. In addition to these substantial levels of direct economic output and employment, the software industry generates additional employment through its purchases of goods and services from other industries and additional output through its impact on the innovative capacity, efficiency and productivity of other industries that purchase and use software.

The direct economic effects of the software industry are based on the growth and operations of companies in three sub-industries: computer systems design and related services; software publishing; and data processing, hosting and information services. The computer systems design industry (NAICS code 5415) covers companies that write, modify, test, and provide support for software, and so would include enterprise software companies such as IBM, Hewlett-Packard, and Oracle, as well as IT consulting companies like Accenture.[10] The software publishing industry (NAICS code 5112) covers companies that produce and distribute computer software, including the development, publishing and installation of software, as well as providing support for software customers. This sub-industry is comprised of 1) prepackaged software produced by companies such as Apple and Microsoft (25.6 percent of software publishing); 2) custom software built by companies such as IBM and Hewlett Packard (37.6 percent); and 3) software developed by companies in-house for their own use (36.8 percent). Finally, the data processing, hosting, and other information services industry (NAICS codes 518 and 519) covers companies that provide web-based software, infrastructure and data storage, as well as search engines, social networks, auction sites, and web publishing companies. Services included under this designation include web-based platforms and applications, cloud computing services, and streaming services. The companies include Google, eBay, Salesforce, and Netflix.

From 1997 to 2002, the value added produced by the three sub-industries increased from about $150 billion to just over $425 billion, for average annual growth of more than 7.2 percent. (See Table 1, below)

Table 1. Value-Added Produced by the Software Industry, 1997-2012 ($ millions) [11]

Sub-Industry	1997	2000	2005	2010	2012
Computer systems design & related services	$75,259	$113,596	$134,964	$189,882	$229,792
Software publishers	$43,831	$66,171	$78,482	$103,958	$115,435
Data processing, hosting, & info. services	$30,314	$23,970	$71,822	$69,224	$80,186
Total	**$149,404**	**$203,737**	**$285,268**	**$363,064**	**$425,413**

[9] Andreessen (Aug 20, 2011).
[10] Companies classified as part of the computer systems design industry also includes those which plan and design computer systems, manage and operate computer systems, train and support users of these systems, and provide other technical computer-related services.
[11] Bureau of Economic Analysis

The software industry has also consistently grown faster than the rest of the economy. As a result, its annual value-added as a share of GDP has consistently increased. From 1997 to 2012, the share of GDP attributable to the software industry has risen from 1.7 percent to 2.6 percent, an increase of more than 50 percent. (Table 2, below)

Table 2. Value-Added Produced by the Software Industry as a Share of GDP, 1997-2012 [12]

Sub-Industry	1997	2000	2005	2010	2012
Computer systems design and related services	0.9%	1.1%	1.0%	1.3%	1.4%
Software publishers	0.5%	0.6%	0.6%	0.7%	0.7%
Data processing, hosting, and information services	0.4%	0.2%	0.5%	0.5%	0.5%
Total	**1.7%**	**2.0%**	**2.2%**	**2.4%**	**2.6%**

Software-related employment has grown nearly as rapidly as overall software production. From 1990 to 2014, the number of combined workforce of U.S. software companies increased from 778,000 to 2.5 million, a 5.0 percent average annual rate. (Table 3, below)

Table 3. Software Industry Employment, 1990-2014 (thousands)[13]

Sub-Industry	1990	1995	2000	2005	2010	2014
Computer systems design and related services	410	611	1,254	1,195	1,449	1,733
Software publishers	98	157	261	238	261	299
Data processing, hosting, and information services	271	314	473	380	385	471
Total	**778**	**1,083**	**1,988**	**1,813**	**2,095**	**2,503**

Since 1990, software-industry employment has consistently increased faster than overall private employment. As a result, the software industry's share of the total private workforce has grown from 0.9 percent in 1990 to 2.2 percent in 2014. (Table 4, below)

Table 4. Software Industry Employment as a Share of Total Private Employment, 1990-2014[14]

Sub-Industry	1990	1995	2000	2005	2010	2014
Computer systems design and related services	0.4%	0.6%	1.1%	1.1%	1.3%	1.5%
Software publishers	0.1%	0.2%	0.2%	0.2%	0.2%	0.3%
Data processing, hosting, and information services	0.3%	0.3%	0.4%	0.3%	0.4%	0.4%
Total	**0.9%**	**1.1%**	**1.8%**	**1.6%**	**1.9%**	**2.2%**

