Connecticut Information Technology: Powering the Connecticut Economy

The Economic Impact of Connecticut's Information Technology Industry

Fred V. Carstensen, Director
William F. Lott, Director of Research
Stan McMillen, Manager, Research Projects
With valuable research assistance from Joel Corona, Madhuri Saripalle, and Xiaozhong Liang,

Revision Date:
April 7, 2003

CONNECTICUT CENTER FOR ECONOMIC ANALYSIS©
University of Connecticut
341 Mansfield Road
Unit 1240
Storrs, CT 06269
Voice: 860-486-0485 Fax: 860-486-0204

http://ccea.uconn.edu

Executive Summary

One of every 10 workers in Connecticut worked in a Software/IT-related position in 2001, demonstrating the importance of that sector to the state economy, this new report concludes. The CT Technology Council commissioned "Connecticut Information Technology: Powering the Connecticut Economy," with research conducted by the University of Connecticut's Connecticut Center for Economic Analysis (CCEA).

The 10 percent of state workers engaged in Software/IT-related jobs – those who intensively produce or use Information Technology – represents approximately 175,000 jobs out of Connecticut's 1.7 million strong workforce.

Other key findings of the study:

For each of Connecticut's "essential" Software/IT jobs (those that directly produce computer hardware, software or networks – approximately 66,000 jobs in 2001), another 2.33 jobs were created in the Connecticut economy (the total multiplier is 3.3).

Approximately 109,000 jobs are Software/IT "related," referring to intensive use of IT technology in diverse work environments (that is, essential- and IT-related jobs total 175,000 in 2001). These 175,000 IT-related jobs in turn leverage an additional 172,000 jobs in the Connecticut economy in any given year through multiplier effects. The implied total multiplier in this case is 1.98 because many IT-related jobs are in smaller impact industries. Because of the higher paying (more productive) jobs in Connecticut, population grows by almost 590,000 people in any given year.

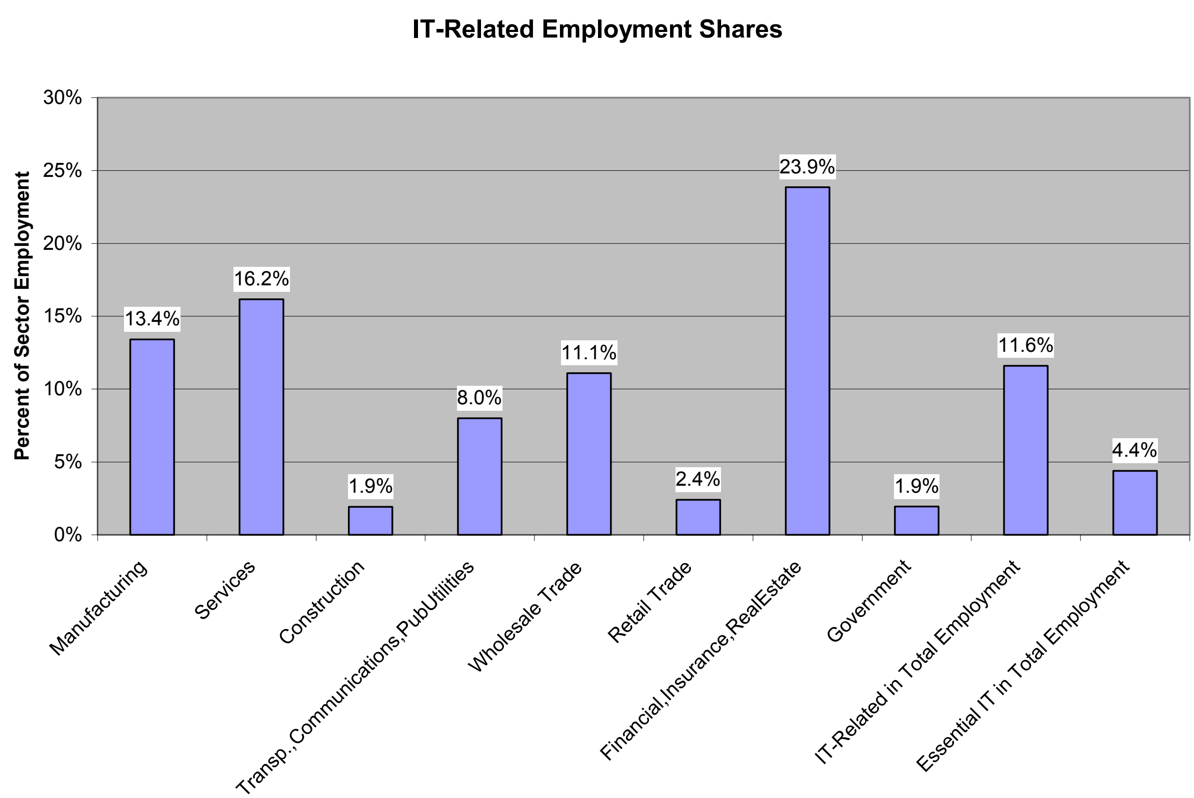
20.9% of Connecticut's total employment is attributable to essential Software/IT through multiplier effects.

Each Software/IT-related and essential IT job (in total, those that intensively produce or use IT) adds $493,000 in new state output for a 59.5% total increase in Connecticut's GSP generated through multiplier effects in any given year.

Furthermore, each IT-related job generates an additional $195,000 in new personal income for Connecticut residents for a 24% total increase and more than $23,400 in new state revenue per IT-related job for a total increase of 22.7% through multiplier effects in any given year.

Connecticut's IT-related workers are ubiquitous in the state's economy, with the largest concentration in the service industries and other significant concentrations in the manufacturing and FIRE sectors. The year 2001 percentages represent the share of industry employment that is IT-related. IT-related jobs represent 11.6% of all Connecticut jobs, while essential IT jobs represent 4.4% of total Connecticut employment. One could expect a significant reduction of IT jobs from the Connecticut economy to devastate these industries.

Distribution of IT-Related Employment Across Connecticut Industries



CCEA

The report details the significance of “essential” and “related” Software/IT jobs to the Connecticut economy by showing the vast ripple effects they exert through the economy. Jobs in the Software/IT cluster and the productivity they create translate into increases in disposable income, total factor productivity (TFP) and Gross State Product (GSP) and decreases in selling prices, and increases in labor and capital costs (because they are both more productive). Continued growth would only increase the competitiveness of Connecticut companies compared to their national counterparts and an increase in these companies’ market shares.

The CT Technology Council, the state’s largest technology industry association, commissioned the study as part of its on-going mission to promote the growth and awareness of the Software/IT Cluster.

CCEA used public data sources and the Connecticut Economic Model (REMI) in analyzing economic impact in the Software/IT sectors of the economy. CCEA assumes that the impact of IT in Connecticut arises from two sources: increases in employment and productivity. People in IT occupations work in firms that create IT products and in firms that intensively use IT products and services in the production of their output. In each case, IT products dramatically improve Connecticut’s labor and total factor productivity.

Table of Contents

CCEA

Introduction

The Connecticut Technology Council has asked the Connecticut Center for Economic Analysis (CCEA) to measure the economic impact of information technology on the Connecticut economy. That would seem simple enough, except to define what information technology (IT) is and through what channels it acts to produce impact. These days most people have some idea about what IT is and how it may produce economic growth. IT certainly includes computer software and hardware production; it also is network deployment and administration. IT encompasses a broad range of occupations found in almost every Connecticut industry. We do not distinguish for purposes of this analysis firms or occupations that produce IT goods and services from firms or occupations that use them. Our 'definition' of IT occupations is therefore broader than that used for example in the Battelle and CERC reports.[1] To the extent that self-employed persons are omitted from these reports, the Occupational Employment Statistics', and the Connecticut Department of Labor's counts, our analysis is conservative.

Each firm and occupation (IT user or producer) benefits from IT. Benefits take the form of employment in IT-producing occupations and the increased productivity that results from using IT (e.g., with PCs, robots, automated testing, CAD/CAM, molecular modeling, computational fluid dynamics). Productivity improvements include labor productivity and multi- (sometimes called total) factor productivity. CCEA imputed the effects of Connecticut's IT uptake due to total factor productivity (TFP). A TFP measure is preferred over a partial productivity measure such as output per unit of labor, because partial productivity measures can provide a misleading picture of economic performance. Thus, we have accounted (we believe) for a broad range of effects of IT labor and capital (and services) on the Connecticut economy. One should read the first three sections of the literature review in Appendix 4 to glean basic insight into our approach and the context of our analysis.

[1] Battelle Study (2001), "Information technology workforce strategy for the state of Connecticut."
Connecticut Economic Resource Center (2001), "Information Technology Occupations in Connecticut," (January).

Connecticut's Department of Labor graciously assembled the IT employment profile for Connecticut by detailing the number of jobs for each IT occupation (as defined by BLS and CERC) aggregated by 2-digit industry in Connecticut. However, we think these occupational categories seriously understate those occupations that depend heavily on IT, in fact, their jobs could not be performed in many cases were it not for IT. Consider the biotech scientist who uses molecular modeling to discover new drugs or the marketing manager who uses data mining to understand relevant markets and their potential. Consider the graphic designer or the special effects people in the motion picture industry who use computers very creatively. Consider the aeronautical engineer who designs aircraft and tests them using CAD/CAM and finite element stress analysis. The old design and test methodology was to create crude designs and 'build it and bust it' iteratively. Therefore, our more inclusive set of occupations includes the core IT professionals who create hardware, software and networks, as well as those who use this technology intensively to perform their job. Our expanded dataset complements those of Battelle and CERC and represents new information (see Appendix 1). The Quinnipiac Survey, while not used in this report, provides additional new information on IT in Connecticut, specifically about firms that produce software for sale.[2]

The approach we take to measure the economic impact of IT on Connecticut is to subtract it from the Connecticut economy. The difference between the current level of the Connecticut economy and the void left by IT's counterfactual absence, measures its economic impact. We do not allow for any substitute activity to evolve in the absence of IT: that would diminish and dilute the wide ranging, cumulative economic effects that IT has wrought, and would constitute an opportunity cost analysis. The issue in that case is to determine the magnitude and distribution of 'the next best alternative.' In reality, the departure of an industry would set in motion capital and labor substitution processes as relative factor prices change and encourage the entry and exit of firms in certain markets. Through our counterfactual approach we estimate the essentially instantaneous impact of IT's highly evolved and ongoing impact.

[2] 2001 Connecticut Technology Council, Survey Results, December 2001, Mark A. Thompson, PhD, Quinnipiac University, School of Business, 275 Mt. Carmel Ave., Hamden, CT 06518, 203-582-8914, DRAFT FOR CTC REVIEW.

We conclude several things from our broad overview of the IT literature. While much has been written in the economic literature on the contribution of IT investment to productivity ***growth***, few venture to measure the impact of out-sourced, in-house, and embedded software production on productivity ***levels***. Several studies estimate the output elasticity of IT (see Stiroh (2002)). Some studies have attempted to analyze the impact of technology in a dynamic setting. Others compare the IT sector in Connecticut to other states across the nation. No study combines IT employment and productivity gains in a dynamic impact analysis. Our study is unique in both the dynamic model (REMI) we use and in the method by which we measure the various contributions of the IT sector to the Connecticut economy. In the next section, we provide a description of our methodology followed by an exposition of our results.

Methodology and Modeling Strategy

We assume the impact of IT in Connecticut arises from two sources: increases in employment and productivity. People in IT occupations work in firms that create IT products and in firms that use IT products and services in the production of their output. In each case, IT improves labor and total factor productivity (as defined by Brynjolfsson and Yang [1996] in footnote 4, page 33). We examine the employment and total factor productivity impacts separately and in total on the Connecticut economy.

The employment impact arises from the number of IT-related employees in Connecticut IT-producing and IT-using industries. The change in total factor productivity is measured by the Tornqvist index[3] of TFP of Connecticut's industries relative to U.S. industries, that is, we assume no TFP or employment changes take place outside Connecticut. The Tornqvist index represents the change in output relative to the change in each input (capital and labor) in each 2-digit Connecticut industry. We measure these changes from a Connecticut economy with IT to one without IT. We estimate the change in an industry's output (measured as valued added or GSP) as the difference between its year 2000 GSP and the sum of the industry's (year 2000) IT wage bill and its IT spending relative to its GSP. The IT wage bill is the sum of the products of the number of IT workers in each IT occupation and its average wage. IT spending represents the flow of services from IT 'capital' including hardware, software, networks and services. Metagroup supplied year 2000 IT spending data at the 1-digit industry level. We scale this spending by using the 2-digit industries' employment shares in 1-digit industries' total employment to impute IT spending at the 2-digit level. We need IT spending at the 2-digit level because industries exist at that level in the Connecticut Economic Model (REMI). We estimate the change in an industry's inputs as the product of the proportional changes in each input raised to the power of their value share. This procedure is standard in estimating TFP changes (see Appendix 2).

The challenge in this study is the assumption of what the Connecticut economy looks like after the counterfactual disappearance of IT. Prices of goods, services and labor surely change, but by how much? Does industry output simply change by the lack of IT spending and the IT wage bill? We assume that prices are the same in each economy and that industry output simply changes (declines) by the sum of IT spending and the IT wage bill representing the change in the value added (that is, payments to factors). We assume the only inputs to production are undifferentiated capital that includes hardware, software, IT services and physical capital, and undifferentiated labor that includes laborers and knowledge workers.

In general, when total factor productivity is increased, firms produce the same output using both less labor and less capital. When labor productivity is increased, firms produce the same output using less labor, and they substitute labor for capital. For both (regional) productivity variables, relative profits increase for Connecticut's national industries, while relative industry sales prices should fall for regional industries. Because we use both TFP and employment variables in REMI, we suppress in REMI investment and intermediate demand due to IT employment changes. The TFP calculation partially accounts for IT employment-related investment and intermediate demand and we avoid double counting by these suppressions.

We allocate IT employment by IT occupations across Connecticut's 2-digit industries. The Connecticut Economic Resource Center Inc. (CERC) Occupational Demand Study identifies 12 occupations in IT-related industries (CERC, 2001).[4] The Bureau of

---

[3] See, Coelli, Rao, and Battese (2002), An Introduction to Efficiency and Productivity Analysis, chapter 4, Kluwer Academic Publishers.

[4] These 12 occupations are systems analysts, computer support specialists, computer programmers, engineering/math/info systems managers, computer engineers, electrical & electronics engineers, electrical & electronic techs/technologists,

Labor Statistics (BLS) Occupational and Employment Statistics (OES) includes additional IT occupations under their Computer and Mathematical Occupations category. We combine the two definitions to cover the following 17 occupations in IT producing and using industries: computer and information scientists, research; computer programmers; computer software engineers, applications; computer software engineers, systems software; computer specialists, all other; computer support specialists; computer systems analysts; database administrators; network and computer systems administrators; network systems and data communications analysts; computer programmer aides; computer operators; data entry keyers; data processing equipment repairers; electrical and electronics engineers; electrical and electronics technicians; and, engineer/math/information system managers. These two definitions are similar except that the latter includes occupations related to networking.

We augment the combined definition with occupations that, in our judgment, intensively produce or use IT in the performance of their jobs. For example, computer hardware engineers as an occupational category is missing from the CERC/BLS definition. Absent as well are several occupations such as computer science teachers, postsecondary, graduate teaching assistants, multimedia artists and animators, desktop publishers, computer repairers, computer controlled machine operators, numerical tool and process control programmers, and air traffic controllers who depend heavily on IT to perform their jobs. Because we include these additional ***essential*** IT occupations, our approach is broader and likely to produce a more comprehensive analysis. By aggregating the number of employees in different occupations within each industry, we obtain total ***essential*** IT employment in each 2-digit industry in Connecticut. The table in Appendix 1 shows the Connecticut industry distribution detail for each IT occupational category. Table 1 below aggregates essential IT employment across 2-digit Connecticut industries for the year 2000. Several OES occupational categories had insufficient employment data and the Connecticut DoL could not provide certain employment numbers at the 2-digit level because of confidentiality. In the latter case, we evenly allocate the remainder of reported OES employment to each suppressed industry slot within an occupation. The essential 65,851 IT jobs in Connecticut are therefore understated.

---

database administrators, data entry keyers (except composing computer operators and peripheral equipment), data processing equip repairers, and computer programmer aides.

We believe there are many more jobs in all sectors that depend heavily on IT and therefore the analysis using only essential IT jobs is conservative. We therefore further augment essential IT occupations with IT-related occupations. These include engineering managers, accountants and auditors, budget analysts, credit analysts, financial analysts, personal financial advisors, actuaries, mathematicians, operations research analysts, statisticians, architects, except landscape and naval, cartographers and photogrammetrists, engineers of all kinds, drafters of all kinds, technicians of all kinds, scientists of all kinds, market research analysts, survey researchers, lawyers, postsecondary teachers of all kinds other than computer science, librarians, graphic designers, editors, technical writers, pharmacists, securities, commodities, and financial services sales agents, travel agents, sales engineers, telemarketers, legal and medical secretaries, word processors and typists, and, telecommunications line installers and repairers. One could argue that additional occupations should be included, in fact, IT use is so ubiquitous that perhaps all jobs are IT-related. We have included what we believe are the most intensive IT users. We report results for both groups focusing on results for the essential group.

Table 1 reports as well the 174,359 IT-related jobs by sector that includes the 65,851 essential jobs. These occupations' functions would be extremely difficult to perform were it not for the IT networks, hardware and software they use intensively. In the counterfactual economy, these workers would have to perform their jobs the old-fashioned way—with calculators and pencils. They would not be nearly as productive and their wages would decline relative to other regions. They would likely migrate away from Connecticut over time to find jobs commensurate with their skills. Connecticut would become drastically less competitive relative to other states. We report results primarily for essential IT employment and productivity in this study and claim they are conservative for this reason. In addition, we have omitted the government sector from the essential IT impact because of the lack of data necessary to calculate its Tornqvist index.

Table 1: Connecticut IT Employment by Industry

Connecticut IT Employment by 2-Digit Industry-2000

SIC Code	Industry	IT-Related Employment	Essential IT Employment
15	Building construction--general contractors	300	0
16	Heavy construction	70	0
17	Construction	520	20
20	Food and kindred products	100	10
22	Textiles	20	10
24	Lumber and wood products	20	0
25	Furniture and fixtures	10	0
26	Paper	555	200
27	Printing and allied products	4270	1110
28	Chemicals and allied products	4882	825
30	Rubber and miscellaneous plastics products	770	360
32	Stone, clay, glass and concrete products	30	0
33	Primary metal industries	860	480
34	Fabricated metal products	2000	560
35	Machinery and computer equipment	5753	2510
36	Electronic equipment, except computer equipment	4909	1079
37	Transportation equipment (Motor vehicles and others	5900	2048
38	Instruments and related products	4437	1583
39	Miscellaneous manufacturing industries	180	20
41	Local and suburban transit and interurban highway passenger transportation	20	0
42	Motor freight transportation and warehousing	90	0
44	Water transportation	180	90
47	Other transportation and transportation services	2240	180
48	Communications	2740	660
49	Electric, gas, and sanitary services	670	90
50	Wholesale trade-durable goods	6253	3863
51	Wholesale trade-nondurable goods	2793	810
52	Retail trade-Building materials, hardware, garden supply, & mobile home dealers	90	60
53	Retail trade-General merchandise stores	60	0
54	Retail trade-Food stores	470	110
55	Retail trade-Automotive dealers & gasoline service stations	255	205
56	Retail trade-Apparel & accessory stores	50	10
57	Retail trade-Home furniture, furnishings, & equipment stores	420	370
59	Retail trade-Miscellaneous retail	3444	464
60	Depository and non-depository credit institutions	2521	1259
61	Non-depository institutions	1946	809
62	Security and commodity brokers and investment services	8686	3254
63	Insurance carriers	13805	7865
64	Insurance agents, brokers, and services	1768	520
65	Real estate	3351	1294
67	Holding and other investment offices	1695	280
70	Hotels, rooming houses camps and other lodging places	80	0
73	Business services	29915	22575
75	Automotive repair, services and parking	20	0
78	Motion Pictures	50	20
79	Amusement and recreation services	510	220
80	Health services	8120	1700
81	Legal, engineering and management, and misc. Services	10116	889
82	Educational services	11189	2805
83	Social services	1000	210
84	Museums, art galleries, and botanical and zoological gardens	550	0
86	Membership organizations	2170	140
87	Engineering, accounting, research, management, and related services	17437	3275
89	Miscellaneous Services	240	20
90	Government	3830	990
	Total	174,359	65,851

Finally, the data for IT employment, annual wages, industry GSP and total employment are for the year 2000. Appendix 3 contains a description of the REMI model and the input producing the results below.

Results

As we are interested in the impact of an existing industry, we counterfactually remove it from the Connecticut economy. The difference between the forecast of Connecticut's economy ***with and without*** its IT-related employment and productivity is the impact or value of IT to Connecticut. We are interested in the long run results after the Connecticut economy adjusts fully to the presence (counterfactually, the absence) of IT in Connecticut. The reported total impact of IT is composed of direct (e.g., employment), indirect (e.g., business-to-business activity) and induced (rounds of spending by wages earned and spent by the direct and indirect employment) effects throughout Connecticut. Table 2 represents the results of the combined productivity and employment shocks (that is, the addition or removal of the associated direct activity) due to ***essential*** IT. Tables 3 and 4 summarize separately the key results for the economic impact of essential IT due to employment and productivity.

The reported numbers appear as positive changes in values from the baseline forecast in the terminal year, 2035, of the study period reflecting IT's positive, continuing contribution to the Connecticut economy. The baseline forecast is the long run forecast of the Connecticut economy ***with*** IT employment and productivity built in. The charts below show the time paths of key economic variables. The year 2035 represents the economy's long run equilibrium, as it is REMI's last forecast year.

The economy ***counterfactually*** responds as follows: direct ***essential*** IT employment of 65,851 disappears from the state economy and jobs and labor productivity decline due to its absence. Through the employment multiplier, in any given year in the long run, employment declines by more than 219,000 total jobs. This release of labor reduces the real wage rate as demand for IT labor shifts downward. The productivity shock comes in two parts: labor and total factor productivity both decline driving down the real wage. These forces reduce the price of labor and, initially, the quantity of labor demanded increases (a movement along the labor demand curve). However, output (GSP) declines due to falling employment and productivity, profits decline and selling prices increase which decreases real disposable income (goods are locally more expensive). Market shares for local and export goods decline and over time employment declines because Connecticut firms cannot compete with their cohorts in other regions (whose IT-related productivity and employment has not declined). Table 2 presents results for the total effects of the loss of all essential IT jobs and the total factor productivity they create. These results (changes from the baseline forecast of the Connecticut economy) are relative to the 2001 levels of the variables.

Table 2: Economic Impact of Essential IT Employment & Productivity in Connecticut

Combined Employment & Productivity Effect		
Variable Year	2035	% Current CT
Population (Units)	420,700	13.1%
Employment (Jobs)	219,600	13.2%
Private Non-Farm (Jobs)	194,700	11.8%
GSP (Mil 2001$)	$64,646	44.6%
Pers Inc (2001 mil $)	$19,365	13.7%
State Revenues at State Average Rates (Mil 2001$)	$2,385	13.3%
State Expenditures at State Average Rates (Mil 2001$)	$835	5.0%

The effects of the three shocks are not strictly additive: there is some offsetting effect of the large release of labor and the total factor productivity decline. The larger excess supply of labor in the region induces real wage rate reductions that may outweigh the loss of profits and market share so that in the combined (employment and TFP) case, total employment declines less than the sum of employment in the employment and productivity cases (219,600 jobs versus 270,600 jobs). The larger long run wage reductions lead to lower costs in certain industries relative to their national competitors in the combined case that in turn leads to lower GSP growth relative to the sum of GSP in the separate employment and productivity cases (Tables 3 and 4). GSP measures the value of all goods and services produced in Connecticut in a year on a value added basis and is a (size) measure of overall economic activity. Personal income is the aggregate income earned by state residents and is a measure of overall wellbeing.

The magnitude of the combined IT employment and productivity contributions to the Connecticut economy is striking: for each 'essential' IT job, there are another 2.33 jobs created in the Connecticut economy resulting in a 13.2% increase in total employment, and an additional $979,485 in GSP resulting in a 44.6% increase in total GSP through multiplier effects. Each essential IT job generates an additional $294,000 in

Connecticut personal income and more than $36,000 in new state revenue, while increasing state spending by $7,745 through multiplier effects. We believe these results are conservative due to the lack of data for the public sector and suppressions by BLS and CT DoL.

Table 3: Economic Impact of ESSENTIAL IT Employment in Connecticut

Employment Effect		
Variable Year	2035	% Current CT
Population (Jobs)	187,100	5.8%
Employment (Jobs)	137,200	8.3%
Private Non-Farm (Jobs)	126,100	7.6%
GSP (Mil Fixed 2001$)	$22,102	15.2%
Pers Inc (Mil 2001 $)	$15,146	10.7%
State Revenues at State Average Rates (Mil 2001$)	$2,004	11.1%
State Expenditures at State Average Rates(Mil 2001$)	$343	2.1%

Table 4: Economic Impact of ESSENTIAL IT Productivity in Connecticut

Productivity Effect		
Variable Year	2035	% Current CT
Population (Units)	307,200	9.6%
Employment (Jobs)	133,400	8.0%
Private Non-Farm (Jobs)	115,200	7.0%
GSP (Mil Fixed 2001$)	$49,425	34.1%
Pers Inc (Mil 2001 $)	$9,014	6.4%
State Revenues at State Average Rates (Mil 2001$)	$1,180	6.6%
State Expenditures at State Average Rates(Mil 2001$)	$614	3.7%

Considering the economy without IT-related employment and the TFP of essential IT employment and IT spending portrayed in the positive sense in Table 5, we see a much greater impact relative to the combined essential IT impact in Table 2.

Table 5: Economic Impact of IT-Related Employment & Productivity in Connecticut

Combined IT-related employment + essential TFP		
Variable Year	2035	% Current CT
Population (Thous)	589,600	18.4%
Employment (Jobs)	347,300	20.9%
Private Non-Farm (Jobs)	312,300	18.9%
GSP (Mil Fixed 2001$)	$86,237	59.5%
Pers Inc (Mil 2001 $)	$34,098	24.2%
State Revenues at State Average Rates (Mil 2001$)	$4,080	22.7%
State Expenditures at State Average Rates(Mil 2001$)	$1,158	6.9%

These results obtain from counterfactually removing essential IT employment and the additional 108,508 IT-related workers from the Connecticut economy and the TFP accruing only to essential IT employment.

These results imply that if we include IT-related jobs as we have defined them, for each IT-related and essential IT job, one additional job is created in the Connecticut economy resulting in a 20.9% increase in total employment through multiplier effects. Each IT-related and essential IT job adds $489,983 in new GSP for a 59.5% increase in the state's value added through multiplier effects. Each IT-related and essential IT job generates an additional $195,562 in Connecticut personal income and more than $23,400 in new state revenue, while increasing state spending by $4,141 through multiplier effects.

Essential IT Transition Dynamics Response

The transition dynamics illustrate the endogenous adjustment process of the Connecticut economy as it responds counterfactually to the disappearance of essential IT employment and IT spending. The graphs and narrative below depict these responses positively to reflect the ongoing, positive contribution of IT to the Connecticut economy. Figures 1, 2, and 3 below show the time path of the ***changes in*** GSP and personal income from the REMI baseline forecast under the combined ***essential*** employment and productivity IT impact, ***essential*** IT employment only impact and ***essential*** IT TFP only impact scenarios, respectively from 2000 through 2035. These changes from the REMI baseline forecast do not represent year over year changes.

Both GSP and personal income increase smoothly over time and reach their peak in 2035 in the combined case. Personal income represents payments to labor, while GSP represents payments to all factors. Interestingly, the employment impact exhibits a flipped relative trend between GSP and personal income, because initially there is a shortage of labor and wages are bid up. In the long run, labor demand and supply catch up and GSP exceeds personal income. In the TFP only case, the initial surge in productivity depresses wages because fewer workers are needed to produce the same output. In the long run, Connecticut firms become more competitive as their prices fall and pass along productivity improvements in increased wages. However, notice that the change in GSP is much larger than that of personal income in the productivity case. This is because employment and therefore personal income does not increase as much as in the employment only case. On the other hand, in the productivity (TFP) only case, the change in value added (GSP) increases much more than in the employment only case because the productivity improvements reduce sales prices and increase wages and profitability relative to other regions, whereas exclusive employment changes do not have this effect.

Figure 1

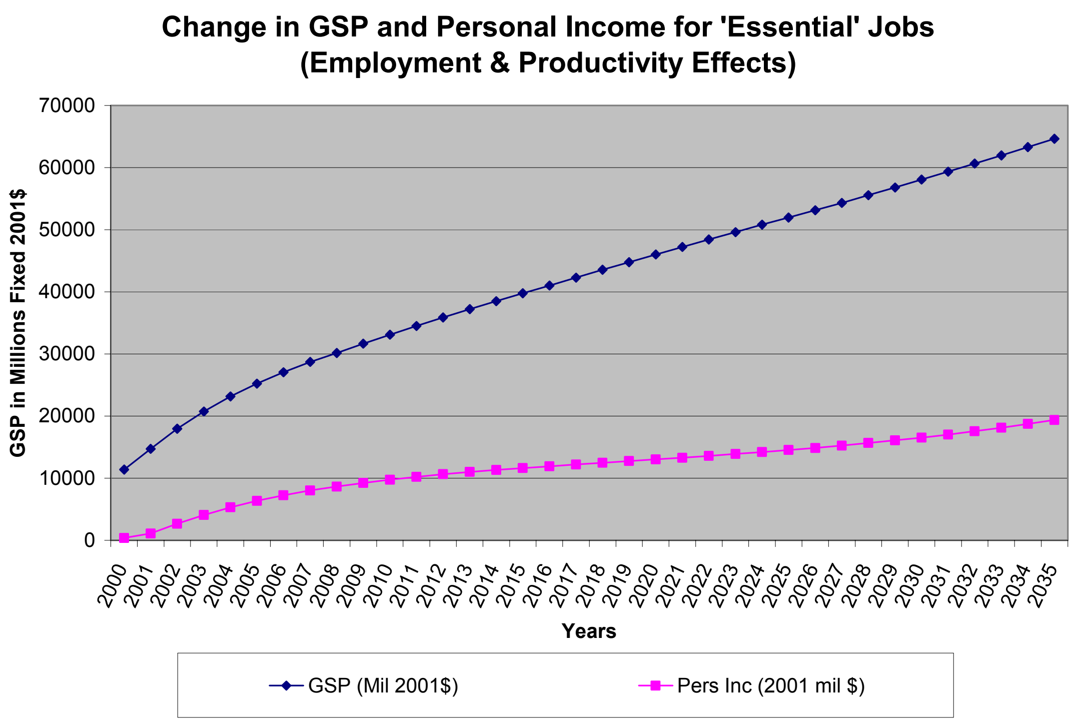


Figure 2

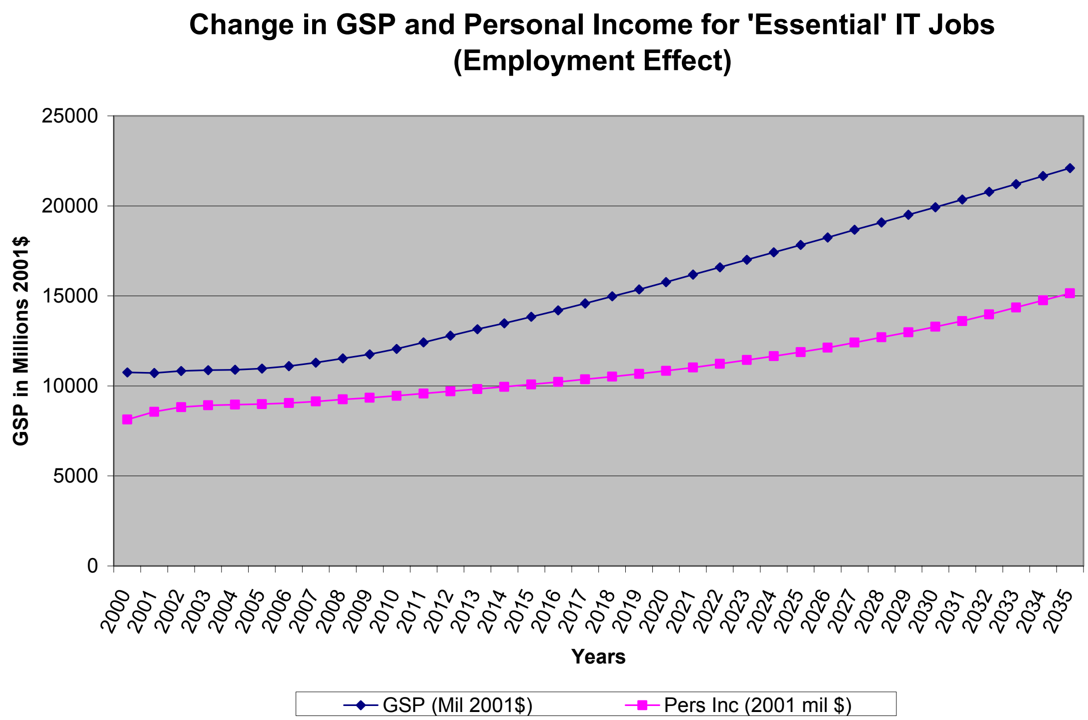
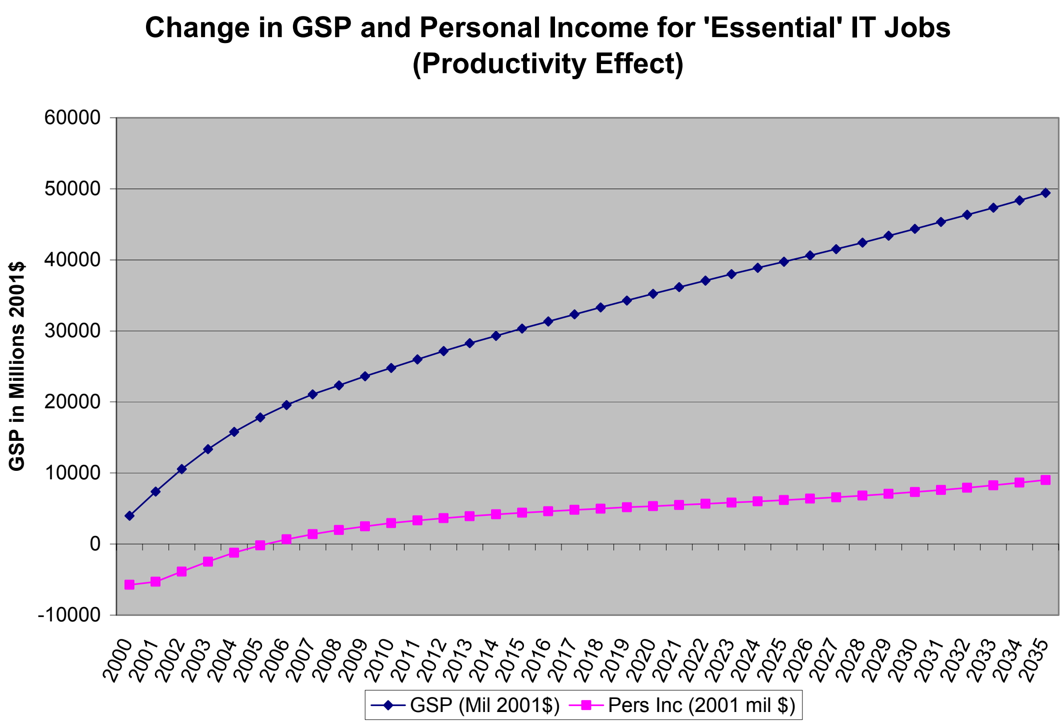
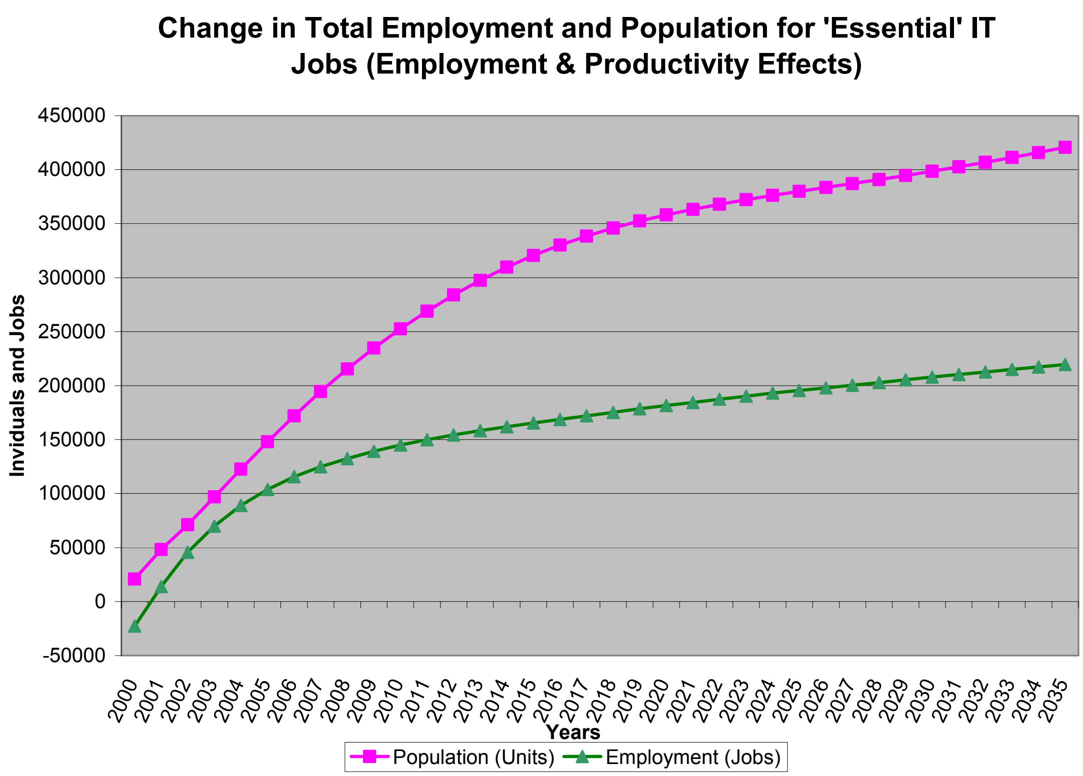


Figure 3



Employment change (that is, jobs created) and new population are important measures of economic impact because they describe the situation in the labor market that closely relates to the health of the whole economy. Figures 4, 5, and 6 represent the time trends of the ***changes*** in population and private non-farm employment under the combined essential IT employment/TFP impact, the impact of essential IT employment only, and the impact of essential IT productivity only, respectively. As with the changes in GSP and personal income, changes (counterfactual losses) in private non-farm employment and population steadily increase for 30 years to 2035. This is because as Connecticut's workforce becomes more productive relative to other regions, output prices drop, Connecticut firms' market shares increase, and they add workers.

Figure 4



Figures 5 and 6 show initially countervailing effects. The addition of IT jobs in year 2000 (and the same number each year thereafter) creates growth in the economy generally. However, the initial TFP increase releases labor because it (and capital) is suddenly more productive and less of both is needed to produce the same output. Gradually, Connecticut's competitive position (relative costs and profit) improves relative to other regions and its employment takes off.