U.S. Exports of Software and Related Services

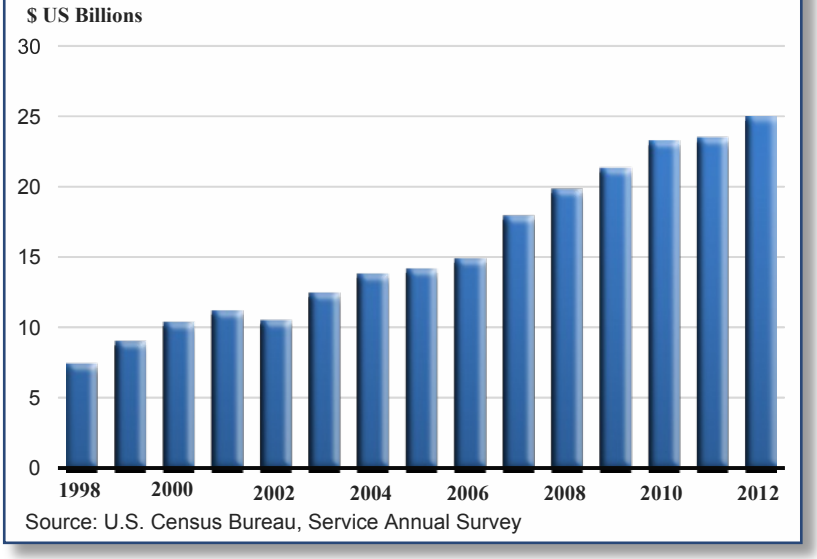
Domestic demand for U.S. software has been strong for more than two decades, and foreign demand for software exports has been even stronger in recent years. Using data from the Service Annual Survey (Census) and the series on Cross-Border Services Trade (BEA), we

[12] Bureau of Economic Analysis
[13] Bureau of Labor Statistics.
[14] Bureau of Labor Statistics.

estimate that U.S. software companies exported $50 billion to $57 billion in software products in 2012. The Census Bureau Service Annual Survey provides estimates of export revenues in service sectors by their NAICS industry codes. This survey found that in 2012, software publishers (NAICS code 5112) generated exports of $25 billion in 2012 and the computer systems design industry (NAICS code 5415) produced exports of $17.7 billion. The most recent Census data on the information services and data processing services industry (NAICS codes 518 and 519) is from 2007. Assuming a conservative five percent growth rate since then, we estimate that information services and data processing services generated exports in 2012 of at least $7.5 billion. All told, the Census Bureau survey suggests that the U.S. software industry generated about $50 billion in exports in 2012.

The survey also provides consistent data on exports by software publishers for the last 15 years. These data show that exports by U.S. software publishers grew by 9 percent per-year since 1998, compared to a total of 6.4 percent annual growth for all U.S. exports. (Figure 1, below)

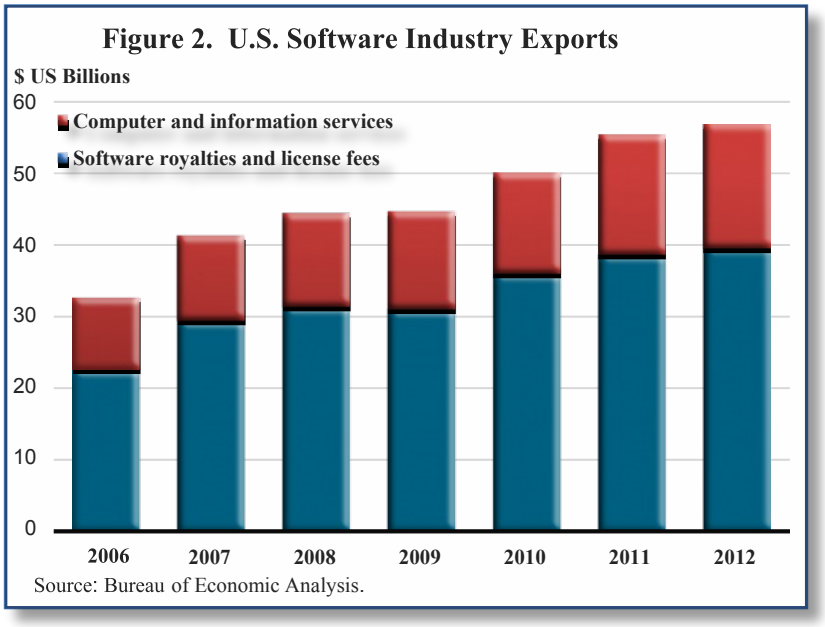
Figure 1. U.S. Software Publishing Industry Exports



Source: U.S. Census Bureau, Service Annual Survey

BEA data on cross-border services trade, which cover services exports and imports by type of service, show that U.S. firms generated $39.5 billion in foreign royalties and licensing fees in 2012 for software, plus another $17.3 billion in foreign royalties and fees for computer and information services, for a total of $56.9 billion in export revenues. Since 2006, when these export revenues totaled about $33 billion, software exports as tracked by the BEA have grown at an annual rate of 9.6 percent. (Figure 2, below) By comparison, foreign revenues for all U.S. private services grew by 7.6 percent per-year over the same period.

All told, we estimate that U.S. exports of software and related services have risen at an annual rate of 9-to-10 percent since at least 2006, and totaled $50 billion to $57 billion in 2012.