Figure 5

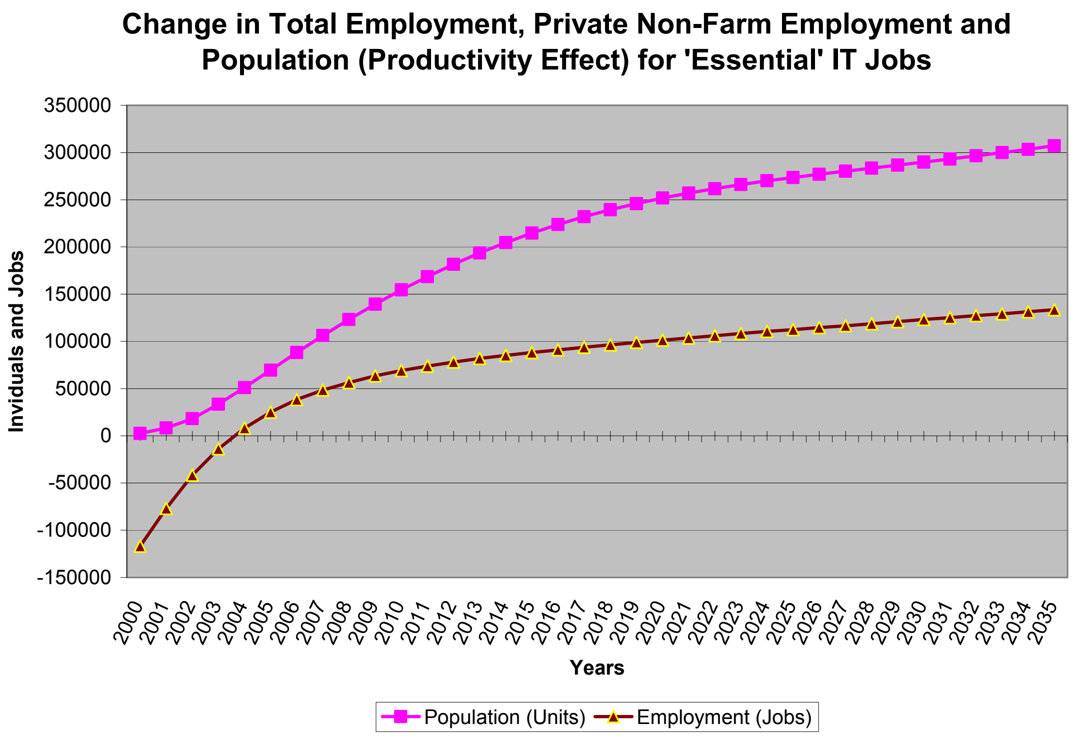
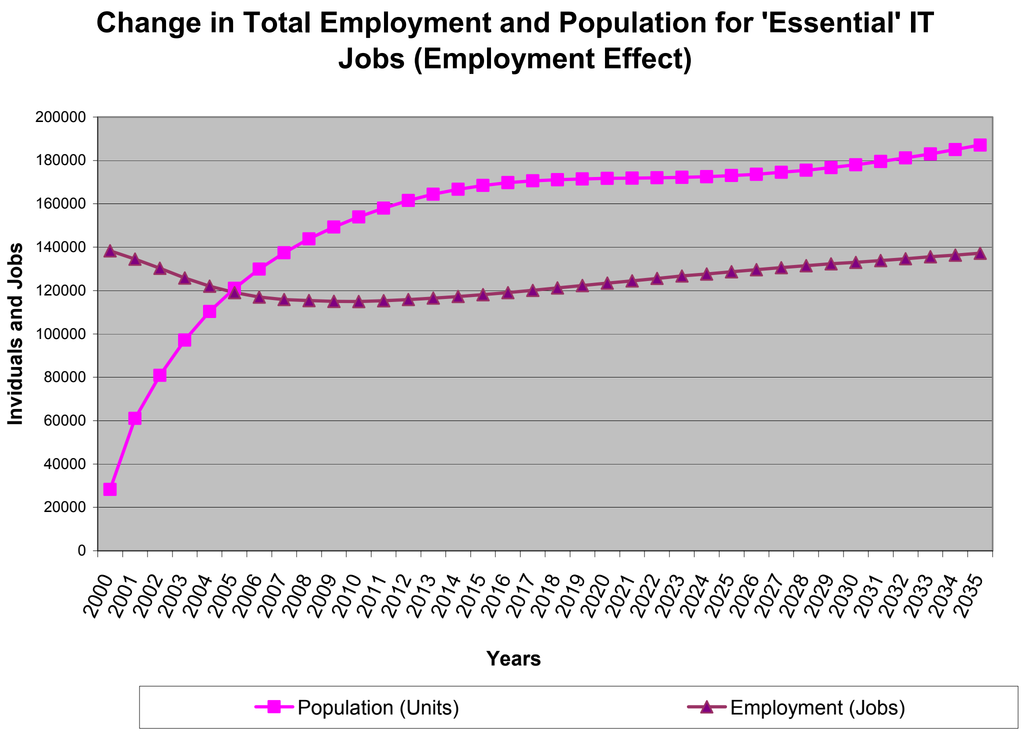


Figure 6



Figures 7, 8 and 9 show the Long-run Equilibrium (LRE)[5] values for private non-farm and total job growth, as well as for population. The difference between total employment and private, nonfarm employment is public, farm employment, of which public employment is the lion's share.

[5]We take the value at the terminal year (i.e., 2035) as the Long-Run Equilibrium value.

Figure 7

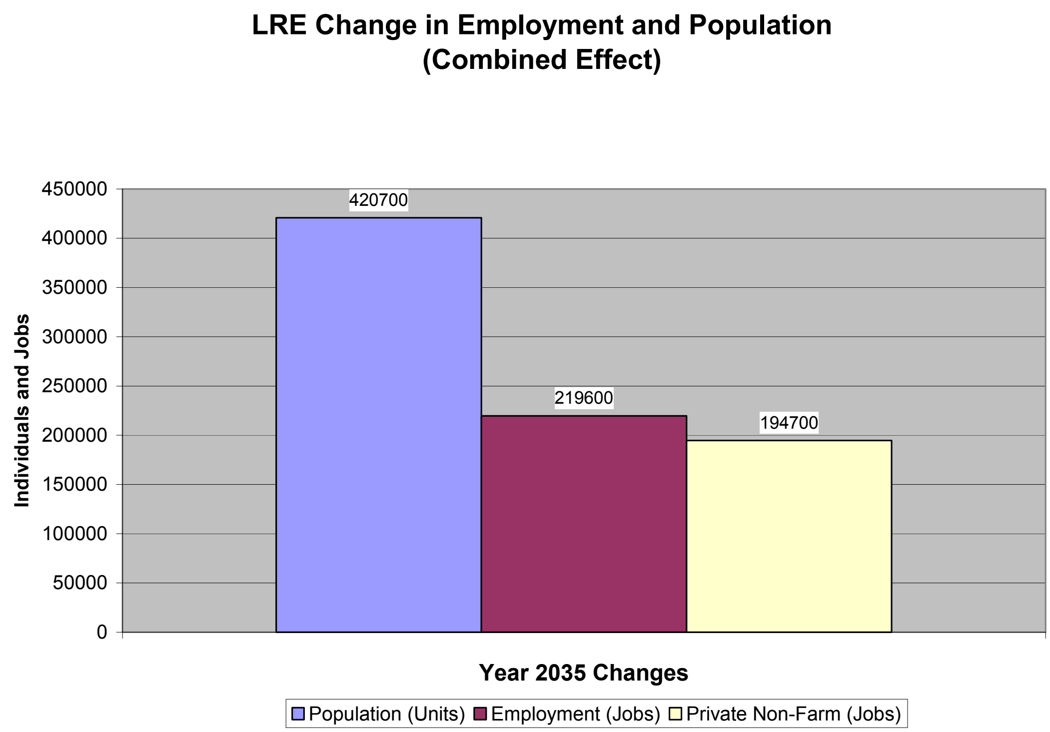


Figure 8

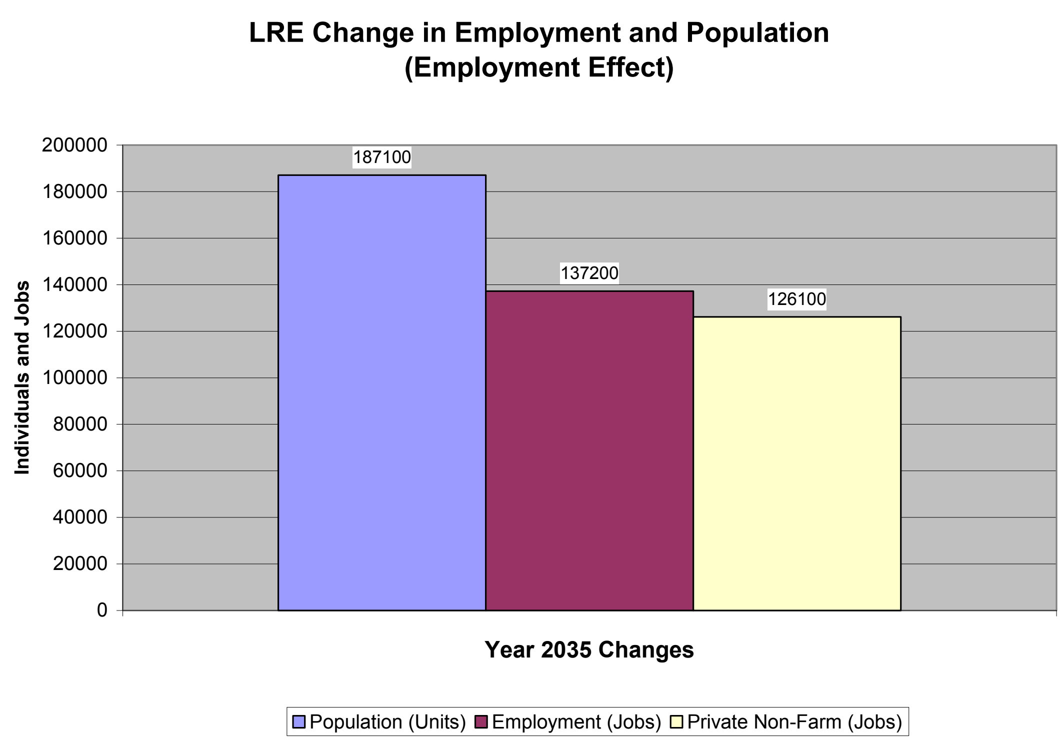
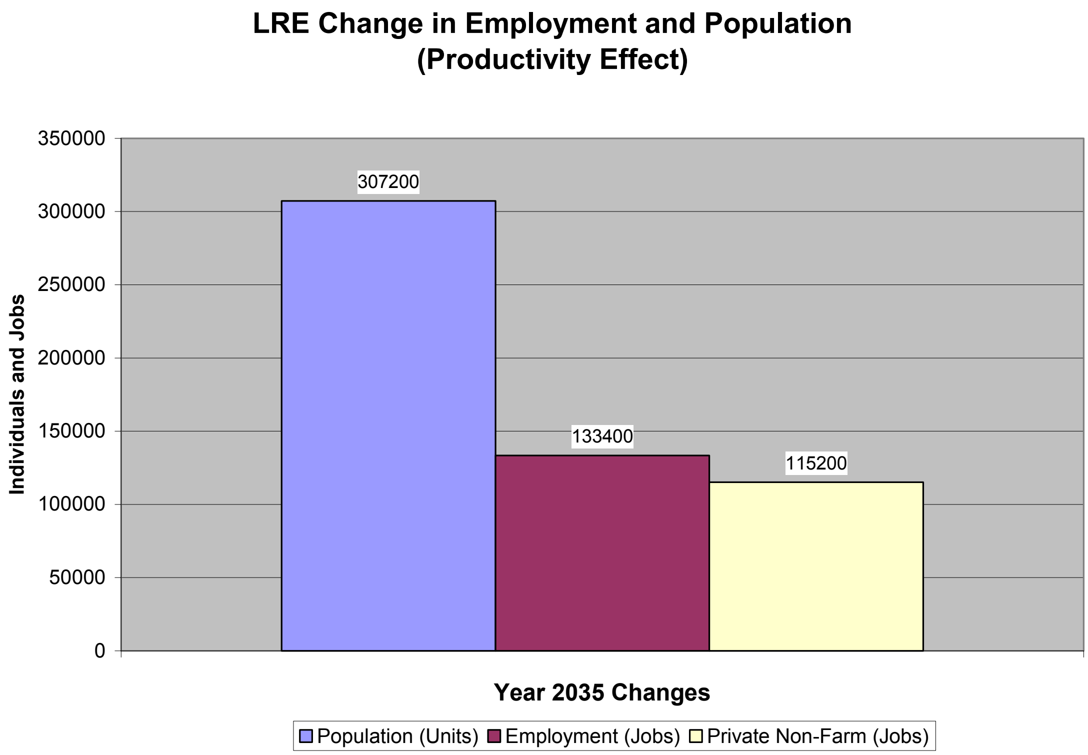


Figure 9



Figures 10 to 12 represent the dynamics of state revenue and expenditure *changes* for the (essential IT) combined, productivity only, and employment only cases. In the combined employment and productivity and productivity only cases, state revenue changes are initially negative because personal income drops reducing sales and income tax revenues. The change in personal income is initially negative because labor is released due to its increased productivity, but becomes positive as Connecticut firms become more competitive and add jobs that increase personal income and therefore tax revenues.

Figure 10

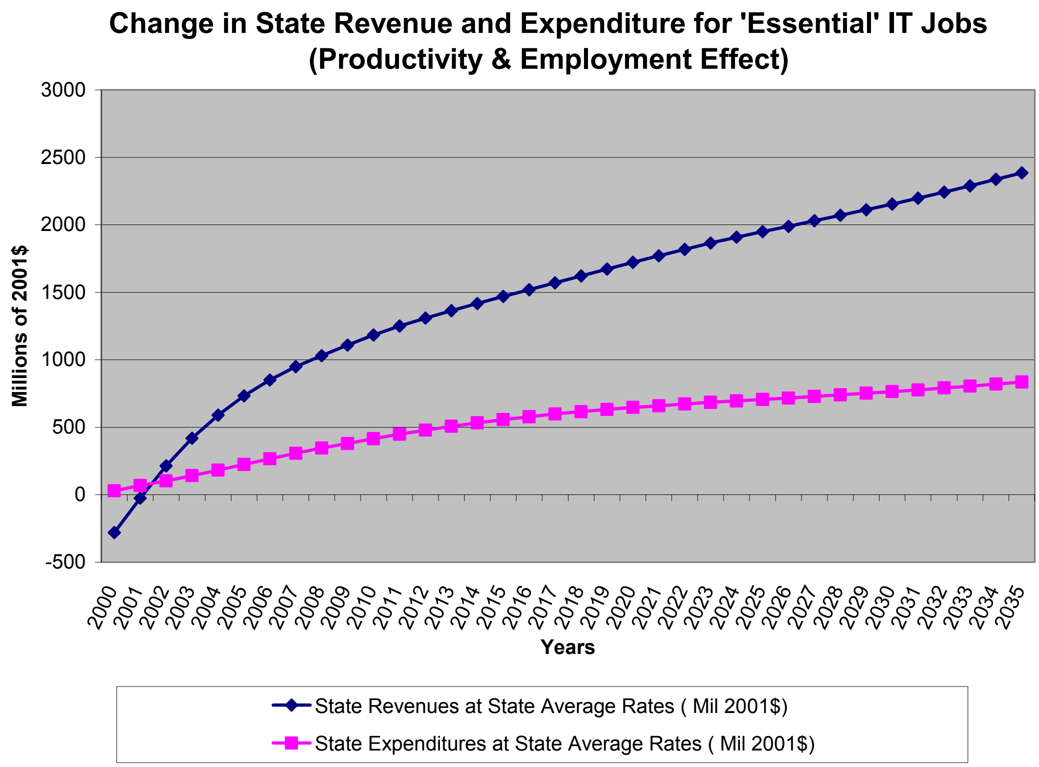


Figure 11

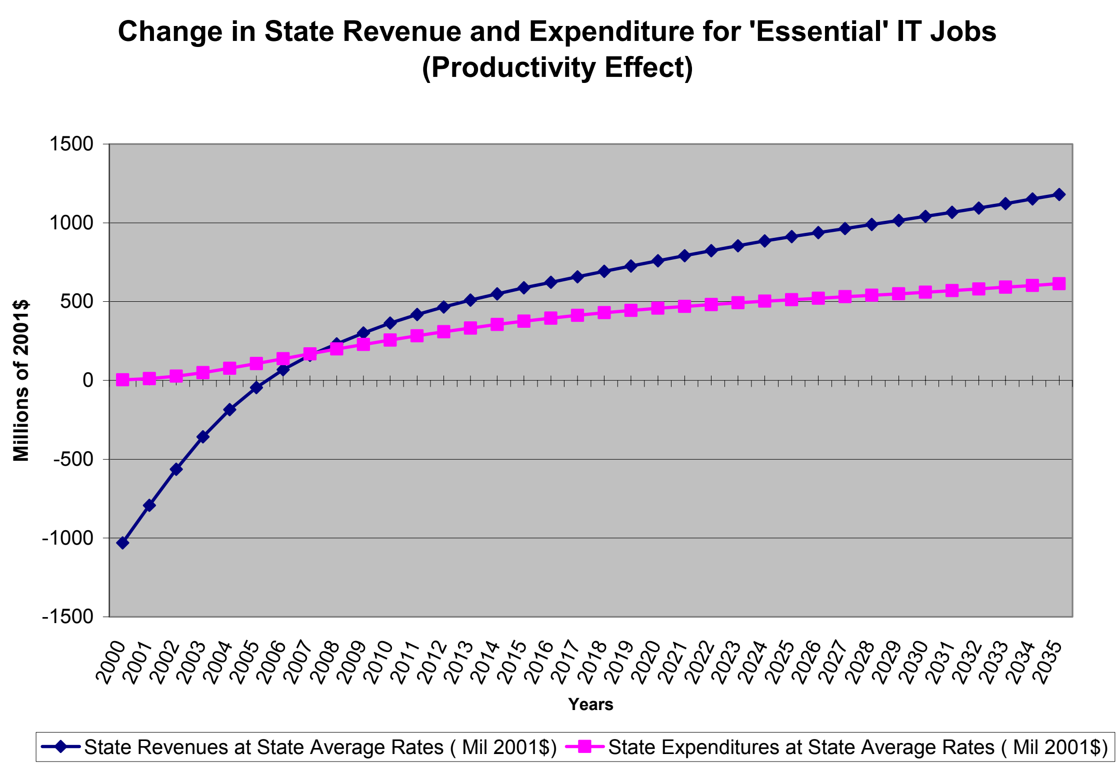
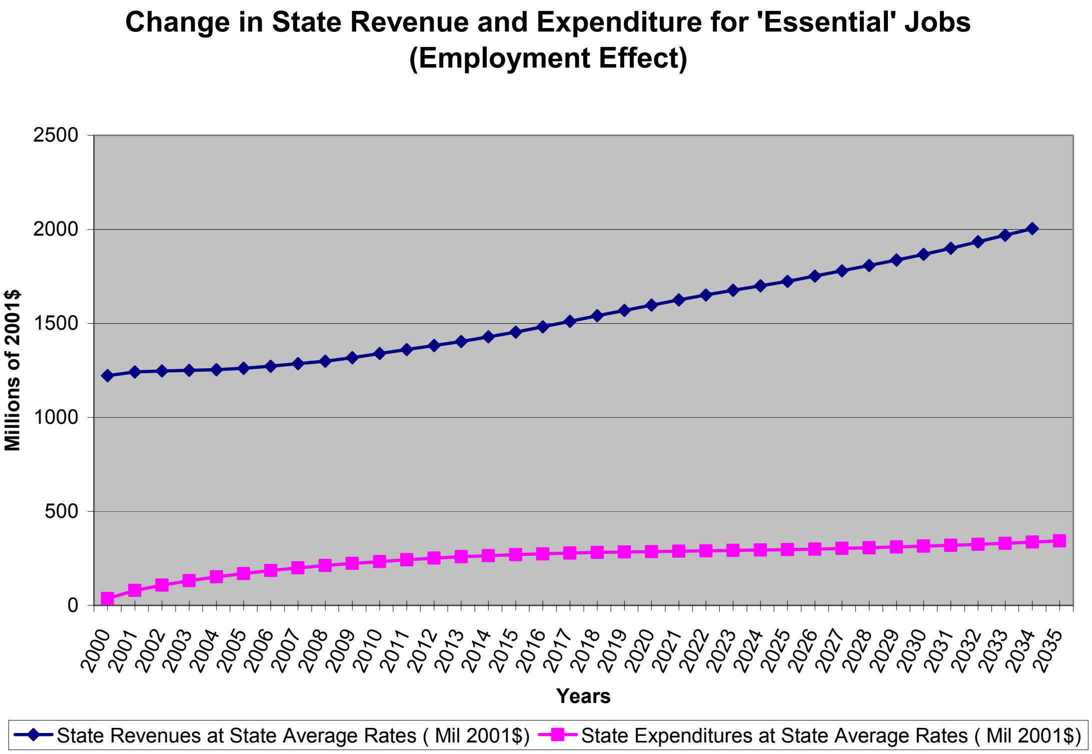


Figure 12


Change in State Revenue and Expenditure for 'Essential' Jobs
(Employment Effect)
2500
2000
1500
1000
500
0
Millions of 2001$
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
Years
State Revenues at State Average Rates (Mil 2001$)
State Expenditures at State Average Rates (Mil 2001$)