III. Software's Major Role in Rising Productivity Gains

Through most of the 1990s, the U.S. economy experienced a sustained period of strong growth, unusually low inflation and unemployment, and rising productivity gains. In fact, the combination of strong growth and low unemployment with modest inflation depended on the acceleration in productivity, and most academic researchers now attribute that acceleration largely to increased investments in IT. Most of those studies rely on the "neoclassical growth model," in which output is determined by the mix of capital, labor, and technological progress. In these models, three factors drive productivity growth: 1) *capital deepening*, or increases in the amount of capital (equipment) used, per-hour worked, 2) *labor quality*, or increases in labor input, per-hour worked, and 3) *total factor productivity (TFP)*, which captures any remaining productivity gains and attributes them to technological advances. To measure the role of IT in these dynamics, researchers had to quantify the contributions of software, computers, and telecom.

These studies found that each of these industries contributed to the acceleration in productivity in two ways. First, when companies invest in and use software, computers and telecom equipment, they contribute to productivity growth through capital deepening. Second, the companies that develop and produce new software, computers and telecom equipment contribute to productivity gains through technological advances that increase the power, speed and capacity of their hardware and software.[15] Studies covering the second half of the 1990s found that capital deepening in information technologies accounted for about 45 percent of the increases in labor productivity over those years, and advances in these technologies accounted for another 25 percent.[16]

[15] Jorgenson and Stiroh (2000).
[16] Oliner and Sichel (2000).

In addition, other research suggests that IT investments have encouraged firms to invest in other forms of "intangible" capital which also have contributed to TFP gains.[17] In this dynamic, firms that invest in computers and software also undertake complementary investments such as human and organizational capital, R&D, and new business processes, all of which can help boost productivity.[18] Many economists point to TFP growth outside of the IT sector as evidence that software and computers generate productivity gains across industries by changing the way that firms produce, finance, market and distribute their goods and services.[19]

The latest academic research has shown that the U.S. software industry continues to boost productivity across the economy. A recent study by economists at the Federal Reserve Board found that software accounted for 12.1 percent of all labor productivity growth from 1995 to 2004 and 15.4 percent of labor productivity gains from 2004 to 2012.[20] (0.37/3.06 = 12.09; and 0.24/1.56 = 15.36) (Table 5, below) Applying these results to BEA data on total U.S. nonfarm business output growth over these periods, we estimate that software accounted for about 9.5 percent of all nonfarm output growth from 1995 to 2004 and 15.4 percent of that growth from 2004 to 2012. (3.06/3.9 = 0.785 x 12.09 = 9.49; and 1.56/ 1.6 = 0.975 x 15.36 = 14.98)

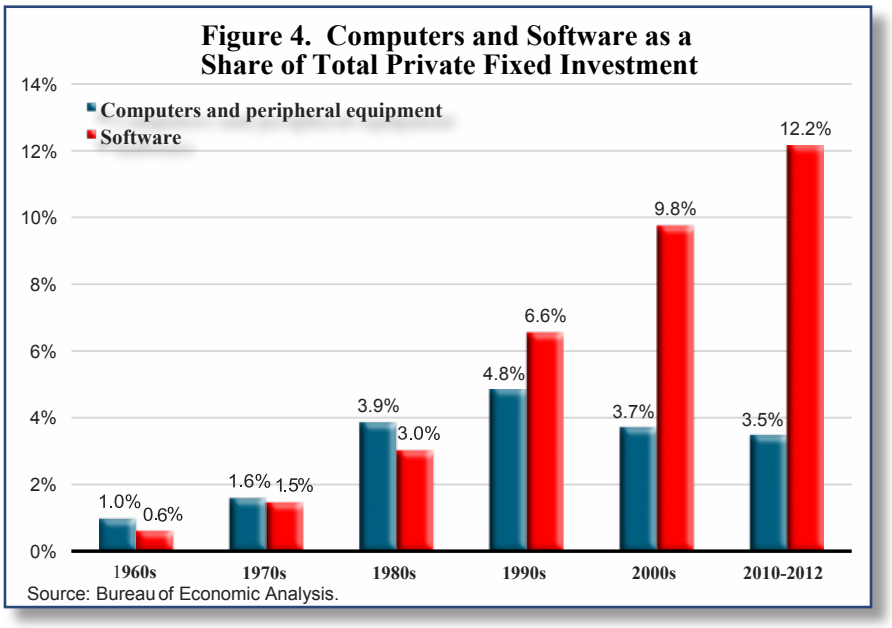
Table 5. Contributions to U.S. Labor Productivity Growth, Various Periods, 1974-2012[21]

	1974-1995	**1995-2004**	**2004-2012**
Growth of Real Nonfarm Business Output	3.31%	3.90%	1.60%
Growth of Labor Productivity	1.56%	3.06%	1.56%
Contribution to Labor Productivity Growth, Per-Year			
Capital Deepening	0.74%	1.22%	0.74%
IT Capital	0.41%	0.78%	0.36%
Software	0.16%	0.27%	0.16%
Computer Hardware	0.18%	0.38%	0.12%
Telecommunications Equipment	0.07%	0.13%	0.08%
Other Capital	0.33%	0.44%	0.36%
Composition of the Workforce (Increased Skills)	0.26%	0.22%	0.34%
Multifactor Productivity (Technological Advance), Adjusted [22]	0.50%	1.61%	0.34%
IT-Producing Industries	0.36%	0.72%	0.28%
Software	0.06%	0.10%	0.08%
Computer Hardware	0.17%	0.17%	0.04%
Telecommunications Equipment	0.05%	0.07%	0.02%
Semiconductors	0.09%	0.37%	0.14%
Other Nonfarm Industries	0.13%	0.90%	0.06%
Software's Total Contribution to Productivity Growth	**0.22%**	**0.37%**	**0.24%**
Software Share of Productivity Growth	**14.10%**	**12.09%**	**15.36%**
Software's Share of Nonfarm Output Growth	**6.65%**	**9.49%**	**14.98%**

[17] Corrado *et a*l. (2006).
[18] Brynjolfsson and Hitt (2000).
[19] Basu*, et al.* (2004).
[20] Byrne *et al*. (2013).
[21] *Ibid*., (2013); Bureau of Economic Analysis; and author's calculations.
[22] These data show multifactor productivity, adjusted for utilization and adjustment costs.

Figure 3, below, illustrates the magnitude of the productivity gains generated directly and indirectly by software, showing the total output of the software industry and the output of other industries attributed to software's contribution to labor productivity growth. In 2012, the software industry generated $425 billion in final output, and its contribution to productivity gains in that year resulted in $101 billion in output by other industries.

Data also show that U.S. businesses invest heavily in software, an unsurprising result given the substantial share of productivity growth associated with its production and use. Moreover, the share of total private fixed investment devoted to software has increased steadily from the 1970s to the present. By contrast, the share of fixed business investment devoted to computers and peripheral equipment increased from the 1970s to the 1990s, but has declined since 2000 (Figure 4, below). In the 1970s, businesses invested about as much in IT hardware as in software; and in the 1980s, they invested about one-third more in hardware than in software. In the 1990s, those priorities changed, and businesses invested one-third more in software than in hardware. This trend has accelerated since then: From 2000 to 2009, U.S. businesses invested 2.6 times as much in software as in hardware; and from 2010 to 2012, they invested 3.5 times as much in software as in hardware. While firms continue to invest in all forms of information technology, software has become the main driver of IT investment by U.S. businesses.



IV. The Software Industry's Major Impact, Direct and Indirect, on Job Creation

While growth accounting models provide the best insight into the industries and factors that drive long-term output growth and productivity gains, academic analysis of an industry or firm's impact over shorter periods typically relies on input-output (I-O) models which track the detailed flows of goods and services between industries. By analyzing the purchases and sales among and across all industries, input-output analysis can provide valuable insights into the economy's underlying structure, measure the economic relationships between industries, and ultimately estimate an industry's network of effects on the overall economy. Input-output analysis relies on a series of statistics issued regularly by the Bureau of Economic Analysis tracking the commodity outputs *produced* by each industry, called the "Make" tables, and the commodity inputs *used* by each industry to produce its output, called the "Use" tables. The BEA issues input-output accounts that include data on 65 industries once a year, and benchmark accounts that cover 425 industries once every five years.

Input-output analysis is used to estimate the direct effects of an industry or a change in demand for an industry's goods and services on a variety of aspects of the economy, including output, employment and income. In addition, I-O analysis can track and estimate an industry's indirect effects on output, employment and income generated by its purchases of intermediate inputs from other industries or supply chains. The sum of these direct and indirect effects is used to estimate an industry's "multipliers," which in turn can be used to estimate the industry's full economic impact on the economy.

We will next apply input-output analysis to estimate the direct and indirect impact of the U.S. software industry on output and employment. We define the software industry here as the three, four-digit NAICS categories which, according to the Bureau of Labor Statistics, employ the largest number of software developers and programmers: 1) computer systems design industry (NAICS code 5415); software publishing (NAICS code 5112); and data processing, hosting, and information services (NAICS codes 518 and 519). As noted earlier, the Bureau of

Economic Analysis reports that the output of these three categories in 2012 totaled $425 billion.[23] Further, the Bureau of Labor Statistics reports that these sub-industries in 2012 employed 2.34 million workers, and they earned a total of $308.4 billion.

To estimate the software industry's indirect employment impact across other industries, we begin with the BEA "Use" table to calculate the amount of each commodity consumed by software companies as intermediate inputs, and the BEA "Make" table identify the source of these intermediate inputs by industry. Next, we aggregate the industry totals to estimate the value of goods and services consumed by the software industry on an industry-by-industry basis. We find that that in order to produce its $425 billion in output in 2012, U.S. software companies consumed $212 billion in goods and services produced by other industries. Further, we estimate that this economic demand from the software industry supported 1.1 million jobs in other industries, including 145,000 workers in the accommodation and food services industry, 364,000 workers in the administrative services industry (office administration, clerical services, security, cleaning, and waste disposal services), and 181,000 jobs in the professional, scientific, and technical services industry.