Appendix 1: IT-Related and Essential Occupational Employment by Industry

Connecticut Computer and Related Occupations & Employment by Industry - 2000 [BLS]					
Industry	SOC Code	Occupational Title	Employment	Adjusted Employment (if N/A, then allocate OES occupation remainder over these cells)	Annual Wages ($)
7	13-2011	Accountants and auditors	30	30	$71,050
7	41-9041	Telemarketers	30	30	$24,720
7	43-6013	Medical secretaries	100	100	$24,210
15	13-2011	Accountants and auditors	30	30	$56,990
15	17-2051	Civil engineers	50	50	$53,540
15	17-3011	Architectural and civil drafters	N/A	220	$55,390
16	13-2011	Accountants and auditors	40	40	$51,470
16	17-2051	Civil engineers	30	30	$57,710
17	11-9041	Engineering managers	30	30	$83,820
17	13-2011	Accountants and auditors	100	100	$46,070
17	15-1071	Network and computer systems administrators	20	20	$54,160
17	17-2071	Electrical engineers	N/A	130	$44,060
17	17-3011	Architectural and civil drafters	20	20	$43,740
17	17-3012	Electrical and electronics drafters	40	40	$39,660
17	41-9031	Sales engineers	90	90	$50,480
17	41-9041	Telemarketers	90	90	$18,790
20	13-2011	Accountants and auditors	40	40	$49,670
20	15-1071	Network and computer systems administrators	10	10	$40,370
20	17-2112	Industrial engineers	20	20	$65,860
20	19-4011	Agricultural and food science technicians	20	20	$47,230
20	19-4021	Biological technicians	10	10	$43,190
22	13-2011	Accountants and auditors	10	10	$79,110
22	43-9021	Data entry keyers	10	10	$21,970
24	17-3011	Architectural and civil drafters	20	20	$43,470
25	13-2011	Accountants and auditors	10	10	$49,450
26	11-3021	Computer and information systems managers	50	50	$87,320
26	11-9041	Engineering managers	20	20	$85,420
26	13-2011	Accountants and auditors	50	50	$50,420
26	15-1021	Computer programmers	40	40	$58,230
26	15-1041	Computer support specialists	30	30	$51,290
26	15-1051	Computer systems analysts	30	30	$64,350
26	15-1061	Database administrators	20	20	$65,850
26	15-1071	Network and computer systems administrators	30	30	$62,470
26	17-2112	Industrial engineers	50	50	$53,490
26	17-2141	Mechanical engineers	N/A	115	$58,730
26	17-3013	Mechanical drafters	20	20	$51,780
26	19-2031	Chemists	40	40	$56,760
26	19-4031	Chemical technicians	50	50	$33,970
26	27-1024	Graphic designers	10	10	$37,490
27	11-3021	Computer and information systems managers	70	70	$83,890
27	13-2011	Accountants and auditors	150	150	$54,040
27	15-1021	Computer programmers	70	70	$52,340
27	15-1041	Computer support specialists	80	80	$41,160
27	15-1051	Computer systems analysts	50	50	$58,020
27	15-1061	Database administrators	40	40	$54,130
27	15-1071	Network and computer systems administrators	60	60	$47,490
27	15-1099	Computer specialists, all other	20	20	$46,720
27	17-2112	Industrial engineers	20	20	$41,080
27	25-4021	Librarians	20	20	$43,530
27	27-1024	Graphic designers	740	740	$36,940
27	27-3041	Editors	1,430	1,430	$46,850
27	41-9041	Telemarketers	740	740	$21,890
27	43-9011	Computer operators	90	90	$32,180
27	43-9021	Data entry keyers	120	120	$26,070
27	43-9022	Word processors and typists	60	60	$26,550
27	43-9031	Desktop publishers	510	510	$37,700
28	11-9041	Engineering managers	110	110	$106,830
28	13-2011	Accountants and auditors	140	140	$61,570
28	13-2051	Financial analysts	90	90	$60,160
28	15-1021	Computer programmers	50	50	$63,990
28	15-1041	Computer support specialists	110	110	$46,370
28	15-1061	Database administrators	N/A	595	$64,680
28	15-1071	Network and computer systems administrators	40	40	$65,880
28	15-2021	Mathematicians	10	10	$63,620
28	17-2041	Chemical engineers	170	170	$70,240
28	17-2081	Environmental engineers	10	10	$90,830
28	17-2111	Health and safety engineers, except mining safety engineers and inspectors	30	30	$65,420
28	17-2112	Industrial engineers	100	100	$71,750
28	17-2131	Materials engineers	N/A	163	$60,520
28	17-2141	Mechanical engineers	30	30	$77,590
28	17-3013	Mechanical drafters	N/A	150	$47,430
28	17-3023	Electrical and electronic engineering technicians	50	50	$43,690
28	17-3027	Mechanical engineering technicians	N/A	103	$43,630
28	19-1042	Medical scientists, except epidemiologists	750	750	$84,650
28	19-2031	Chemists	1,050	1,050	$71,500
28	19-2032	Materials scientists	N/A	60	$69,880
28	19-3021	Market research analysts	50	50	$74,230
28	19-4021	Biological technicians	150	150	$47,650
28	19-4031	Chemical technicians	620	620	$40,400
28	41-9031	Sales engineers	N/A	220	$71,290
28	43-9011	Computer operators	30	30	$48,630
30	11-3021	Computer and information systems managers	20	20	$77,770
30	11-9041	Engineering managers	50	50	$77,080
30	13-2011	Accountants and auditors	30	30	$44,350
30	17-2041	Chemical engineers	20	20	$62,260
30	17-2112	Industrial engineers	70	70	$52,830
30	17-2131	Materials engineers	10	10	$55,990

30	17-2141	Mechanical engineers	50	50	$60,050
30	17-3013	Mechanical drafters	30	30	$46,910
30	17-3026	Industrial engineering technicians	30	30	$31,030
30	17-3027	Mechanical engineering technicians	30	30	$56,550
30	19-2031	Chemists	10	10	$71,690
30	19-4031	Chemical technicians	50	50	$31,180
30	41-9031	Sales engineers	30	30	$78,190
30	51-4011	Computer-controlled machine tool operators, metal and plastic	330	330	$26,840
30	51-4012	Numerical tool and process control programmers	10	10	$55,050
32	13-2011	Accountants and auditors	20	20	$57,480
32	17-2141	Mechanical engineers	10	10	$50,260
33	11-3021	Computer and information systems managers	10	10	$76,230
33	11-9041	Engineering managers	50	50	$77,760
33	13-2011	Accountants and auditors	40	40	$46,640
33	15-1031	Computer software engineers, applications	N/A	430	$65,890
33	15-1071	Network and computer systems administrators	10	10	$55,750
33	17-2071	Electrical engineers	N/A	130	$54,300
33	17-2111	Health and safety engineers, except mining safety engineers and inspectors	10	10	$50,310
33	17-2112	Industrial engineers	50	50	$59,530
33	17-2131	Materials engineers	30	30	$54,230
33	17-2141	Mechanical engineers	20	20	$56,180
33	17-3013	Mechanical drafters	30	30	$41,960
33	41-9031	Sales engineers	20	20	$69,390
33	43-9021	Data entry keyers	30	30	$25,170
34	11-3021	Computer and information systems managers	50	50	$79,440
34	11-9041	Engineering managers	130	130	$78,800
34	13-2011	Accountants and auditors	150	150	$49,370
34	15-1021	Computer programmers	50	50	$55,320
34	15-1041	Computer support specialists	20	20	$43,570
34	15-1051	Computer systems analysts	20	20	$68,960
34	15-1071	Network and computer systems administrators	30	30	$57,430
34	15-1081	Network systems and data communications analysts	20	20	$54,360
34	17-2041	Chemical engineers	N/A	53	$67,240
34	17-2071	Electrical engineers	40	40	$57,220
34	17-2081	Environmental engineers	20	20	$57,110
34	17-2111	Health and safety engineers, except mining safety engineers and inspectors	30	30	$48,030
34	17-2112	Industrial engineers	200	200	$56,950
34	17-2131	Materials engineers	N/A	163	$47,770
34	17-2141	Mechanical engineers	320	320	$59,650
34	17-3013	Mechanical drafters	110	110	$43,210
34	17-3026	Industrial engineering technicians	40	40	$50,780
34	17-3027	Mechanical engineering technicians	N/A	103	$38,220
34	19-2031	Chemists	30	30	$34,800
34	41-9031	Sales engineers	50	50	$70,720
34	43-9011	Computer operators	20	20	$31,020
34	43-9021	Data entry keyers	20	20	$26,050
34	51-4011	Computer-controlled machine tool operators, metal and plastic	280	280	$32,690
34	51-4012	Numerical tool and process control programmers	50	50	$47,670
35	11-3021	Computer and information systems managers	140	140	$91,830
35	11-9041	Engineering managers	350	350	$91,340
35	13-2011	Accountants and auditors	220	220	$50,170
35	13-2031	Budget analysts	20	20	$50,570
35	15-1021	Computer programmers	170	170	$67,430
35	15-1031	Computer software engineers, applications	260	260	$79,920
35	15-1032	Computer software engineers, systems software	20	20	$63,560
35	15-1041	Computer support specialists	180	180	$53,780
35	15-1061	Database administrators	40	40	$72,170
35	15-1071	Network and computer systems administrators	10	10	$62,020
35	17-2061	Computer hardware engineers	110	110	$73,810
35	17-2071	Electrical engineers	180	180	$59,700
35	17-2072	Electronics engineers, except computer	160	160	$63,810
35	17-2112	Industrial engineers	680	680	$64,650
35	17-2131	Materials engineers	70	70	$65,000
35	17-2141	Mechanical engineers	650	650	$55,060
35	17-3012	Electrical and electronics drafters	30	30	$46,590
35	17-3013	Mechanical drafters	200	200	$41,760
35	17-3023	Electrical and electronic engineering technicians	110	110	$43,190
35	17-3024	Electro-mechanical technicians	20	20	$31,410
35	17-3026	Industrial engineering technicians	160	160	$45,100
35	17-3027	Mechanical engineering technicians	N/A	103	$34,690
35	19-2031	Chemists	20	20	$59,500
35	27-1024	Graphic designers	20	20	$49,260
35	27-3042	Technical writers	70	70	$54,650
35	41-9031	Sales engineers	180	180	$62,030
35	43-9011	Computer operators	50	50	$37,060
35	43-9021	Data entry keyers	10	10	$32,050
35	51-4011	Computer-controlled machine tool operators, metal and plastic	1,310	1,310	$34,230
35	51-4012	Numerical tool and process control programmers	210	210	$49,320
36	11-3021	Computer and information systems managers	120	120	$92,800
36	11-9041	Engineering managers	300	300	$85,120
36	13-2011	Accountants and auditors	180	180	$54,540
36	15-1021	Computer programmers	90	90	$47,270
36	15-1031	Computer software engineers, applications	120	120	$57,110
36	15-1041	Computer support specialists	70	70	$43,870
36	15-1051	Computer systems analysts	70	70	$64,610
36	15-1061	Database administrators	10	10	$60,460
36	15-1071	Network and computer systems administrators	50	50	$63,310
36	15-1081	Network systems and data communications analysts	40	40	$57,770
36	15-1099	Computer specialists, all other	20	20	$57,910

36	17-2041	Chemical engineers	N/A	53	$65,980
36	17-2061	Computer hardware engineers	20	20	$55,450
36	17-2071	Electrical engineers	480	480	$64,960
36	17-2072	Electronics engineers, except computer	510	510	$66,870
36	17-2112	Industrial engineers	340	340	$53,350
36	17-2131	Materials engineers	70	70	$63,210
36	17-2141	Mechanical engineers	250	250	$57,240
36	17-3012	Electrical and electronics drafters	150	150	$43,500
36	17-3013	Mechanical drafters	110	110	$38,120
36	17-3023	Electrical and electronic engineering technicians	640	640	$35,270
36	17-3024	Electro-mechanical technicians	100	100	$40,200
36	17-3026	Industrial engineering technicians	60	60	$41,120
36	17-3027	Mechanical engineering technicians	70	70	$43,010
36	19-3021	Market research analysts	40	40	$70,950
36	19-4031	Chemical technicians	N/A	280	$37,010
36	27-1021	Commercial and industrial designers	40	40	$43,810
36	27-1024	Graphic designers	10	10	$51,230
36	27-3042	Technical writers	50	50	$46,950
36	41-9031	Sales engineers	100	100	$57,340
36	43-9011	Computer operators	20	20	$28,530
36	43-9021	Data entry keyers	N/A	216	$25,800
36	51-4011	Computer-controlled machine tool operators, metal and plastic	180	180	$27,730
36	51-4012	Numerical tool and process control programmers	50	50	$43,090
37	11-3021	Computer and information systems managers	150	150	$96,580
37	11-9041	Engineering managers	530	530	$89,540
37	13-2011	Accountants and auditors	320	320	$55,380
37	15-1021	Computer programmers	90	90	$52,770
37	15-1041	Computer support specialists	110	110	$59,160
37	15-1051	Computer systems analysts	290	290	$68,300
37	15-1071	Network and computer systems administrators	50	50	$62,770
37	15-1081	Network systems and data communications analysts	40	40	$61,000
37	15-1099	Computer specialists, all other	N/A	1	$59,890
37	17-2011	Aerospace engineers	N/A	1	$72,030
37	17-2072	Electronics engineers, except computer	N/A	140	$62,490
37	17-2081	Environmental engineers	30	30	$74,000
37	17-2112	Industrial engineers	1,120	1,120	$56,990
37	17-2131	Materials engineers	N/A	163	$66,020
37	17-2141	Mechanical engineers	320	320	$58,750
37	17-3013	Mechanical drafters	180	180	$44,370
37	17-3021	Aerospace engineering and operations technicians	N/A	1	$54,250
37	17-3023	Electrical and electronic engineering technicians	140	140	$41,570
37	17-3025	Environmental engineering technicians	20	20	$58,460
37	17-3026	Industrial engineering technicians	N/A	900	$50,190
37	17-3027	Mechanical engineering technicians	140	140	$37,830
37	27-1021	Commercial and industrial designers	40	40	$43,220
37	27-1024	Graphic designers	50	50	$37,710
37	27-3041	Editors	20	20	$65,190
37	41-9031	Sales engineers	20	20	$58,080
37	43-9011	Computer operators	30	30	$31,210
37	43-9022	Word processors and typists	30	30	$29,160
37	51-4011	Computer-controlled machine tool operators, metal and plastic	850	850	$33,440
37	51-4012	Numerical tool and process control programmers	N/A	123	$45,130
38	11-3021	Computer and information systems managers	50	50	$85,650
38	11-9041	Engineering managers	230	230	$86,850
38	13-2011	Accountants and auditors	120	120	$48,680
38	13-2031	Budget analysts	40	40	$54,660
38	13-2041	Credit analysts	80	80	$41,390
38	13-2051	Financial analysts	50	50	$57,890
38	15-1021	Computer programmers	110	110	$54,570
38	15-1031	Computer software engineers, applications	N/A	430	$66,710
38	15-1032	Computer software engineers, systems software	170	170	$65,620
38	15-1041	Computer support specialists	100	100	$46,510
38	15-1051	Computer systems analysts	70	70	$63,030
38	15-1061	Database administrators	50	50	$56,370
38	15-1071	Network and computer systems administrators	50	50	$65,950
38	15-1081	Network systems and data communications analysts	30	30	$58,610
38	17-2041	Chemical engineers	N/A	53	$70,710
38	17-2071	Electrical engineers	240	240	$67,340
38	17-2072	Electronics engineers, except computer	210	210	$64,450
38	17-2112	Industrial engineers	370	370	$55,040
38	17-2131	Materials engineers	70	70	$61,460
38	17-2141	Mechanical engineers	290	290	$59,490
38	17-3012	Electrical and electronics drafters	30	30	$42,220
38	17-3013	Mechanical drafters	90	90	$50,430
38	17-3023	Electrical and electronic engineering technicians	330	330	$43,660
38	17-3024	Electro-mechanical technicians	130	130	$38,170
38	17-3026	Industrial engineering technicians	80	80	$40,510
38	17-3027	Mechanical engineering technicians	60	60	$42,620
38	19-2031	Chemists	20	20	$61,880
38	19-2032	Materials scientists	N/A	60	$79,300
38	19-3021	Market research analysts	40	40	$59,410
38	19-4031	Chemical technicians	60	60	$46,580
38	23-1011	Lawyers	30	30	$132,380
38	27-1024	Graphic designers	20	20	$36,640
38	27-3042	Technical writers	30	30	$51,310
38	41-9031	Sales engineers	120	120	$73,280
38	43-9011	Computer operators	20	20	$40,090
38	43-9021	Data entry keyers	80	80	$29,380
38	51-4011	Computer-controlled machine tool operators, metal and plastic	300	300	$31,840
38	51-4012	Numerical tool and process control programmers	N/A	123	$46,780
39	11-9041	Engineering managers	10	10	$74,870

39	13-2011	Accountants and auditors	30	30	$50,760
39	17-2112	Industrial engineers	10	10	$59,350
39	17-3013	Mechanical drafters	30	30	$37,230
39	27-1021	Commercial and industrial designers	50	50	$54,960
39	27-1024	Graphic designers	30	30	$39,330
39	43-9021	Data entry keyers	20	20	$20,070
41	13-2011	Accountants and auditors	20	20	$54,590
42	13-2011	Accountants and auditors	70	70	$49,160
42	43-9022	Word processors and typists	20	20	$27,380
44	11-3021	Computer and information systems managers	20	20	$77,790
44	13-2011	Accountants and auditors	40	40	$54,300
44	15-1041	Computer support specialists	40	40	$49,350
44	23-1011	Lawyers	10	10	$93,890
44	41-3031	Securities, commodities, and financial services sales agents	40	40	$90,370
44	43-9011	Computer operators	30	30	$34,280
45	13-2011	Accountants and auditors	20	20	$45,110
45	53-2021	Air traffic controllers	N/A	60	$39,130
47	13-2011	Accountants and auditors	150	150	$39,940
47	41-3031	Securities, commodities, and financial services sales agents	210	210	$90,670
47	41-3041	Travel agents	1,700	1,700	$26,790
47	43-9011	Computer operators	N/A	180	$30,480
48	11-3021	Computer and information systems managers	60	60	$67,540
48	11-9041	Engineering managers	50	50	$75,090
48	13-2011	Accountants and auditors	110	110	$46,860
48	15-1041	Computer support specialists	N/A	600	$34,150
48	17-3023	Electrical and electronic engineering technicians	140	140	$48,330
48	41-9031	Sales engineers	110	110	$62,310
48	49-9052	Telecommunications line installers and repairers	1,670	1,670	$37,600
49	11-3021	Computer and information systems managers	30	30	$86,710
49	11-9041	Engineering managers	80	80	$87,490
49	13-2011	Accountants and auditors	100	100	$61,620
49	13-2031	Budget analysts	10	10	$67,110
49	15-1061	Database administrators	30	30	$62,600
49	15-1071	Network and computer systems administrators	30	30	$57,000
49	17-2071	Electrical engineers	240	240	$69,750
49	17-2081	Environmental engineers	20	20	$66,990
49	17-2141	Mechanical engineers	40	40	$70,290
49	17-3013	Mechanical drafters	30	30	$52,620
49	17-3027	Mechanical engineering technicians	20	20	$63,470
49	19-2031	Chemists	20	20	$66,960
49	19-3021	Market research analysts	20	20	$55,610
50	11-3021	Computer and information systems managers	150	150	$82,910
50	11-9041	Engineering managers	90	90	$92,300
50	13-2011	Accountants and auditors	490	490	$56,620
50	13-2031	Budget analysts	30	30	$55,770
50	13-2041	Credit analysts	60	60	$44,130
50	13-2051	Financial analysts	30	30	$60,880
50	15-1021	Computer programmers	500	500	$45,530
50	15-1031	Computer software engineers, applications	N/A	430	$76,770
50	15-1032	Computer software engineers, systems software	160	160	$67,730
50	15-1041	Computer support specialists	690	690	$50,440
50	15-1051	Computer systems analysts	120	120	$63,270
50	15-1061	Database administrators	20	20	$56,000
50	15-1071	Network and computer systems administrators	340	340	$68,120
50	15-1081	Network systems and data communications analysts	30	30	$51,720
50	15-1099	Computer specialists, all other	60	60	$62,720
50	17-2061	Computer hardware engineers	N/A	220	$72,070
50	17-2071	Electrical engineers	60	60	$60,900
50	17-2072	Electronics engineers, except computer	50	50	$66,800
50	17-2112	Industrial engineers	40	40	$57,880
50	17-2141	Mechanical engineers	140	140	$52,550
50	17-3011	Architectural and civil drafters	20	20	$29,020
50	17-3023	Electrical and electronic engineering technicians	290	290	$36,810
50	17-3024	Electro-mechanical technicians	180	180	$33,190
50	17-3027	Mechanical engineering technicians	30	30	$42,200
50	19-3021	Market research analysts	20	20	$56,190
50	23-1011	Lawyers	N/A	330	$123,060
50	27-1024	Graphic designers	40	40	$33,800
50	27-3042	Technical writers	10	10	$46,180
50	41-9031	Sales engineers	190	190	$73,010
50	41-9041	Telemarketers	80	80	$25,290
50	43-6013	Medical secretaries	N/A	170	$20,900
50	43-9011	Computer operators	120	120	$38,690
50	43-9021	Data entry keyers	150	150	$28,770
50	43-9022	Word processors and typists	40	40	$24,450
50	49-2011	Computer, automated teller, and office machine repairers	750	750	$38,850
50	51-4012	Numerical tool and process control programmers	N/A	123	$57,790
51	11-3021	Computer and information systems managers	90	90	$79,370
51	13-2011	Accountants and auditors	350	350	$59,710
51	13-2031	Budget analysts	30	30	$54,120
51	13-2041	Credit analysts	50	50	$48,040
51	13-2051	Financial analysts	30	30	$76,450
51	15-1021	Computer programmers	80	80	$60,590
51	15-1041	Computer support specialists	60	60	$52,250
51	15-1051	Computer systems analysts	N/A	210	$84,210
51	15-1071	Network and computer systems administrators	60	60	$57,990
51	15-1099	Computer specialists, all other	10	10	$60,470
51	17-2111	Health and safety engineers, except mining safety engineers and inspectors	N/A	510	$80,810
51	17-3023	Electrical and electronic engineering technicians	N/A	220	$42,880
51	19-2031	Chemists	30	30	$71,980
51	19-4031	Chemical technicians	20	20	$33,610
51	27-1024	Graphic designers	N/A	130	$32,280

51	29-1051	Pharmacists	180	180	$69,800
51	41-9041	Telemarketers	N/A	403	$25,490
51	43-9011	Computer operators	170	170	$33,380
51	43-9021	Data entry keyers	130	130	$28,490
51	43-9022	Word processors and typists	30	30	$31,460
52	13-2011	Accountants and auditors	30	30	$58,930
52	43-9011	Computer operators	60	60	$41,390
53	29-1051	Pharmacists	40	40	$61,230
53	43-9021	Data entry keyers	20	20	$20,180
54	13-2011	Accountants and auditors	60	60	$47,020
54	15-1041	Computer support specialists	40	40	$25,900
54	29-1051	Pharmacists	300	300	$74,150
54	43-9011	Computer operators	40	40	$26,690
54	43-9021	Data entry keyers	30	30	$20,350
55	11-3021	Computer and information systems managers	N/A	205	$44,720
55	13-2011	Accountants and auditors	50	50	$58,530
56	13-2011	Accountants and auditors	40	40	$46,860
56	15-1041	Computer support specialists	10	10	$32,680
57	11-3021	Computer and information systems managers	20	20	$62,190
57	13-2011	Accountants and auditors	50	50	$54,650
57	15-1021	Computer programmers	60	60	$39,140
57	15-1041	Computer support specialists	70	70	$32,810
57	49-2011	Computer, automated teller, and office machine repairers	220	220	$45,770
58	13-2011	Accountants and auditors	N/A	550	$46,880
59	13-2011	Accountants and auditors	110	110	$44,090
59	13-2031	Budget analysts	N/A	520	$44,540
59	13-2041	Credit analysts	N/A	410	$32,850
59	27-1024	Graphic designers	N/A	130	$32,260
59	29-1051	Pharmacists	1,410	1,410	$76,130
59	41-9041	Telemarketers	N/A	403	$16,380
59	43-9011	Computer operators	N/A	180	$27,420
59	43-9021	Data entry keyers	N/A	216	$17,710
59	49-2011	Computer, automated teller, and office machine repairers	N/A	65	$20,600
60	11-3021	Computer and information systems managers	210	210	$83,440
60	13-2011	Accountants and auditors	300	300	$46,450
60	13-2031	Budget analysts	20	20	$46,520
60	13-2041	Credit analysts	230	230	$48,560
60	13-2051	Financial analysts	130	130	$43,180
60	13-2052	Personal financial advisors	180	180	$85,600
60	15-1021	Computer programmers	90	90	$51,180
60	15-1031	Computer software engineers, applications	30	30	$66,180
60	15-1041	Computer support specialists	120	120	$35,530
60	15-1051	Computer systems analysts	220	220	$48,250
60	15-1071	Network and computer systems administrators	90	90	$48,750
60	15-1081	Network systems and data communications analysts	50	50	$36,170
60	19-3021	Market research analysts	70	70	$50,480
60	41-3031	Securities, commodities, and financial services sales agents	N/A	335	$76,510
60	43-9011	Computer operators	230	230	$25,820
60	43-9021	Data entry keyers	N/A	216	$18,710
61	11-3021	Computer and information systems managers	130	130	$108,610
61	13-2011	Accountants and auditors	180	180	$59,920
61	13-2041	Credit analysts	180	180	$59,370
61	13-2051	Financial analysts	320	320	$61,970
61	13-2052	Personal financial advisors	40	40	$66,120
61	15-1031	Computer software engineers, applications	140	140	$79,330
61	15-1032	Computer software engineers, systems software	10	10	$89,400
61	15-1041	Computer support specialists	100	100	$50,850
61	15-1051	Computer systems analysts	70	70	$64,960
61	15-1061	Database administrators	40	40	$78,190
61	15-1071	Network and computer systems administrators	50	50	$82,720
61	17-2061	Computer hardware engineers	50	50	$75,360
61	19-3021	Market research analysts	40	40	$66,690
61	27-1024	Graphic designers	10	10	$49,370
61	41-3031	Securities, commodities, and financial services sales agents	360	360	$62,750
61	43-6012	Legal secretaries	10	10	$39,260
61	43-9021	Data entry keyers	N/A	216	$26,140
62	11-3021	Computer and information systems managers	80	80	$98,580
62	13-2011	Accountants and auditors	510	510	$64,520
62	13-2031	Budget analysts	10	10	$40,800
62	13-2041	Credit analysts	N/A	410	$89,350
62	13-2052	Personal financial advisors	500	500	$99,830
62	15-1021	Computer programmers	N/A	1,455	$61,780
62	15-1031	Computer software engineers, applications	80	80	$83,830
62	15-1032	Computer software engineers, systems software	N/A	560	$78,230
62	15-1041	Computer support specialists	40	40	$45,020
62	15-1051	Computer systems analysts	60	60	$58,170
62	15-1071	Network and computer systems administrators	N/A	670	$67,180
62	15-2031	Operations research analysts	N/A	250	$77,800
62	19-3011	Economists	40	40	$118,720
62	19-3021	Market research analysts	50	50	$56,200
62	23-1011	Lawyers	N/A	330	$123,980
62	41-3031	Securities, commodities, and financial services sales agents	3,270	3,270	$100,040
62	43-6012	Legal secretaries	N/A	65	$39,110
62	43-9011	Computer operators	90	90	$28,410
62	43-9021	Data entry keyers	N/A	216	$26,050
63	11-3021	Computer and information systems managers	970	970	$89,720
63	13-2011	Accountants and auditors	1,300	1,300	$53,650
63	13-2031	Budget analysts	70	70	$52,680
63	13-2041	Credit analysts	70	70	$55,140
63	13-2051	Financial analysts	1,360	1,360	$55,560
63	13-2052	Personal financial advisors	160	160	$76,660

63	15-1021	Computer programmers	N/A	1,455	$59,400
63	15-1031	Computer software engineers, applications	1,570	1,570	$66,780
63	15-1032	Computer software engineers, systems software	100	100	$54,770
63	15-1051	Computer systems analysts	1,760	1,760	$64,140
63	15-1071	Network and computer systems administrators	320	320	$55,170
63	15-1081	Network systems and data communications analysts	N/A	400	$59,460
63	15-1099	Computer specialists, all other	450	450	$64,980
63	15-2011	Actuaries	710	710	$75,150
63	15-2031	Operations research analysts	190	190	$54,250
63	15-2041	Statisticians	N/A	200	$42,150
63	19-3021	Market research analysts	390	390	$49,960
63	23-1011	Lawyers	650	650	$94,770
63	27-1024	Graphic designers	N/A	130	$44,040
63	27-3042	Technical writers	30	30	$44,090
63	41-3031	Securities, commodities, and financial services sales agents	80	80	$55,230
63	41-9041	Telemarketers	280	280	$31,470
63	43-6012	Legal secretaries	150	150	$37,320
63	43-9011	Computer operators	190	190	$29,040
63	43-9021	Data entry keyers	650	650	$25,650
63	43-9022	Word processors and typists	170	170	$22,360
64	11-3021	Computer and information systems managers	90	90	$75,580
64	13-2011	Accountants and auditors	70	70	$47,840
64	13-2051	Financial analysts	100	100	$46,410
64	13-2052	Personal financial advisors	180	180	$60,550
64	15-1021	Computer programmers	20	20	$59,670
64	15-1041	Computer support specialists	30	30	$39,140
64	15-1051	Computer systems analysts	N/A	210	$65,920
64	15-1071	Network and computer systems administrators	40	40	$51,970
64	23-1011	Lawyers	90	90	$86,470
64	41-3031	Securities, commodities, and financial services sales agents	N/A	335	$139,710
64	41-9041	Telemarketers	N/A	403	$27,890
64	43-6012	Legal secretaries	40	40	$37,380
64	43-9021	Data entry keyers	130	130	$25,650
64	43-9022	Word processors and typists	30	30	$25,120
65	11-3021	Computer and information systems managers	N/A	205	$91,430
65	13-2011	Accountants and auditors	270	270	$52,310
65	13-2051	Financial analysts	160	160	$63,770
65	15-1041	Computer support specialists	N/A	600	$39,530
65	15-1051	Computer systems analysts	N/A	210	$71,400
65	15-1071	Network and computer systems administrators	60	60	$53,880
65	17-2051	Civil engineers	N/A	1,170	$60,390
65	23-1011	Lawyers	N/A	330	$125,850
65	43-9021	Data entry keyers	N/A	216	$20,270
65	43-9022	Word processors and typists	N/A	130	$19,210
67	11-3021	Computer and information systems managers	40	40	$94,480
67	13-2011	Accountants and auditors	300	300	$54,330
67	13-2051	Financial analysts	100	100	$63,680
67	13-2052	Personal financial advisors	310	310	$88,910
67	15-1021	Computer programmers	110	110	$63,050
67	15-1031	Computer software engineers, applications	30	30	$70,930
67	15-1041	Computer support specialists	60	60	$47,590
67	15-1051	Computer systems analysts	20	20	$60,000
67	15-1071	Network and computer systems administrators	20	20	$65,890
67	19-3021	Market research analysts	20	20	$67,420
67	23-1011	Lawyers	130	130	$93,500
67	41-3031	Securities, commodities, and financial services sales agents	490	490	$74,660
67	43-6012	Legal secretaries	N/A	65	$44,350
70	13-2011	Accountants and auditors	80	80	$38,080
73	11-3021	Computer and information systems managers	1240	1,240	$109,250
73	11-9041	Engineering managers	220	220	$115,840
73	13-2011	Accountants and auditors	650	650	$52,610
73	13-2031	Budget analysts	40	40	$53,960
73	13-2041	Credit analysts	N/A	410	$54,620
73	13-2051	Financial analysts	270	270	$58,650
73	15-1011	Computer and information scientists, research	310	310	$82,680
73	15-1021	Computer programmers	4,780	4,780	$70,390
73	15-1031	Computer software engineers, applications	2,300	2,300	$73,920
73	15-1032	Computer software engineers, systems software	1,090	1,090	$64,670
73	15-1041	Computer support specialists	2,760	2,760	$42,690
73	15-1051	Computer systems analysts	3,140	3,140	$67,940
73	15-1061	Database administrators	N/A	595	$49,910
73	15-1071	Network and computer systems administrators	710	710	$62,300
73	15-1081	Network systems and data communications analysts	770	770	$66,740
73	15-1099	Computer specialists, all other	870	870	$62,720
73	15-2031	Operations research analysts	N/A	250	$66,330
73	17-1011	Architects, except landscape and naval	N/A	130	$76,160
73	17-2061	Computer hardware engineers	130	130	$62,880
73	17-2071	Electrical engineers	130	130	$74,870
73	17-2072	Electronics engineers, except computer	30	30	$65,960
73	17-2112	Industrial engineers	90	90	$66,710
73	17-2141	Mechanical engineers	N/A	115	$78,300
73	17-3012	Electrical and electronics drafters	N/A	65	$49,970
73	17-3023	Electrical and electronic engineering technicians	N/A	220	$42,410
73	19-3021	Market research analysts	270	270	$68,950
73	23-1011	Lawyers	N/A	330	$123,810
73	27-1014	Multi-media artists and animators	240	240	$61,490
73	27-1021	Commercial and industrial designers	170	170	$53,510
73	27-1024	Graphic designers	1,380	1,380	$42,850
73	27-3041	Editors	300	300	$52,550
73	27-3042	Technical writers	300	300	$54,000
73	29-1051	Pharmacists	40	40	$65,820
73	41-9031	Sales engineers	240	240	$85,770

73	41-9041	Telemarketers	800	800	$19,230
73	43-6012	Legal secretaries	40	40	$30,130
73	43-9011	Computer operators	450	450	$32,380
73	43-9021	Data entry keyers	2300	2,300	$23,760
73	43-9022	Word processors and typists	620	620	$26,660
73	43-9031	Desktop publishers	30	30	$42,550
73	49-2011	Computer, automated teller, and office machine repairers	860	860	$34,880
73	49-9052	Telecommunications line installers and repairers	N/A	230	$39,320
75	13-2011	Accountants and auditors	20	20	$54,120
78	13-2011	Accountants and auditors	30	30	$51,730
78	27-1014	Multi-media artists and animators	20	20	$48,800
79	13-2011	Accountants and auditors	230	230	$37,760
79	15-1021	Computer programmers	20	20	$58,360
79	15-1041	Computer support specialists	80	80	$28,690
79	15-1061	Database administrators	20	20	$52,130
79	41-9041	Telemarketers	60	60	$27,030
79	43-9011	Computer operators	90	90	$23,770
79	43-9021	Data entry keyers	10	10	$22,100
80	11-3021	Computer and information systems managers	210	210	$86,990
80	13-2011	Accountants and auditors	420	420	$50,280
80	13-2031	Budget analysts	80	80	$54,420
80	13-2051	Financial analysts	40	40	$52,630
80	15-1021	Computer programmers	160	160	$57,650
80	15-1031	Computer software engineers, applications	100	100	$59,300
80	15-1041	Computer support specialists	190	190	$39,600
80	15-1061	Database administrators	50	50	$52,470
80	15-1071	Network and computer systems administrators	90	90	$62,050
80	15-1081	Network systems and data communications analysts	N/A	400	$53,200
80	15-1099	Computer specialists, all other	90	90	$57,100
80	17-2031	Biomedical engineers	40	40	$52,220
80	19-3021	Market research analysts	10	10	$61,880
80	19-3031	Clinical, counseling, and school psychologists	420	420	$50,770
80	25-1072	Nursing instructors and teachers, postsecondary	120	120	$58,260
80	25-4021	Librarians	40	40	$47,630
80	29-1051	Pharmacists	480	480	$68,780
80	43-6013	Medical secretaries	4,580	4,580	$28,920
80	43-9011	Computer operators	130	130	$31,630
80	43-9021	Data entry keyers	280	280	$23,330
80	43-9022	Word processors and typists	190	190	$24,200
81	11-3021	Computer and information systems managers	30	30	$78,380
81	13-2011	Accountants and auditors	N/A	550	$55,560
81	15-1041	Computer support specialists	N/A	600	$40,690
81	15-1071	Network and computer systems administrators	40	40	$52,270
81	23-1011	Lawyers	5,370	5,370	$103,640
81	25-4021	Librarians	N/A	70	$50,420
81	43-6012	Legal secretaries	3,160	3,160	$36,040
81	43-9021	Data entry keyers	N/A	216	$37,260
81	43-9022	Word processors and typists	80	80	$38,600
82	11-3021	Computer and information systems managers	150	150	$70,550
82	11-9041	Engineering managers	20	20	$82,020
82	13-2011	Accountants and auditors	560	560	$51,380
82	13-2031	Budget analysts	70	70	$52,200
82	13-2051	Financial analysts	30	30	$57,300
82	15-1021	Computer programmers	210	210	$55,270
82	15-1041	Computer support specialists	700	700	$37,140
82	15-1051	Computer systems analysts	90	90	$51,180
82	15-1061	Database administrators	80	80	$47,220
82	15-1071	Network and computer systems administrators	210	210	$54,420
82	15-1081	Network systems and data communications analysts	60	60	$58,070
82	15-1099	Computer specialists, all other	80	80	$40,210
82	19-3031	Clinical, counseling, and school psychologists	870	870	$54,250
82	23-1011	Lawyers	20	20	$118,370
82	25-1011	Business teachers, postsecondary	970	970	$74,150
82	25-1021	Computer science teachers, postsecondary	840	840	$63,580
82	25-1022	Mathematical science teachers, postsecondary	650	650	$60,610
82	25-1032	Engineering teachers, postsecondary	420	420	$86,110
82	25-1042	Biological science teachers, postsecondary	660	660	$62,780
82	25-1052	Chemistry teachers, postsecondary	N/A	1	$57,750
82	25-1053	Environmental science teachers, postsecondary	N/A	1	$58,250
82	25-1054	Physics teachers, postsecondary	N/A	1	$66,260
82	25-1063	Economics teachers, postsecondary	310	310	$66,790
82	25-1065	Political science teachers, postsecondary	130	130	$66,520
82	25-1066	Psychology teachers, postsecondary	480	480	$62,720
82	25-1067	Sociology teachers, postsecondary	N/A	1	$53,770
82	25-1071	Health specialties teachers, postsecondary	450	450	$71,160
82	25-1072	Nursing instructors and teachers, postsecondary	290	290	$57,460
82	25-1081	Education teachers, postsecondary	460	460	$55,860
82	25-1191	Graduate teaching assistants	80	80	$44,080
82	25-4021	Librarians	1,580	1,580	$49,720
82	27-1024	Graphic designers	80	80	$37,830
82	27-3041	Editors	40	40	$44,110
82	43-9011	Computer operators	N/A	180	$34,160
82	43-9021	Data entry keyers	60	60	$27,240
82	43-9022	Word processors and typists	290	290	$28,130
82	49-2011	Computer, automated teller, and office machine repairers	N/A	65	$38,320
83	11-3021	Computer and information systems managers	30	30	$73,260
83	13-2011	Accountants and auditors	150	150	$42,790
83	13-2031	Budget analysts	20	20	$46,750
83	15-1021	Computer programmers	20	20	$47,020
83	15-1041	Computer support specialists	50	50	$39,680
83	15-1061	Database administrators	60	60	$49,470
83	15-1071	Network and computer systems administrators	20	20	$54,980
83	19-3022	Survey researchers	20	20	$31,280