Based on these data, we calculate that every ten jobs in the software industry supported five more jobs in other industries – that is, the software industry had an employment multiplier of about 1.5 in 2012. Moreover, the software industry has a greater indirect impact on employment than many other industries. Using the same methodology, we found, for example, that the employment multiplier of 1.11 for the accommodations and food services industry, 1.14 for the retail industry, 1.12 for the education sector, 1.18 for the health care sector, and 1.19 for the arts, entertainment, and recreation sector.

Since software companies employed 2.34 million workers in 2012, this tells us that the purchases by software companies supported another 1.08 million jobs. All told, therefore, the software industry was responsible for 3.42 million jobs in 2012 (2.34 + 1.08 = 3.42). According to the most recent data from the Bureau of Labor Statistics, the software industry currently employs about 2.5 million workers. Using the 2012 employment multiplier, we find that in 2014, the software industry is responsible for about 3.65 million U.S. jobs.[24] A detailed industry-by-industry analysis of these indirect effects is provided in Appendix A.

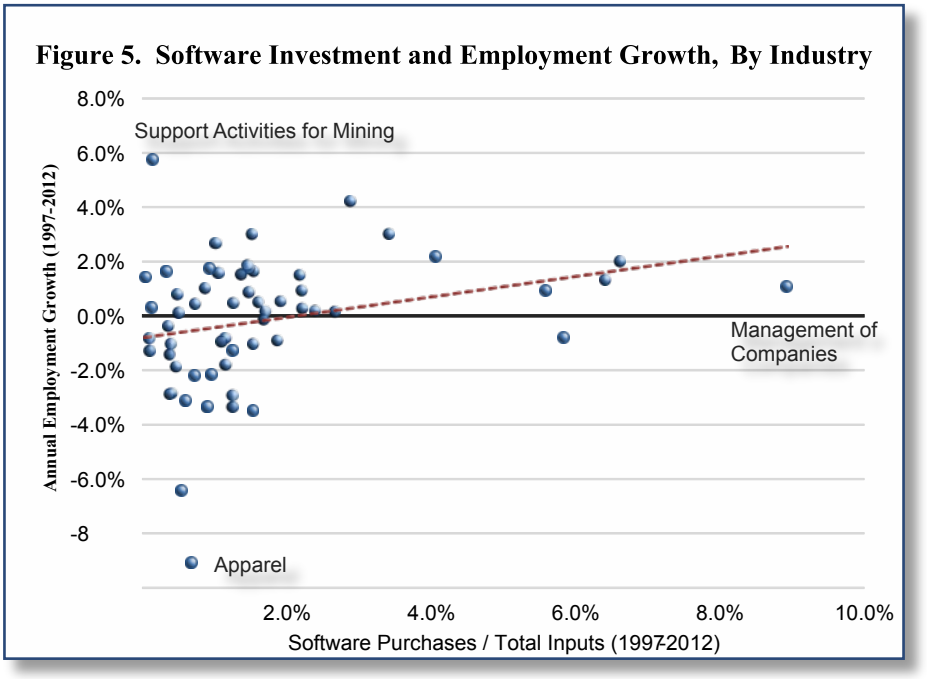
While this analysis can be used to estimate the additional jobs supported by the increase in wealth and incomes that follows from the software industry's contribution to productivity gains, it does not directly address concerns that the same productivity gains lead to job losses by the companies and industries that make sound use of software. Companies downsize their labor force for many reasons, from falling demand for their products to more efficient ways of producing those products. As noted earlier, when the downsizing is driven by efficiency gains

[23] This understates the size of the software industry. Detailed data from the BEA on final sales of software show sales totaling $382.4 billion in 2012. For analytic consistency, however, we use NAICS codes 5415 and 5112 to define the industry.

[24] These estimates of the indirect employment effects of the U.S. software industry also understate its full impact, because the analysis does not include "induced effects" associated with the consumption by workers employed by the software industry: Their earnings create additional demand for goods and services, which in turn require employment to satisfy that demand. We do not include these effects, because we cannot determine how many of those workers would have been employed elsewhere if the software industry did not exist.

associated with business investment, including investments in software and ICT generally, those job losses may be largely or entirely offset by new jobs based on additional demand which in turn comes from the higher incomes or wealth created by the efficiency gains. There is no empirical model, however, that can determine whether those offsets are smaller or larger than the original job losses. But if the use of software did tend to destroy jobs, on balance, we would expect to find a correlation, industry by industry, in software investments and employment losses. As Figure 5, below, shows, the industries that invested most heavily in software over the 15 years from 1997 to 2012 (financial services, scientific and technical services, education) had relatively strong rates of job growth, while industries investing the least in software experienced both high levels (mining) and low levels (apparel) of job growth. This suggests that far from destroying jobs, on a net basis, software investments may have positive effects on employment.

Figure 5. Software Investment and Employment Growth, By Industry

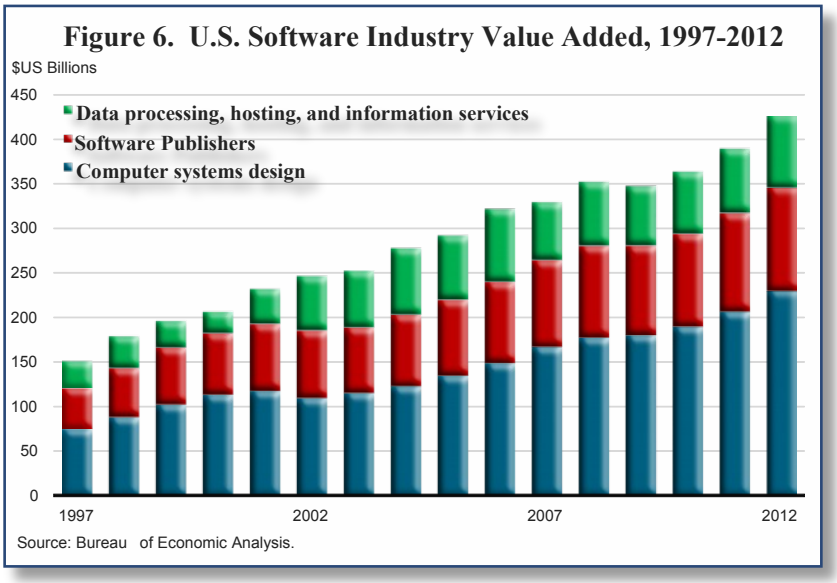


V. The Software Industry's Singular Success in Creating More Jobs during the 2008-2009 Recession and the Current Recovery

Our analysis also found that the software industry has been an unusually strong source of demand and employment growth in the Great Recession of 2008-2009 and the current recovery. This finding is part of the larger pattern. From 1997 to 2012, GDP grew at an average annual nominal rate of 4.3 percent. By contrast, the value-added or output of the computer systems design industry (NAICS code 5415) increased from $75 billion in 1997 to $230 billion in 2012, or at an average annual rate of 7.7 percent. Similarly, the output of the software publishing industry (NAICS code 5112) grew from $44 billion in 1997 to $115 billion in 2012, for average annual growth of 6.7 percent. Finally, the production of the data processing, hosting, and information services industry (NAICS codes 518 and 519) increased from $30 billion in 1997 to $80 billion in 2012, an average annual growth rate of 6.7 percent. All told, the output of the software industry grew from $149 billion in 1997 to $425 billion in 2012, for average annual growth of 7.2 percent – a growth rate 67 percent greater than overall economy over the same period.

The relative performance of the software industry, compared to the overall economy, has been even more impressive throughout the recent economic recession and subsequent recovery. Since 2007, the output of the computer systems design industry has increased at an average annual rate of 6.6 percent, the output of the software publishing industry has grown at an average annual rate of 3.5 percent, and the output of the data processing, hosting, and information services industry has increased at an average annual rate of 4.4 percent (Figure 6, below). All told, the software industry has grown at an average annual rate of 5.3 percent since 2012, compared to 2.3 percent for the overall economy: The software industry, therefore, has grown 130.4 percent faster than the rest of the economy.

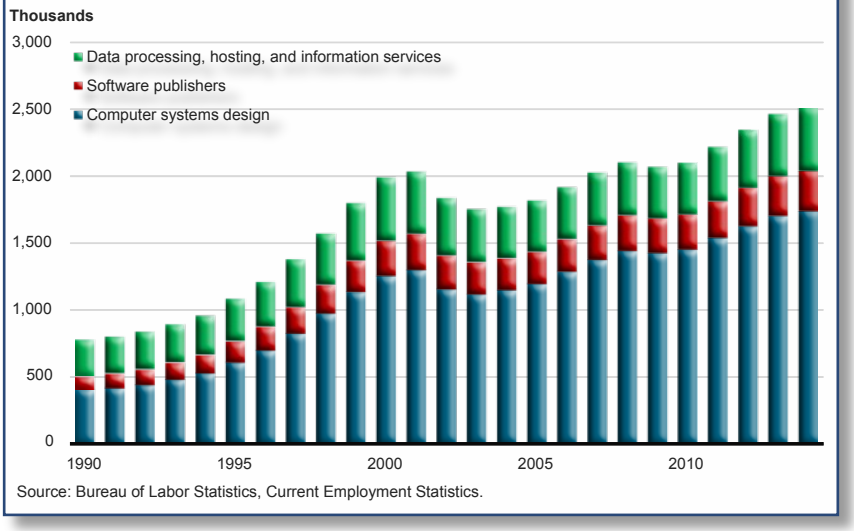
Figure 6. U.S. Software Industry Value Added, 1997-2012



Since the 1990s expansion, the U.S. economy has experienced periods of relatively strong GDP growth accompanied by only modest job gains, a development often referred to as a "jobless recovery."[25] This phenomenon has been a prominent feature of several of the economy's faster- growing industries. For example, since 2000, the output of the petroleum refining, oil and gas extraction, and mining industry has grown at an average annual rate of 11 percent per year while its total employment has declined by about 1 percent per year. By contrast, from 2000 to 2014, employment in the software industry has grown from just under 2 million positions to about 2.5 million positions, or about 1.7 percent per-year (Figure 7).