83	19-3031	Clinical, counseling, and school psychologists	540	540	$42,110
83	43-6013	Medical secretaries	50	50	$27,560
83	43-9021	Data entry keyers	30	30	$19,950
83	43-9022	Word processors and typists	10	10	$24,760
84	13-2011	Accountants and auditors	N/A	550	$49,660
86	11-3021	Computer and information systems managers	20	20	$63,730
86	13-2011	Accountants and auditors	110	110	$49,410
86	13-2051	Financial analysts	N/A	1,540	$41,400
86	15-1021	Computer programmers	10	10	$54,600
86	15-1041	Computer support specialists	30	30	$44,280
86	15-1071	Network and computer systems administrators	20	20	$37,830
86	23-1011	Lawyers	N/A	330	$61,980
86	27-1024	Graphic designers	10	10	$34,580
86	27-3041	Editors	40	40	$53,150
86	43-9021	Data entry keyers	60	60	$23,600
87	11-3021	Computer and information systems managers	250	250	$75,220
87	11-9041	Engineering managers	450	450	$96,840
87	13-2011	Accountants and auditors	2,600	2,600	$57,320
87	13-2031	Budget analysts	60	60	$48,980
87	13-2051	Financial analysts	520	520	$72,270
87	15-1011	Computer and information scientists, research	50	50	$83,210
87	15-1021	Computer programmers	360	360	$53,410
87	15-1031	Computer software engineers, applications	240	240	$62,680
87	15-1032	Computer software engineers, systems software	90	90	$70,250
87	15-1041	Computer support specialists	460	460	$43,470
87	15-1051	Computer systems analysts	320	320	$64,660
87	15-1061	Database administrators	80	80	$52,180
87	15-1071	Network and computer systems administrators	220	220	$62,140
87	15-1081	Network systems and data communications analysts	N/A	400	$60,820
87	15-1099	Computer specialists, all other	N/A	1	$62,450
87	15-2021	Mathematicians	N/A	90	$61,730
87	15-2031	Operations research analysts	200	200	$47,450
87	15-2041	Statisticians	50	50	$54,160
87	17-1011	Architects, except landscape and naval	660	660	$58,860
87	17-1021	Cartographers and photogrammetrists	N/A	1	$41,320
87	17-2051	Civil engineers	1,700	1,700	$58,200
87	17-2071	Electrical engineers	210	210	$62,490
87	17-2072	Electronics engineers, except computer	N/A	140	$49,890
87	17-2081	Environmental engineers	N/A	610	$61,050
87	17-2111	Health and safety engineers, except mining safety engineers and inspectors	80	80	$43,220
87	17-2112	Industrial engineers	190	190	$88,980
87	17-2141	Mechanical engineers	570	570	$65,350
87	17-3011	Architectural and civil drafters	900	900	$36,670
87	17-3012	Electrical and electronics drafters	N/A	65	$44,040
87	17-3013	Mechanical drafters	N/A	150	$42,930
87	17-3022	Civil engineering technicians	370	370	$43,470
87	17-3023	Electrical and electronic engineering technicians	N/A	220	$38,840
87	17-3025	Environmental engineering technicians	50	50	$30,790
87	17-3026	Industrial engineering technicians	40	40	$37,400
87	17-3027	Mechanical engineering technicians	70	70	$38,430
87	17-3031	Surveying and mapping technicians	280	280	$33,540
87	19-1031	Conservation scientists	N/A	50	$86,430
87	19-1042	Medical scientists, except epidemiologists	230	230	$53,260
87	19-2012	Physicists	110	110	$97,560
87	19-2031	Chemists	190	190	$53,890
87	19-2041	Environmental scientists and specialists, including health	410	410	$46,270
87	19-2042	Geoscientists, except hydrologists and geographers	190	190	$55,810
87	19-2043	Hydrologists	60	60	$52,830
87	19-3021	Market research analysts	670	670	$45,980
87	19-3022	Survey researchers	N/A	420	$33,970
87	19-4011	Agricultural and food science technicians	20	20	$23,860
87	19-4021	Biological technicians	520	520	$35,330
87	19-4031	Chemical technicians	210	210	$29,590
87	19-4091	Environmental science and protection technicians, including health	120	120	$35,330
87	25-4021	Librarians	40	40	$38,750
87	27-1014	Multi-media artists and animators	N/A	80	$41,040
87	27-1021	Commercial and industrial designers	N/A	310	$43,220
87	27-1024	Graphic designers	170	170	$38,600
87	27-3041	Editors	30	30	$68,200
87	27-3042	Technical writers	20	20	$56,100
87	41-9031	Sales engineers	70	70	$93,500
87	41-9041	Telemarketers	100	100	$32,580
87	43-6013	Medical secretaries	20	20	$28,460
87	43-9011	Computer operators	70	70	$32,200
87	43-9021	Data entry keyers	420	420	$27,530
87	43-9022	Word processors and typists	160	160	$30,770
89	11-3021	Computer and information systems managers	20	20	$93,050
89	15-2011	Actuaries	110	110	$109,530
89	27-3041	Editors	N/A	110	$35,210
90	11-9041	Engineering managers	140	140	$72,280
90	13-2051	Financial analysts	30	30	$57,560
90	15-1041	Computer support specialists	130	130	$39,760
90	15-1051	Computer systems analysts	170	170	$54,040
90	15-1061	Database administrators	30	30	$53,610
90	15-1099	Computer specialists, all other	10	10	$51,510
90	15-2031	Operations research analysts	60	60	$62,650
90	17-1011	Architects, except landscape and naval	30	30	$67,620
90	17-2011	Aerospace engineers	10	10	$65,540
90	17-2072	Electronics engineers, except computer	40	40	$64,200
90	17-2111	Health and safety engineers, except mining safety engineers and inspectors	10	10	$58,510
90	17-2112	Industrial engineers	10	10	$63,860
90	17-2141	Mechanical engineers	40	40	$64,820

90	17-3011	Architectural and civil drafters	40	40	$42,520
90	17-3023	Electrical and electronic engineering technicians	160	160	$46,060
90	17-3031	Surveying and mapping technicians	50	50	$41,220
90	19-1031	Conservation scientists	40	40	$57,900
90	19-2043	Hydrologists	10	10	$51,830
90	19-3021	Market research analysts	40	40	$54,110
90	19-3031	Clinical, counseling, and school psychologists	180	180	$64,610
90	19-3051	Urban and regional planners	250	250	$59,070
90	19-4011	Agricultural and food science technicians	30	30	$40,310
90	19-4021	Biological technicians	40	40	$35,740
90	19-4091	Environmental science and protection technicians, including health	60	60	$42,160
90	25-1072	Nursing instructors and teachers, postsecondary	10	10	$58,360
90	25-4021	Librarians	640	640	$44,560
90	29-1051	Pharmacists	40	40	$64,890
90	43-6012	Legal secretaries	90	90	$35,330
90	43-6013	Medical secretaries	10	10	$29,810
90	43-9021	Data entry keyers	520	520	$31,340
90	43-9022	Word processors and typists	780	780	$27,560
90	49-2011	Computer, automated teller, and office machine repairers	20	20	$42,550
90	53-2021	Air traffic controllers	110	110	$69,190
		Total IT-Related Connecticut Employment		175,149	

The table above reports IT-related employment by occupation as we have defined it. Yellow highlighted job numbers represent DoL industry suppressions containing the evenly divided residual of OES occupation totals less the sum of given CT DoL figures in other industries. Red highlighted job numbers represent suppressions by both agencies in which we assume at least one job exists. The total number of IT-related jobs in Connecticut is therefore conservative. As one example, there are several thousand graduate assistants at Yale University and the University of Connecticut, while the table reports only 80.

The table below reports essential IT employment in Connecticut in the year 2000 as we have defined it. Yellow highlighted job numbers represent DoL industry suppressions containing the evenly divided residual of OES occupation totals less the sum of given CT DoL figures in other industries.

Connecticut Essential Computer Occupations & Employment by Industry - 2000 [BLS]

Industry	SOC Code	Occupational Title	Employment	Adjusted Employment (if N/A, then divide industry total less allocated workers by #NAs)	Annual Wages ($)
17	15-1071	Network and computer systems administrators	20	20	54,160.00
20	15-1071	Network and computer systems administrators	10	10	40,370.00
22	43-9021	Data entry keyers	10	10	21,970.00
26	11-3021	Computer and information systems managers	50	50	87,320.00
26	15-1021	Computer programmers	40	40	58,230.00
26	15-1041	Computer support specialists	30	30	51,290.00
26	15-1051	Computer systems analysts	30	30	64,350.00
26	15-1061	Database administrators	20	20	65,850.00
26	15-1071	Network and computer systems administrators	30	30	62,470.00
27	11-3021	Computer and information systems managers	70	70	83,890.00
27	15-1021	Computer programmers	70	70	52,340.00
27	15-1041	Computer support specialists	80	80	41,160.00
27	15-1051	Computer systems analysts	50	50	58,020.00
27	15-1061	Database administrators	40	40	54,130.00
27	15-1071	Network and computer systems administrators	60	60	47,490.00
27	15-1099	Computer specialists, all other	20	20	46,720.00
27	43-9011	Computer operators	90	90	32,180.00
27	43-9021	Data entry keyers	120	120	26,070.00
27	43-9031	Desktop publishers	510	510	37,700.00
28	15-1021	Computer programmers	50	50	63,990.00
28	15-1041	Computer support specialists	110	110	46,370.00
28	15-1061	Database administrators	N/A	595	64,680.00
28	15-1071	Network and computer systems administrators	40	40	65,880.00
28	43-9011	Computer operators	30	30	48,630.00
30	11-3021	Computer and information systems managers	20	20	77,770.00
30	51-4011	Computer-controlled machine tool operators, metal and plastic	330	330	26,840.00
30	51-4012	Numerical tool and process control programmers	10	10	55,050.00
33	11-3021	Computer and information systems managers	10	10	76,230.00
33	15-1031	Computer software engineers, applications	N/A	430	65,890.00
33	15-1071	Network and computer systems administrators	10	10	55,750.00
33	43-9021	Data entry keyers	30	30	25,170.00
34	11-3021	Computer and information systems managers	50	50	79,440.00
34	15-1021	Computer programmers	50	50	55,320.00
34	15-1041	Computer support specialists	20	20	43,570.00
34	15-1051	Computer systems analysts	20	20	68,960.00
34	15-1071	Network and computer systems administrators	30	30	57,430.00
34	15-1081	Network systems and data communications analysts	20	20	54,360.00
34	43-9011	Computer operators	20	20	31,020.00
34	43-9021	Data entry keyers	20	20	26,050.00
34	51-4011	Computer-controlled machine tool operators, metal and plastic	280	280	32,690.00
34	51-4012	Numerical tool and process control programmers	50	50	47,670.00
35	11-3021	Computer and information systems managers	140	140	91,830.00
35	15-1021	Computer programmers	170	170	67,430.00
35	15-1031	Computer software engineers, applications	260	260	79,920.00
35	15-1032	Computer software engineers, systems software	20	20	63,560.00
35	15-1041	Computer support specialists	180	180	53,780.00
35	15-1061	Database administrators	40	40	72,170.00
35	15-1071	Network and computer systems administrators	10	10	62,020.00
35	17-2061	Computer hardware engineers	110	110	73,810.00
35	43-9011	Computer operators	50	50	37,060.00
35	43-9021	Data entry keyers	10	10	32,050.00
35	51-4011	Computer-controlled machine tool operators, metal and plastic	1,310	1,310	34,230.00
35	51-4012	Numerical tool and process control programmers	210	210	49,320.00
36	11-3021	Computer and information systems managers	120	120	92,800.00
36	15-1021	Computer programmers	90	90	47,270.00
36	15-1031	Computer software engineers, applications	120	120	57,110.00
36	15-1041	Computer support specialists	70	70	43,870.00
36	15-1051	Computer systems analysts	70	70	64,610.00
36	15-1061	Database administrators	10	10	60,460.00
36	15-1071	Network and computer systems administrators	50	50	63,310.00
36	15-1081	Network systems and data communications analysts	40	40	57,770.00
36	15-1099	Computer specialists, all other	20	20	57,910.00
36	17-2061	Computer hardware engineers	20	20	55,450.00
36	43-9011	Computer operators	20	20	28,530.00
36	43-9021	Data entry keyers	N/A	219	25,800.00
36	51-4011	Computer-controlled machine tool operators, metal and plastic	180	180	27,730.00
36	51-4012	Numerical tool and process control programmers	50	50	43,090.00
37	11-3021	Computer and information systems managers	150	150	96,580.00
37	15-1021	Computer programmers	90	90	52,770.00
37	15-1041	Computer support specialists	110	110	59,160.00
37	15-1051	Computer systems analysts	290	290	68,300.00
37	15-1071	Network and computer systems administrators	50	50	62,770.00
37	15-1081	Network systems and data communications analysts	40	40	61,000.00
37	15-1099	Computer specialists, all other	N/A	315	59,890.00
37	43-9011	Computer operators	30	30	31,210.00
37	51-4011	Computer-controlled machine tool operators, metal and plastic	850	850	33,440.00
37	51-4012	Numerical tool and process control programmers	N/A	123	45,130.00
38	11-3021	Computer and information systems managers	50	50	85,650.00
38	15-1021	Computer programmers	110	110	54,570.00
38	15-1031	Computer software engineers, applications	N/A	430	66,710.00
38	15-1032	Computer software engineers, systems software	170	170	65,620.00
38	15-1041	Computer support specialists	100	100	46,510.00
38	15-1051	Computer systems analysts	70	70	63,030.00
38	15-1061	Database administrators	50	50	56,370.00
38	15-1071	Network and computer systems administrators	50	50	65,950.00
38	15-1081	Network systems and data communications analysts	30	30	58,610.00
38	43-9011	Computer operators	20	20	40,090.00
38	43-9021	Data entry keyers	80	80	29,380.00

38	51-4011	Computer-controlled machine tool operators, metal and plastic	300	300	31,840.00
38	51-4012	Numerical tool and process control programmers	N/A	123	46,780.00
39	43-9021	Data entry keyers	20	20	20,070.00
44	11-3021	Computer and information systems managers	20	20	77,790.00
44	15-1041	Computer support specialists	40	40	49,350.00
44	43-9011	Computer operators	30	30	34,280.00
47	43-9011	Computer operators	N/A	180	30,480.00
48	11-3021	Computer and information systems managers	60	60	67,540.00
48	15-1041	Computer support specialists	N/A	600	34,150.00
49	11-3021	Computer and information systems managers	30	30	86,710.00
49	15-1061	Database administrators	30	30	62,600.00
49	15-1071	Network and computer systems administrators	30	30	57,000.00
50	11-3021	Computer and information systems managers	150	150	82,910.00
50	15-1021	Computer programmers	500	500	45,530.00
50	15-1031	Computer software engineers, applications	N/A	430	76,770.00
50	15-1032	Computer software engineers, systems software	160	160	67,730.00
50	15-1041	Computer support specialists	690	690	50,440.00
50	15-1051	Computer systems analysts	120	120	63,270.00
50	15-1061	Database administrators	20	20	56,000.00
50	15-1071	Network and computer systems administrators	340	340	68,120.00
50	15-1081	Network systems and data communications analysts	30	30	51,720.00
50	15-1099	Computer specialists, all other	60	60	62,720.00
50	17-2061	Computer hardware engineers	N/A	220	72,070.00
50	43-9011	Computer operators	120	120	38,690.00
50	43-9021	Data entry keyers	150	150	28,770.00
50	49-2011	Computer, automated teller, and office machine repairers	750	750	38,850.00
50	51-4012	Numerical tool and process control programmers	N/A	123	57,790.00
51	11-3021	Computer and information systems managers	90	90	79,370.00
51	15-1021	Computer programmers	80	80	60,590.00
51	15-1041	Computer support specialists	60	60	52,250.00
51	15-1051	Computer systems analysts	N/A	210	84,210.00
51	15-1071	Network and computer systems administrators	60	60	57,990.00
51	15-1099	Computer specialists, all other	10	10	60,470.00
51	43-9011	Computer operators	170	170	33,380.00
51	43-9021	Data entry keyers	130	130	28,490.00
52	43-9011	Computer operators	60	60	41,390.00
54	15-1041	Computer support specialists	40	40	25,900.00
54	43-9011	Computer operators	40	40	26,690.00
54	43-9021	Data entry keyers	30	30	20,350.00
55	11-3021	Computer and information systems managers	N/A	205	44,720.00
56	15-1041	Computer support specialists	10	10	32,680.00
57	11-3021	Computer and information systems managers	20	20	62,190.00
57	15-1021	Computer programmers	60	60	39,140.00
57	15-1041	Computer support specialists	70	70	32,810.00
57	49-2011	Computer, automated teller, and office machine repairers	220	220	45,770.00
59	43-9011	Computer operators	N/A	180	27,420.00
59	43-9021	Data entry keyers	N/A	219	17,710.00
59	49-2011	Computer, automated teller, and office machine repairers	N/A	65	20,600.00
60	11-3021	Computer and information systems managers	210	210	83,440.00
60	15-1021	Computer programmers	90	90	51,180.00
60	15-1031	Computer software engineers, applications	30	30	66,180.00
60	15-1041	Computer support specialists	120	120	35,530.00
60	15-1051	Computer systems analysts	220	220	48,250.00
60	15-1071	Network and computer systems administrators	90	90	48,750.00
60	15-1081	Network systems and data communications analysts	50	50	36,170.00
60	43-9011	Computer operators	230	230	25,820.00
60	43-9021	Data entry keyers	N/A	219	18,710.00
61	11-3021	Computer and information systems managers	130	130	108,610.00
61	15-1031	Computer software engineers, applications	140	140	79,330.00
61	15-1032	Computer software engineers, systems software	10	10	89,400.00
61	15-1041	Computer support specialists	100	100	50,850.00
61	15-1051	Computer systems analysts	70	70	64,960.00
61	15-1061	Database administrators	40	40	78,190.00
61	15-1071	Network and computer systems administrators	50	50	82,720.00
61	17-2061	Computer hardware engineers	50	50	75,360.00
61	43-9021	Data entry keyers	N/A	219	26,140.00
62	11-3021	Computer and information systems managers	80	80	98,580.00
62	15-1021	Computer programmers	N/A	1,455	61,780.00
62	15-1031	Computer software engineers, applications	80	80	83,830.00
62	15-1032	Computer software engineers, systems software	N/A	560	78,230.00
62	15-1041	Computer support specialists	40	40	45,020.00
62	15-1051	Computer systems analysts	60	60	58,170.00
62	15-1071	Network and computer systems administrators	N/A	670	67,180.00
62	43-9011	Computer operators	90	90	28,410.00
62	43-9021	Data entry keyers	N/A	219	26,050.00
63	11-3021	Computer and information systems managers	970	970	89,720.00
63	15-1021	Computer programmers	N/A	1,455	59,400.00
63	15-1031	Computer software engineers, applications	1,570	1,570	66,780.00
63	15-1032	Computer software engineers, systems software	100	100	54,770.00
63	15-1051	Computer systems analysts	1,760	1,760	64,140.00
63	15-1071	Network and computer systems administrators	320	320	55,170.00
63	15-1081	Network systems and data communications analysts	N/A	400	59,460.00
63	15-1099	Computer specialists, all other	450	450	64,980.00
63	43-9011	Computer operators	190	190	29,040.00
63	43-9021	Data entry keyers	650	650	25,650.00
64	11-3021	Computer and information systems managers	90	90	75,580.00
64	15-1021	Computer programmers	20	20	59,670.00
64	15-1041	Computer support specialists	30	30	39,140.00
64	15-1051	Computer systems analysts	N/A	210	65,920.00
64	15-1071	Network and computer systems administrators	40	40	51,970.00
64	43-9021	Data entry keyers	130	130	25,650.00
65	11-3021	Computer and information systems managers	N/A	205	91,430.00
65	15-1041	Computer support specialists	N/A	600	39,530.00
65	15-1051	Computer systems analysts	N/A	210	71,400.00
65	15-1071	Network and computer systems administrators	60	60	53,880.00
65	43-9021	Data entry keyers	N/A	219	20,270.00