[25] See for example Groshen and Potter (2003); and Schreft and Singh (2003).

Figure 7. U.S. Software Industry Employment, 1990-2014



Source: Bureau of Labor Statistics, Current Employment Statistics.

As Figure 7 shows, employment in the software industry has continued to expand at a relatively healthy rate during the current difficult period for the economy. Since 2007, employment in the computer systems design industry has grown at an average rate of 3.4 percent per-year, employment in the software publishing industry has increased at an average rate of 2.3 percent per-year, and employment in the data processing, hosting, and information services industry has grown at an average rate of 2.6 percent per-year. All told, employment in the software industry has grown at an average annual rate of 3.1 percent per-year from 2007 to 2014, even as total nonfarm employment declined by 0.1 percent per year over the same period.

In fact, the software industry is one of the leading sources of new jobs in the American economy. Since 2008, the computer systems design industry, which accounts for about 85 percent of all software industry workers, has generated some 360,658 net, new jobs. Across the economy, only two other industries have generated more new jobs over this period -- the restaurant industry with 665,633 additional jobs, and the individual and family services industry (social assistance organizations) with 581,183 new jobs (Figure 8, below).

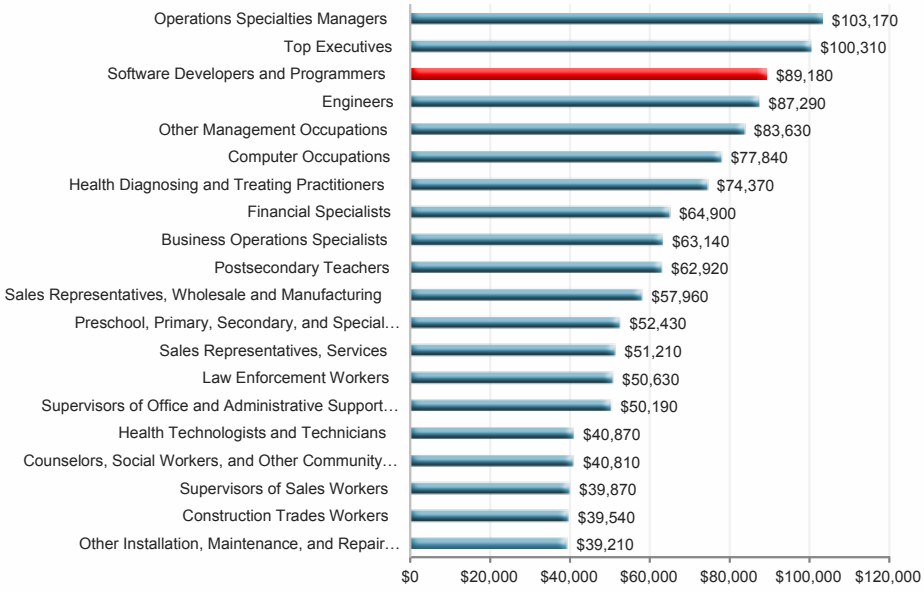
The software industry not only created an unusually large number of jobs in this difficult period; in addition, the jobs created by software companies are on average much higher quality than those created by other industries with large employment gains. The Bureau of Labor Statistics reports that five industries created more than 300,000 new jobs each from 2008 to 2014 – in addition to software, restaurants, and individual and family services, home health care services and retail (general merchandise stores). Apart from software, the four other industries produced relatively low-paying and often part-time positions.[26] Employees in the four other strong job-creating industries work on average less than 30 hours per week -- a common cutoff for full-time status with access to benefits – for wages averaging between $12 and $19 per-hour. The employees of the software industry work an average of 39 hours per week and are paid average of more than $42 per hour. As a result, the average annual income of workers in the computer systems design and related services industry, which again account for 85 percent of all

[26] For a discussion of this phenomenon, see Wiseman (Aug. 4, 2013); and Casselman (Aug. 3, 2013).

software industry employment, is $86,457 today, compared to $28,278 for home health care services workers, $23,394 for workers in the individual and family services industry, $22,502 for retail workers and $15,888 for restaurant workers (Figure 6, below). As a result, software workers earn, on average, three times as much as workers in the other four industries that created large numbers of new jobs.

In fact, according to the Occupational Employment Statistics database of the Bureau of Labor Statistics, software developers and programmers currently earned more in 2013 than any other major occupation in the economy, with the exceptions of "operations specialties managers," which covers chief information officers, chief technology officers, corporate controllers and treasurers, and "top executives," which covers Chief Executive Officers, Chief Operating Officers and Chief Financial Officers. (Figure 8, below)

Figure 8. Median Annual Income by Occupation, 2013:
Top 20 occupation groups with at least 1 million workers



Source: Bureau of Labor Statistics, Occupational Employment Statistics .

VI. Conclusions

This study has presented a rigorous empirical analysis of economic effects arising from the extraordinary diffusion of software across businesses and households throughout the American economy. Over the last 15 years, the software industry's economic footprint expanded by more than 50 percent, from 1.7 percent of U.S. GDP in 1997 to 2.6 percent of GDP in 2012, or some $425 billion. Over the same period, employment in the software industry increased by nearly 65 percent, from 1.4 million workers in 1997 to 2.3 million workers in 2012. Moreover, software industry employees earn, an average, about three times the average wage or salary for other private-sector workers in America.

Furthermore, business investments in software have increased at more than twice the rate of all other fixed business investments. The reason is clear: The use of software by businesses

was responsible for more than 15 percent of all U.S. productivity growth from 2004 to 2012, or more than one-third of the productivity benefits attributed to all information and communications technologies (ICT) considered as a whole. As a result, some $101 billion in output by other industries can also be attributed to the use of software. Therefore, the total U.S. production attributable to the software industry in 2012 was $526 billion in goods and services ($425 + $101 = $526), or 3.2 percent of U.S. GDP.

The software industry also has substantial indirect effects on employment. Much like many other types of businesses investment, the adoption of new forms of software entails both the creation of new jobs – for example, to design, produce, install and maintain new software – and the destruction of some old jobs rendered obsolete by the new programs. There are legitimate public concerns about job losses associated with the increased use of software, but there is no question that the job gains associated with that use dwarf any such job losses. For example, employment in the software industry increased in 2012 by 128,000 positions. Software industry demand for goods and services produced by other industries also increased in 2012 by $8.2 billion, and that additional demand supported another 43,800 new jobs. Beyond those direct effects, the 2012 increases in productivity in other industries attributable to software increased GDP by some $101 billion, which in turn supported another 850,000 new jobs in that year. So, the production and use of software in 2012 led directly to the creation of an estimated 163,000 new jobs – more jobs than could plausibly be linked to job obsolescence associated with software in that year -- plus another 850,000 new jobs linked indirectly to the production and use of software.

This study provides empirical analyses that support the intuition of most Americans, including most economists, that software has changed the operations of nearly every aspect of the American economy, and that the consequences of those changes, in the main, are resoundingly positive.

Appendix A

Input-Output Analysis of the U.S. Software Industry, 2012

Input-Output Analysis of the U.S. Software Industry, 2012

Sector Code	Sector Description	Computer Systems Design Output Demand	Software Publishing Output Demand	Data Processing, Internet Publishing Output Demand	Total Software Industry Output Demand	Total Sector Gross Output	Employment (Thousands)	Employment Attributable to Software Demand (Thousands)
11	Agriculture, Forestry, Fishing and Hunting	7	5	9	20	445,515	2,113	0
21	Mining, Quarrying, and Oil and Gas Extraction	35	8	122	165	572,306	801	0
22	Utilities	394	140	698	1,232	378,146	554	2
23	Construction	35	17	164	216	1,065,881	5,641	1
31-33	Manufacturing	9,756	3,256	19,297	32,310	5,800,665	11,919	66
42	Wholesale Trade	1,762	4,189	2,998	8,950	1,413,058	5,673	36
44-45	Retail Trade	620	137	745	1,501	1,478,108	14,875	15
48-49	Transportation and Warehousing	3,589	1,508	6,871	11,968	965,255	4,415	55
51	Information	5,059	4,507	5,256	14,822	1,377,783	2,678	29
52	Finance and Insurance	5,587	2,542	3,221	11,349	1,999,422	5,834	33
53	Real Estate and Rental and Leasing	10,899	3,835	11,113	25,848	2,832,376	1,952	18
54	Professional, Scientific, and Technical Services	16,531	7,735	15,943	40,209	1,750,594	7,892	181
55	Management of Companies and Enterprises	3,199	2,148	1,842	7,189	531,148	2,008	27
56	Administrative and Support and Waste Management and Remediation Services	22,299	5,412	6,070	33,781	746,063	8,030	364
61	Educational Services	515	40	616	1,172	311,727	3,347	13
62	Health Care and Social Assistance	189	10	237	436	1,937,585	16,972	4
71	Arts, Entertainment, and Recreation	832	431	649	1,913	268,584	1,966	14
72	Accommodation and Food Services	5,079	1,472	3,380	9,931	806,754	11,780	145
81	Other Services (except Public Administration)	1,341	420	1,495	3,257	579,634	6,175	35
92	Public Administration	2,458	394	3,322	6,175	3,432,857	21,917	39
Total		**90,188**	**38,207**	**84,049**	**212,444**	**28,693,461**	**136,540**	**1,077**

Source: Bureau of Economis Analysis, author's calculations.

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