CCEA

67	11-3021	Computer and information systems managers	40	40	94,480.00
67	15-1021	Computer programmers	110	110	63,050.00
67	15-1031	Computer software engineers, applications	30	30	70,930.00
67	15-1041	Computer support specialists	60	60	47,590.00
67	15-1051	Computer systems analysts	20	20	60,000.00
67	15-1071	Network and computer systems administrators	20	20	65,890.00
73	11-3021	Computer and information systems managers	1240	1,240	109,250.00
73	15-1011	Computer and information scientists, research	310	310	82,680.00
73	15-1021	Computer programmers	4,780	4,780	70,390.00
73	15-1031	Computer software engineers, applications	2,300	2,300	73,920.00
73	15-1032	Computer software engineers, systems software	1,090	1,090	64,670.00
73	15-1041	Computer support specialists	2,760	2,760	42,690.00
73	15-1051	Computer systems analysts	3,140	3,140	67,940.00
73	15-1061	Database administrators	N/A	595	49,910.00
73	15-1071	Network and computer systems administrators	710	710	62,300.00
73	15-1081	Network systems and data communications analysts	770	770	66,740.00
73	15-1099	Computer specialists, all other	870	870	62,720.00
73	17-2061	Computer hardware engineers	130	130	62,880.00
73	27-1014	Multi-media artists and animators	240	240	61,490.00
73	43-9011	Computer operators	450	450	32,380.00
73	43-9021	Data entry keyers	2300	2,300	23,760.00
73	43-9031	Desktop publishers	30	30	42,550.00
73	49-2011	Computer, automated teller, and office machine repairers	860	860	34,880.00
78	27-1014	Multi-media artists and animators	20	20	48,800.00
79	15-1021	Computer programmers	20	20	58,360.00
79	15-1041	Computer support specialists	80	80	28,690.00
79	15-1061	Database administrators	20	20	52,130.00
79	43-9011	Computer operators	90	90	23,770.00
79	43-9021	Data entry keyers	10	10	22,100.00
80	11-3021	Computer and information systems managers	210	210	86,990.00
80	15-1021	Computer programmers	160	160	57,650.00
80	15-1031	Computer software engineers, applications	100	100	59,300.00
80	15-1041	Computer support specialists	190	190	39,600.00
80	15-1061	Database administrators	50	50	52,470.00
80	15-1071	Network and computer systems administrators	90	90	62,050.00
80	15-1081	Network systems and data communications analysts	N/A	400	53,200.00
80	15-1099	Computer specialists, all other	90	90	57,100.00
80	43-9011	Computer operators	130	130	31,630.00
80	43-9021	Data entry keyers	280	280	23,330.00
81	11-3021	Computer and information systems managers	30	30	78,380.00
81	15-1041	Computer support specialists	N/A	600	40,690.00
81	15-1071	Network and computer systems administrators	40	40	52,270.00
81	43-9021	Data entry keyers	N/A	219	37,260.00
82	11-3021	Computer and information systems managers	150	150	70,550.00
82	15-1021	Computer programmers	210	210	55,270.00
82	15-1041	Computer support specialists	700	700	37,140.00
82	15-1051	Computer systems analysts	90	90	51,180.00
82	15-1061	Database administrators	80	80	47,220.00
82	15-1071	Network and computer systems administrators	210	210	54,420.00
82	15-1081	Network systems and data communications analysts	60	60	58,070.00
82	15-1099	Computer specialists, all other	80	80	40,210.00
82	25-1021	Computer science teachers, postsecondary	840	840	63,580.00
82	25-1191	Graduate teaching assistants	80	80	44,080.00
82	43-9011	Computer operators	N/A	180	34,160.00
82	43-9021	Data entry keyers	60	60	27,240.00
82	49-2011	Computer, automated teller, and office machine repairers	N/A	65	38,320.00
83	11-3021	Computer and information systems managers	30	30	73,260.00
83	15-1021	Computer programmers	20	20	47,020.00
83	15-1041	Computer support specialists	50	50	39,680.00
83	15-1061	Database administrators	60	60	49,470.00
83	15-1071	Network and computer systems administrators	20	20	54,980.00
83	43-9021	Data entry keyers	30	30	19,950.00
86	11-3021	Computer and information systems managers	20	20	63,730.00
86	15-1021	Computer programmers	10	10	54,600.00
86	15-1041	Computer support specialists	30	30	44,280.00
86	15-1071	Network and computer systems administrators	20	20	37,830.00
86	43-9021	Data entry keyers	60	60	23,600.00
87	11-3021	Computer and information systems managers	250	250	75,220.00
87	15-1011	Computer and information scientists, research	50	50	83,210.00
87	15-1021	Computer programmers	360	360	53,410.00
87	15-1031	Computer software engineers, applications	240	240	62,680.00
87	15-1032	Computer software engineers, systems software	90	90	70,250.00
87	15-1041	Computer support specialists	460	460	43,470.00
87	15-1051	Computer systems analysts	320	320	64,660.00
87	15-1061	Database administrators	80	80	52,180.00
87	15-1071	Network and computer systems administrators	220	220	62,140.00
87	15-1081	Network systems and data communications analysts	N/A	400	60,820.00
87	15-1099	Computer specialists, all other	N/A	315	62,450.00
87	43-9011	Computer operators	70	70	32,200.00
87	43-9021	Data entry keyers	420	420	27,530.00
89	11-3021	Computer and information systems managers	20	20	93,050.00
90	15-1041	Computer support specialists	130	130	39,760.00
90	15-1051	Computer systems analysts	170	170	54,040.00
90	15-1061	Database administrators	30	30	53,610.00
90	15-1099	Computer specialists, all other	10	10	51,510.00
90	43-9021	Data entry keyers	520	520	31,340.00
90	49-2011	Computer, automated teller, and office machine repairers	20	20	42,550.00
90	53-2021	Air traffic controllers	110	110	69,190.00
		Total Essential IT	51,770	65,850	

Appendix 2: TFP Calculation

We measure total factor productivity (TFP) by calculating the Tornqvist quantity indexes of input and output and taking their quotient. We estimate the Tornqvist index for 2-digit sectors for the economy in two states: the first is the Connecticut economy with IT present; the other is the Connecticut economy without IT present. Thus, the TFP measure we use estimates the contribution of IT to TFP. We have,

$$TFP_{io} = \frac{OutputIndex_{io}}{InputIndex_{io}},$$

where *io* refers to the two states of the economy (in and out) and

$$OutputIndex_{io} = \frac{y_0 - IT_{spend} - IT_{wagebill}}{y_0}, \text{ and}$$

$$InputIndex_{io} = \left(\frac{k_0 - IT_{spend}}{k_0}\right)^{s_{k_0}} \left(\frac{l_0 - IT_{emp}}{l_0}\right)^{s_{l_0}}.$$

y_0 represents the value added of a 2-digit sector in the year 2000, k_0 represents the capital stock in the sector in 2000, l_0 represents sector employment in 2000, IT_{spend} represents IT spending in that sector in 2000, $IT_{wagebill}$ represents the product of the average IT wage in the sector and the IT employment in that sector in 2000, and IT_{emp} represents IT employment in the sector in 2000. The exponents s_{k_0} and s_{l_0} refer to the cost shares of capital and labor for each sector in 2000. Thus, the sector's proportional change in output is its value added less payments to IT 'capital' and IT labor relative to its value added. The sector's change in its input bundle is the product of its proportional change in its capital stock (assuming IT spending represents the change) raised to the power of capital's cost share and the sector's proportional change in labor raised to the power of labor's cost share.

We estimate the capital stock of each Connecticut 2-digit sector by calculating the capital-output ratio of the sector for the U.S. and multiplying this by the sector's Connecticut output (value added or GSP) for 2000. This assumes that the distribution of capital vintages and productivities in Connecticut is the same as those for the U.S. We estimate each sector's cost share of capital as 5% of its capital stock divided by the sum of this and the sector's wage bill. The sector's cost share of labor is unity less capital's cost share.

The change in TFP is then unity subtracted from the above number because it represents the cumulative change from the base period in which it was unity. Appendix 3 provides these sectoral TFP changes or contributions, as well as Connecticut's imputed sectoral capital stock, employment, IT essential and related employment, and capital value shares.

Appendix 3: The REMI Model and Input for IT Impact

The REMI Model

The Connecticut REMI model is a dynamic, multi-sector, regional model developed and maintained for the Connecticut Center for Economic Analysis by Regional Economic Models, Inc. of Amherst, Massachusetts. This model provides detail on all eight counties in the State of Connecticut and any combination of these counties. The REMI model includes all of the major inter-industry linkages among 466 private industries, aggregated into 49 major industrial sectors. With the addition of farming and three public sectors (state and local government, civilian federal government, and military), there are 53 sectors represented in the model for the eight counties.

The REMI model is based on a nationwide *input-output* (I/O) model that the U.S. Department of Commerce (DOC) developed and continues to maintain. Modern input-output models are largely the result of groundbreaking research by Nobel laureate Wassily Leontief. Such models focus on the inter-relationships between industries and provide information about how changes in specific variables—whether economic variable such as employment or prices in a certain industry or other variables like population affect factor markets, intermediate goods production, and final goods production and consumption.

The REMI Connecticut model takes the U.S. I/O "table" results and scales them according to traditional regional relationships and current conditions, allowing the relationships to adapt at reasonable rates to changing conditions. Listed below are some salient structural characteristics of the REMI model:

- REMI determines consumption on an industry-by-industry basis, and models real disposable income in Keynesian fashion, i.e., with prices fixed in the short run and GDP (Gross Domestic Product) determined solely by aggregate demand.

- The demand for labor, capital, fuel, and intermediate inputs per unit of output depends on relative prices of inputs. Changes in relative prices cause producers to substitute cheaper inputs for relatively more expensive inputs.

- Supply and demand for labor in a sector determine the wage level, and these characteristics are factored by regional differences. The supply of labor depends on the size of the population and the size of the workforce.

- Migration—that affects population size—depends on real after-tax wages as well as employment opportunities and amenity value in a region relative to other areas.

- Wages and other measures of prices and productivity determine the cost of doing business. Changes in the cost of doing business will affect profits and/or prices in a given industry. When the change in the cost of doing business is specific to a region, the share of local and U.S. market supplied by local firms will also be affected. Market share and demand determine local output.

- "Imports" and "exports between states are related to relative prices and relative production costs.

- Property income depends only on population and its distribution adjusted for traditional regional differences, *not* on market conditions or building rates relative to business activity.

- Estimates of transfer payments depend on unemployment details of the previous period, and total government expenditures are proportional to population size.

- Federal military and civilian employment is exogenous and maintained at a *fixed* share of the corresponding total U.S. values, unless specifically altered in the analysis.

Because the variables in the REMI model are all related, a change in any one variable affects many others. For example, if wages in a certain sector rise, the relative prices of inputs change and may cause the producer to substitute capital for labor. This changes demand for inputs, which affects employment, wages, and other variables in those industries. Changes in employment and wages affect migration and the population level that in turn affect other employment variables. Such chain-reactions continue throughout the model. Depending on the analysis performed, the nature of the chain of events cascading through the model economy can be as informative for the policymaker as the final aggregate results. Because REMI generates extensive sectoral detail, it is possible for experienced economists in this field to discern the dominant causal linkages involved in the results.

The IT impacts reported above derive from counterfactually removing essential IT employment, IT-related employment that includes essential IT employment, and the sectoral TFP change accruing to the loss of essential IT employment and IT spending in the year 2000. Because we account for some intermediate demand through IT spending, we suppress intermediate demand induced due to the change in employment. We assume as well that all physical capital remains intact, that is, IT workers just walk away. We therefore suppress investment induced due to the change in employment. As average IT wages in each sector differ from REMI's average sector wage, we make a wage bill adjustment equal to the product of the number of IT workers in each 2-digit sector and the difference between REMI's average sector wage and that reported by DoL or OES. This accounts for the difference in productivity of these workers and the REMI average worker in each sector. The table below shows the REMI input for each direct effect.

Connecticut IT Employment by Industry - 2000

SIC	Standard Industry	REMI Industry	IT-Related Employment in 2000	Essential IT Employment in 2000	Total Sector Employment	IT-Related Labor Fraction	IT-Related wage bill/GSP	IT spend/GSP	IT spend/K0	IT-Related TFP Tornqvist index	Essential IT Labor Fraction	Essential IT wage bill/GSP	Essential IT TFP Tornqvist index	Sector Capital Value (K0)	Sector Labor Value	Sector Capital Value Share
33	Primary metal industries	Primary metal industries	860	480	9280	0.092672414	0.08169756	0.1517812	0.05998301	0.84	0.05172414	0.04768473	0.85	$1,740,917,211	$410,779,200	0.17485
34	Fabricated metal products	Fabricated metal products	2000	560	33560	0.059594756	0.036332538	0.13603821	0.14947119	0.89	0.01668653	0.00853635	0.88	$2,526,520,893	$1,801,802,840	0.06552
35	Machinery and computer equipment	Machinery and computer equipment	5753	2510	32930	0.17471404	0.130990766	0.13847267	0.16384192	0.88	0.07622229	0.05160436	0.88	$2,261,648,668	$2,436,424,840	0.04435
36	Electronic equipment, except computer equipment	Electronic equipment, except computer equipment	4909	1079	27430	0.178966373	0.07980039	0.0988037	0.09010296	0.99	0.03932087	0.01589045	0.93	$3,425,667,123	$1,836,136,770	0.08533
37*	Transportation equipment (Motor vehicles)	Motor vehicles and equipment	1180	410	9126	0.129293593	0.013292898	0.09020037	0.05797118	1.02	0.04489006	0.00424959	0.95	$871,333,143	$694,954,026	0.05899
37*	Transportation equipment (excluding motor vehicles)	Transportation equipment excluding motor vehicles	4720	1639	36504	0.129293593	0.053171593	0.14489843	0.11844274	0.92	0.04489006	0.01699836	0.88	$3,908,643,910	$2,779,816,104	0.06569
38	Instruments and related products	Instruments and related products	4437	1583	19580	0.22659176	0.121774633	0.10939857	0.09748719	0.97	0.08086483	0.04128355	0.93	$2,260,078,678	$781,379,060	0.12635
39	Miscellaneous manufacturing industries	Miscellaneous manufacturing industries	180	20	6200	0.029032258	0.07700946	0.10833387	0.20177618	0.85	0.00322581	0.04494841	0.86	$345,764,354	$258,403,600	0.06271
20	Food and kindred products	Food and kindred products	100	10	7940	0.012594458	0.005123291	0.08682875	0.06251899	0.93	0.00125945	0.0004068	0.93	$1,429,114,381	$258,050,000	0.21686
22	Textiles	Textiles	20	10	2100	0.00952381	0.009378363	0.21288975	0.1254393	0.79	0.0047619	0.00203841	0.80	$188,384,043	$122,497,200	0.0714
26	Paper	Paper	555	200	7830	0.070881226	0.030990136	0.06478602	0.04629037	0.97	0.02554278	0.0127772	0.95	$1,903,397,624	$364,384,710	0.20709
27	Printing and allied products	Printing and allied products	4270	1110	23980	0.178065054	0.10661224	0.18431748	0.23673608	0.86	0.04628857	0.02963177	0.83	$1,139,838,048	$2,095,971,900	0.02647
28	Chemicals and allied products	Chemicals and allied products	4882	825	22760	0.214484476	0.094407517	0.07059329	0.05158694	1.03	0.0362478	0.01502674	0.95	$4,964,676,413	$1,106,113,240	0.18329
30	Rubber and miscellaneous plastics products	Rubber and miscellaneous plastics products	770	360	10330	0.074540174	0.049553846	0.1769267	0.14136174	0.84	0.03484995	0.01630953	0.84	$822,293,541	$475,861,780	0.07953
17	Construction	Construction	520	20	46260	0.011240813	0.006334411	0.04552218	0.22051297	0.97	0.00043234	0.00030323	0.96	$1,151,715,702	$2,096,410,680	0.02673
44, 46, 47**	Water transportation and other transportation and transportation services	Other transportation and transportation services	2420	270	9660	0.250517598	0.109104877	0.17138314	0.14646761	0.95	0.02795031	0.01254697	0.84	$916,195,744	$1,012,078,200	0.0433
48	Communications	Communications	2740	660	20480	0.133789063	0.031214765	0.07946935	0.02987369	1.00	0.03222656	0.00697305	0.94	$9,523,439,176	$1,351,802,880	0.26049
49	Electric, gas, and sanitary services	Electric, gas, and sanitary services	670	90	12870	0.052059052	0.015870406	0.05983436	0.01178328	0.95	0.00699301	0.00212555	0.95	$15,172,781,156	$276,421,860	0.73294
63, 64**	Insurance carriers and insurance agents, brokers, and services	Insurance carriers, agents, brokers, and services	15573	8385	71500	0.217808858	0.077886647	0.15259988	0.15207297	0.98	0.11727273	0.04233585	0.92	$12,276,921,087	$5,245,883,500	0.10476
60	Depository institutions	Depository institutions	2521	1259	24670	0.102177312	0.005076223	0.22161004	0.24031624	0.87	0.05101627	0.00213339	0.83	$2,680,534,881	$1,713,849,570	0.07253
61,62,67**	Security & commodity brokers & investment services	Security & commodity brokers & investment services	12326	4342	28580	0.431295611	0.133082153	0.10258244	0.05151754	1.26	0.15192942	0.03815281	1.00	$14,485,800,968	$4,714,728,280	0.13317
65	Real estate	Real estate	3351	1294	16730	0.200281786	0.00788466	0.01687843	0.00160589	0.99	0.07734608	0.00251596	0.99	$272,029,748,738	$1,025,231,130	0.92991
52-57,59**	Other retail trade	Rest of retail trade	4789	1219	199370	0.024020904	0.02060004	0.08999181	0.19163913	0.91	0.00611211	0.00353718	0.91	$9,198,050,752	$32,894,455,040	0.01379
50, 51**	Wholesale trade	Wholesale trade	9047	4673	81540	0.110947592	0.049661342	0.07042043	0.09093242	0.99	0.05731338	0.02523982	0.96	$7,928,154,657	$3,502,632,240	0.10167
73	Business services	Business services	29915	22575	117650	0.254271143	0.192626998	0.11312521	0.22514492	0.93	0.1918827	0.14992755	0.92	$4,599,810,537	$1,913,930,200	0.10728
79	Amusement and recreation services	Amusement and recreation services	510	220	36580	0.013942045	0.008399112	0.15749577	0.16738596	0.86	0.00601422	0.00335795	0.85	$1,923,688,933	$1,298,882,640	0.06895
80	Health services	Health services	8120	1700	158030	0.051382649	0.0338735	0.14874502	0.40996664	0.87	0.01075745	0.00921906	0.86	$3,393,135,381	$6,204,099,770	0.02662
81,87,89**	Legal, engineering and management, and miscellaneous services	Legal, engineering and management, and miscellaneous services	27793	4184	52830	0.526078256	0.238934739	0.06550678	0.08217638	1.40	0.07919743	0.03081634	0.98	$5,659,053,086	$3,477,270,600	0.07525
82	Education services	Education services	11189	2805	42930	0.26063359	0.329442118	0.19398825	0.72029001	0.66	0.06533892	0.07284682	0.81	$524,642,739	$982,925,280	0.02599
83, 84, 86**	Social services, membership organizations, and museums	Social services, membership organizations, and museums	3720	350	67710	0.054940186	0.081254382	0.29019931	0.27378494	0.67	0.0051691	0.007357	0.71	$2,176,974,947	$4,208,515,050	0.02521
90	Government	Government	3830	990	197310	0.019411079	0.013304744	N/A			0.00501749	0.0032221				

Note:* In REMI, Transportation equipment (37) is divided into two parts: Motor vehicles and equipment and Transportation equipment excluding motor vehicles. We assume they share IT employment by the ratio 1:4. ** In REMI, these 2-digit level industries are combined into one sector. We take the aggregate value of these industries.

Appendix 4: Literature Review

Literature Review

1. Productivity Paradox

The 1990s witnessed an expansionary phase of U.S. economic growth, a high growth rate of labor productivity, low core inflation and dramatic cost reductions in computers, computer components, and communications equipment. This sustained economic strength with low inflation suggests that the U.S. economy may well have crossed into a new era of greater economic prosperity and possibility, much as it did after the development and spread of the electric dynamo and the internal combustion engine in the early twentieth century. Although information technology (IT) industries still account for a relatively small share of the economy's total output, they contributed nearly a third of real U.S. economic growth between 1995 and 1999. Jorgenson and Stiroh (2000b) note that the sustainability of growth in labor productivity is the key issue for future growth projections.

The literature does not tell this expansionary story before 1990. Many studies in the 1980s found no connection or a negative relationship between IT investment and productivity in the U.S. economy. Although most studies since the mid-1990s document IT-led economic growth, there are still some arguments against the IT growth-engine thesis. In McKinsey (2001) for example, IT investments had a significant impact on productivity in a few particular industries and virtually none in others. Whether the literature supports or rejects the IT growth-engine thesis, we can observe the following trends in the U.S. economy:

1. Computer price declines: the price of computers has dropped by half every 2-3 years.
2. Increased investment in IT equipment: these investments accounted for over 10% of new investment in capital equipment by American firms.
3. Labor force: over half the U.S. labor force works in information-handling activities.
4. Productivity: overall productivity has slowed significantly since the early 1970s and measured productivity growth has fallen especially sharply in the service sectors, which account for 80% of IT investment. However, there is some evidence of a rebound in the mid-1990s (Brynjolfsson & Yang, 1996).

The debate on the contribution of computers to productivity growth has been termed as a "productivity paradox." Its proponents claim that investments in IT, though massive, have not produced significant improvements in industrial productivity. The sharp drop in productivity since the early 1970s roughly coincided with the rapid increase in the use of IT.

Jorgenson and Stiroh (1995) show that average multifactor productivity[6] growth dropped from 1.7% per year for 1947-73 to about 0.5% for the 1973-1992 period. The overall negative correlation between economy-wide productivity and the advent of computers is also evident in the pre-1992 data. Productivity did not increase although companies invested heavily in IT.

During the mid-1990s, the Internet boom and the so-called new economy began to dominate the U.S. economy. The data from the second half of the 1990s showed that overall productivity had reversed its trend: multifactor productivity grew as the investment in IT capital continued to increase. Some researchers attribute such changes to the fact that firms were learning to apply IT capital more productively over time (Dedrick, Gurbaxani, & Kraemer, 2001). In 2000, IT capital investment began to fall sharply, partly due to higher interest rates and slowing economic growth. Moreover, the collapse of many Internet firms had far-reaching impacts. Not only did their own investment in IT disappear, but more established firms felt less pressure to invest in IT in order to respond to competition from those newcomers. Some researchers believe that this reduction in IT investment has had devastating effects on the IT-producing sector, and may lead to slower economic and productivity growth in the U.S. economy.

In any case, the productivity paradox still awaits an explanation. IT-led productivity growth did not just magically appear after 1990s. Moreover, many researchers notice that the manufacturing and service sectors exhibit quite different stories. Much of the evidence supporting the productivity paradox has centered on the service sector. The service sector spent over $750 billion on IT hardware in the 1980s and $862 billion from 1984-1994 (representing about 85% of total U.S. IT hardware investment). An average productivity growth rate of 0.7 percent accompanied the service industry's investment in IT in the 1980s, a rate significantly lower than in the 1970s and much below that of the manufacturing sector during the decade of the eighties. Perhaps, at least partially, this is because service industries provide products that can significantly improve the productivity of their customers, while IT did not necessarily generate internal productivity improvements. On the other hand, manufacturers increasingly elect to outsource many of their services, thus pushing less

[6] Brynjolffson and Yang (1996) define labor and multifactor productivity as: "'Labor productivity' is calculated as the level of output divided by a given level of labor input. 'Multifactor productivity' (sometimes more ambitiously called 'total factor productivity') is calculated as the level of output for a given level of several inputs, typically labor, capital and

productive activities outside of their own organizations (Ives, 1994). However, the difference between the manufacturing and service sectors is only part of the paradox. People have done much beyond that.

There are two principal reasons that can explain the productivity paradox at least partially. The first is measurement errors. Measurement issues are quite daunting in this field. This is the easiest explanation for the confusion about the productivity of IT. For instance, measuring outputs in the service sector, which owns the majority of IT capital, is very difficult. At the firm level, most studies use the value added by firms as a measure of output, which may not capture the quality improvements that a firm makes in its products or services. On the other hand, it has proven to be very difficult to account for investments in software. It is not only conceptually challenging to define units of software, but also difficult in practice to account for the large investments that firms have made in custom software.

As Jorgensen and Stiroh (2000b) point out, new IT investment accrues to the innovating industries producing high-tech assets and to the industries that restructure to implement the latest information technology. Indeed, many of the industries that use information technology most intensively, such as FIRE and services, show high rates of substitution of information technology for other inputs and relatively low rates of productivity growth. In part, this may reflect problems in measuring the output from these industries, but the empirical record provides little support for the "new economy" picture of spillovers cascading from information technology producers to users of this technology.

If errors exist in comparable magnitudes both before and after IT investments, biases do not necessarily occur. However, the sorts of benefits that managers ascribe to IT are precisely the aspects of output measurement for which productivity statistics as well as most firms' accounting numbers poorly account (Brynjolfsson and Hitt 1994). This can lead to systematic underestimates of IT productivity. Therefore, some analysts are skeptical that measurement problems can explain much of the slowdown. However, mismeasurement is not a panacea for the "productivity paradox."

The second explanation for the paradox is lags in impact. Benefits from IT capital investment may take some time to appear on the bottom line. The idea that new technologies may have a delayed impact is a common one in business. However, this explanation is somewhat undermined by the fact that American managers have not been noted for long-term

---

materials. In principle, multifactor productivity is a better measure of a firm or industry's efficiency because it adjusts for cost-benefit analysis. In addition, the sharp price decline in IT capital goods is another explanation for management's investment behavior. Long-term benefits of IT investment are not easy to account for when managers make short run decisions. More recently, Brynjolfsson and Hitt (2000) find that payoffs to IT investment occur not just in labor productivity but also in multifactor productivity (MFP) growth, and that the impact on MFP growth reaches its zenith after a lag of four to seven years.

Beside the above two issues, statistical problems such as redistribution and mismanagement also help to explain the paradox. In production function approaches, perhaps the most significant estimation issue is the notion of simultaneity in investment and growth due to unobservable factors. The same problems arise with macroeconomic data. Meanwhile, IT rearranges the shares of the whole economy without making it any bigger. It is possible that many IT investments are wasteful, and mismanagement will not reduce this waste.

2. Measuring the Economic Impact of IT

Jorgensen and Stiroh (2000b) define IT as investments in computers, software, and communications equipment, as well as the consumption of computer and software as outputs. However, the Bureau of Economic Analysis (BEA) offers an accurate and more commonly used definition (Brynjolfsson & Yang, 1996) for IT: Office, Computing and Accounting Machinery (OCAM) consist primarily of computers. Information Processing Equipment (IPE) under hardware components includes communications equipment, scientific and engineering instruments, photocopiers and related equipment. In addition, software and related services are sometimes included in IT capital. Studies often examine the productivity of information systems' staff, or of workers who use computers at work. IT investment is not only "technology," but also a capital input that contributes to production as firms make IT-related investments and accumulate capital.

Unlike other traditional industries, IT industries "work mostly for other industries." In this sense, many IT industries have been sorted into the service sector. This creates difficulties in measuring the impact of IT, and the indirect effect on other industries becomes intractable. For example, measurement difficulties arise because software, which constitutes a large part of IT, is often produced in-house or embedded into final products. Despite these

shifts among inputs, such as an increase in capital intensity. However, lack of data renders this consideration moot."

difficulties, there are many ongoing studies attempting to measure the economic impact of the IT industry. An earlier study by Crowston and Treacy (1986) argues that measuring the impact of IT is unsuccessful because of the lack of clearly defined variables, which in turn stems from inadequate reference disciplines and methodologies.

Siegel (1994) attempts to tackle some aspects of the data problems. He deals with two possible sources of measurement error. The first kind occurs when computer prices and quantities are measured with error. The second source of error is more delicate. He observes that computers may exacerbate errors in the measurement of productivity: firms invest in computers not only for cost reduction but also for quality improvement. As the latter is not fully taken into account in traditional statistics, errors in output measurement are correlated with computer investment.

The City of Seattle (2000) has developed indicators to measure IT contribution by dividing the economy into five groups: Business, Community Organizations (including non-profits and funders), Schools and the Education Community, Government, and Residents (including information technology professionals, who need technology opportunity programs and/or are active in their community and may volunteer to mentor, create or assist programs such as those provided at Community Technology Centers)[7].

Jorgenson and Stiroh (2000b) employ an "aggregate production function" which relates the amount of output an economy produces to the amount of inputs available for production and the level of technology, in order to understand the historical sources of economic growth and project the potential growth of an economy in the future. Stiroh (2001) uses this approach again to test evidence from three levels: economy-wide, industry-level and firm-level. He concludes the sustainability of growth in labor productivity is the key issue for future growth projections.

Researchers agree that there are certain measurement problems associated with the output and input contribution of IT capital and labor. Traditional growth accounting techniques focus on the observable aspects of investment such as the price and quantity of

[7]This was done for a project of The City of Seattle Department of Information Technology and the Citizens Telecommunications and Technology Advisory Board Information. Their five groups are: 1) **Business** as they target economic and workforce training development. 2) **Community Organization**s, including non-profits and funders, as they plan and implement programs and seek and provide resources to create technology opportunities and increase community capacity. 3) **Schools and the Education Community** as it works to ensure the education system provides adequate resources and enables information technology fluency and opportunities for youth and those seeking technology training. 4) **Government** as it develops e-government services, monitors and encourages appropriate

computer hardware in the economy and neglect the much larger intangible investments in developing new complementary products, services, markets, business processes and worker skills. Similarly, traditional methods focus on the observable aspects of output like price and quantity, neglecting intangible benefits of variety and speed of service. Nominal output is affected by whether firms treat IT expenditure as an expense or an investment. Also standard growth accounting begins by assuming all inputs earn “normal” rates of return, which does not reflect the IT picture in which inputs have unusually high net rates of return. Furthermore, productivity studies underestimate input quantities because they neglect the role of unmeasured, complementary investments resulting in a disproportionately high rate of growth for IT.

Notwithstanding these difficulties, measurement of the extent of IT investment and its relation to productivity has improved. Indirect ways to measure the economic impact of IT do exist. Measuring the productivity of IT (analog to the productivity of other traditional factors, simply defined as the amount of output produced per unit of input); calculating consumer surplus; examining business performance; and comparing economic growth with IT to growth without IT are just some of these. There are two standard methodologies to determine these indicators: econometric analysis, and case studies. Under both methodologies, the literature separates into three tiers. These are economy-wide level, industry level, and firm level. Below is a summary of studies by level.

3. Research on the Impact of IT

As mentioned above, there is a clear departure between the pre-1990 and post-1990 literature. Before the early 1990s, articles disclosed broad negative correlations with economy-wide productivity and information worker productivity. Several econometric estimates indicated low IT capital productivity in a variety of manufacturing and service industries. After 1990, positive relationships between IT and various measures of economic performance began to dominate the academic and empirical research. Table 1 summarizes the major studies reviewed for CCEA’s analysis.

development, and sets priorities for resource allocation. 5) **Resident**s, including information technology professionals, who need technology opportunity programs and/or are active in their community and may volunteer to mentor, create or assist programs such as those provided at Community Technology Centers.

Table 1 Summary of Studies

Level	Study	Sector	Data source	Findings
Economy-wide	Baily [1986]	N/A	N/A	Overall negative correlation between economy-wide productivity and the advent of computers.
Economy-wide	Roach [1987 & 1992]	N/A	N/A	Measured productivity gains have not substantially accelerated in the period 1960-1990.
Economy-wide	Landauer [1996]	N/A	N/A	Computers have been unproductive because of poor design and deployment.
Economy-wide	Bakos, Yannis [1996]	Manufacturing	N/A	Reviews study of Landauer that computers are unproductive despite high investments, contrary to other macro-level studies.
Economy-wide	Beede & Montes [1997]	Manufacturing and services	BEA	No economy-wide trends associated with IT.
Economy-wide	Bond Stephen and Cummings Jason [2000]	Manufacturing	N/A	Identify a limited role for intangible capital resulting in high investment, but believe it can account for the rise in stock market valuation of firm.
Economy-wide	McKinsey [2001]	6 sectors: retail, wholesale, securities, telecom, semiconductors, and computer manufacturing	Principally BLS, BEA,MGI analysis	Attributed the bulk of the post-1995 productivity acceleration to two types of factors: structural factors, which include competition and innovation; and cyclical demand, which include consumer behavior and stock market bubble.
Industry	Brand [1982]	Services	BLS	Productivity growth of 1.3%/year in banking.
Industry	Roach [1987], Roach [1991]	Services	Principally BLS,BEA	Vast increase in IT capital per information worker while measured output decreased.
Industry	Morrison & Berndt [1991]	Manufacturing	BEA	IT marginal benefit is 80 cents per dollar invested.
Industry	Berndt et al, Berndt & Morrison [1992],[1995]	Manufacturing	BEA, BLS	IT not correlated with higher productivity in majority of industries; correlated with more labor.
Industry	Siegel & Griliches [1992]	Manufacturing	Multiple government's sources	IT using industries tend to be more productive; government data is unreliable.
Industry	Siegel [1994]	Manufacturing	Multiple government's sources	A multiple-indicators and multiple-causes model captures significant MFP effects of computers.
Industry	Jorgenson & Stiroh [2000a]	Manufacturing and services	BLS, BEA	Investigate in 37 industries individually, many industries had made important positive contributions to Total Factor Productivity (TFP) growth, while others showed negative productivity growth that pulled down the aggregate.
Industry	McKinsey [2001]	Manufacturing and services	Principally BLS, BEA,MGI analysis	IT investment is only one of several factors at work. Innovation (including, but not limited to, IT and its applications), competition, and to a lesser extent cyclical demand factors, were the most important causes.
Firm	Brand & Duke [1982]	Services	BLS	Moderate productivity growth occurred in banking.
Firm	Pulley & Braunstein [1984]	Services	An info-service firm	Significant economies of scope.
Firm	Clarke [1985]	Services	Case study	Major business process redesign needed to reap benefits in investment firm.
Firm	Strassmann [1985] [1990]	Services	Computerworld survey of 38 companies	No correlation between various IT ratios and performance measures.
Firm	Bender [1986]	Services	LOMA insurance data on 132 firms	Weak relationship between IT and various performance ratios.
Firm	Franke [1987]	Services	Finance industry data	IT was associated with a sharp drop in capital productivity and stagnant labor productivity.
Firm	Harris & Katz [1991]	Services	LOMA insurance data on 132 firms	Weak positive relationship between IT and various performance ratios.
Firm	Noyelle [1990]	Services	US and French industry	Serve measurement problems in services.
Firm	Parsons et al.[1990]	Services	Internal operating data from 2 large banks	IT coefficient in translog production function small and often negative.
Firm	Alpar and Kim [1991]	Services	Large number of banks	IT is cost saving, labor saving, and capital using.
Firm	Weitzendorf & Wigand [1991]	Services	Interactive model of information use	
Firm	Diewert & Smith [1994]	Services	A large Canadian retail firm	Multi-factor productivity grows 9.4% per quarter over 6 quarters.
Firm	Brynjolfsson & Hitt [1995]	Services	IDG, Compustat, BEA	Marginal products of IT do not differ much in services and in the manufacturing; Fim effects account for 50% of the marginal product differential.
Firm	Loveman [1994]	Manufacturing	PIMS/MPIT	IT investments added nothing to output.
Firm	Dudley & Lasserre [1989]	Manufacturing	N/A	IT and communication reduces inventories.
Firm	Weill [1992]	Manufacturing	Valve manufactures	Contextual variables affect IT performance Transaction processing IT produce positive results.
Firm	Barua, Kriebei & Mukhopadhyay [1991]	Manufacturing	PIMS/MPIT	IT improved intermediate outputs, if not necessarily final output.
Firm	Brynjolfsson & Hitt [1993]	Manufacturing	IDG, Compustat, BEA	The gross marginal product of IT capital is over 50% per year in manufacturing.
Firm	Brynjolfsson & Hitt [1995]	Manufacturing	IDG, Compustat, BEA	Firm effects account for half of the productivity benefits of earlier study.
Firm	Lichtenberg [1995]	Manufacturing	IDG, Informationweek (cross sector)	IT has excess return; IT staff's substitution effect is large.

Table 1: continued

Firm	Kwon & Stoneman [1995]	Manufacturing	UK survey	New technology adoption especially computer use has a positive impact on output and productivity.
Firm	Brynjolfsson & Yang [1996]	N/A	N/A	The use of longer and more recent datasets tends to generate evidence of IT's positive effect on firm performance.
Firm	Brynjolfsson Erik and Hitt, Loran [1998]	Manufacturing	N/A	Brynjolfsson and Hitt (1998) use the firm fixed-effect productivity model to find out that *productivity growth is higher in longer time periods.*
Firm	Brynjolfsson Erik and Yang Shinkyu [1999]	Services	N/A	Analysis of 800 large firms by Brynjolfsson and Yang (2000) suggest that the ratio of intangible assets to IT assets may be 10 to 1.
Firm	Brynjolfsson Erik and Hitt, Loran [1999]	Manufacturing		Analyze impact of investment in computer capital and organizational changes for various firms--results in $10-$15 million worth of cost savings per year.
Firm	Gilchrist, Gurbaxani &Town [2001]	Manufacturing	CEA (Council of Economic Advisors)	IT has a substantial and contemporaneous impact on labor productivity and marginal factor productivity growth in the durable goods sector.
Consumer Surplus and Economic Grow	Bresnahan [1986]	Financial service	N/A	Large gains in imputed consumer welfare.
Consumer Surplus and Economic Grow	Lau & Tokutsu [1992]	N/A	Multiple government's sources	Computer capital contributes half of output growth.
Consumer Surplus and Economic Grow	Hitt & Brynjolfsson [1994]	N/A	IDG, Compustat, BEA	Growth contribution of computers is 1% per year among 367 U.S. large firms.
Consumer Surplus and Economic Grow	Oliner & Sichel [1994]	N/A	Principally BEA	Growth contribution of computers is 0.16%-0.38% per year varying by different assumptions.
Consumer Surplus and Economic Grow	Brynjolfsson Erik and Hitt, Loran [1994]	Manufacturing	N/A	Derive production function estimates of the productivity of computer capital which suggest a gross rate of return of nearly 87%.
Consumer Surplus and Economic Grow	Jorgenson & Stiroh [1995]	N/A	Principally BEA	Growth contribution of computers for the 1979-92 period is 0.38%-0.52% per year.
Consumer Surplus and Economic Grow	Brynjolfsson [1995]	N/A	BEA	$70 billion consumer surplus is generated annually in the late 1980s.
Consumer Surplus and Economic Grow	Jorgenson & Stiroh [2000b]	Manufacturing and services	BEA	More than 70% of increased output growth can be attributed to non-IT products.
Firm Structure, Office Productivity	Beede & Montes [1997]	Manufacturing and services	BEA	Economies of scale—gained from using IT to reduce coordination and monitoring costs—influence firm size and structure.
Firm Structure, Office Productivity	Brynjolfsson & Hitt [1998]	N/A	N/A	The long term benefits from IT investment are not just returns from IT investment but from a system of technological and organizational changes.
Firm Structure, Office Productivity	Brynjolfsson & Yang [2000]	N/A	BEA	The ratio of intangible assets to IT assets may be 10 to 1.
Firm Structure, Office Productivity	Dedrick, Gurbaxani & Kraemer [2001]	Manufacturing and services	Council of Economic Advisors, etc.	IT enables fundamental changes in business processes and organizational structures that can enhance both labor productivity and multifactor productivity.
Firm Structure, Office Productivity	Roach [1987]	Services	N/A	There was low office productivity, because statistics indicated that output per production worker grew by 16.9% between the 1970s and 1986, while output per information worker decreased by 6.6%.
Firm Structure, Office Productivity	Berndt & Morrison [1991],[1995]	Manufacturing	N/A	IT capital was correlated with significantly increased demand for skilled labor.
Firm Structure, Office Productivity	Bresnahan, Brynjolfsson and Hitt [2000]	N/A	Survey	The wage gap between skilled labor and unskilled labor may increase.
Connecticut	CASE Report, 1998	N/A	N/A	Analyzes factors encouraging and discouraging growth of software industry in CT. Even though the software industry in Connecticut contributes only 0.8% of total employment, it contributes more than proportionately to GSP (1.3% of total GSP).
Connecticut	Battelle, 2000	N/A	BLS	The Battelle Study methodology constituted of: a comparison of national IT occupational trends vis-à-vis state trends; detailed interviews with senior executives of CT IT-related companies; interviews across educational institutes; and benchmarking analysis of key states and lessons learned.
Connecticut	CERC, 2001	N/A	Horizon Research Group, LLC	The Connecticut Economic Resource Center (CERC) details the state of the IT sector in Connecticut, describes IT-related occupations, and analyzes IT occupational demand in Connecticut.
Connecticut	CTC, 1997	N/A	National Science Foundation, Federal Science & Engineering Support to Universities, Colleges & Nonprofit Institutions	Evaluates trends in technology-based industries and measures of output. Out of the fifty fastest growing technology companies in the state over the past five years, 36% were software producers

I. Economy-wide

Ia. Economy-wide Productivity

Productivity is the fundamental measure of a technology's contribution. Many earlier studies tried to determine the contribution of information technology by examining economy-wide productivity. It is productivity at this level that manifested the "productivity paradox" in a most complete way. The sharp drop in productivity roughly coincided with the rapid increase in the use of information technology. Many researchers observed the overall negative correlation between economy-wide productivity and the advent of computers. This drove the argument proposing that IT has not helped U.S. productivity or even that IT investments had been counter-productive (Baily, 1986).

Despite high investments, Landauer (1995) argues that computers have been unproductive because of poor design and deployment. At the macro-level, studies by Roach (1987, 1991) show that measured productivity gains have not substantially accelerated in the 1960-1990 period, despite rapidly increasing investments in computers and information technology.

McKinsey (2001) suggests that nearly all of the post-1995 productivity growth jump can be explained by the performance of just six economic sectors: retail, wholesale, securities, telecom, semiconductors, and computer manufacturing. The other 70 percent of the economy contributed a mix of small productivity gains and losses that offset each other. The existence of several "jumping" sectors is not unusual. What was unique about the late 1990s was that the jumping sectors either had very large leaps in productivity (e.g., semiconductors, computer manufacturing), or were very large in terms of employment (e.g., retail, wholesale). In other words, McKinsey attributed the bulk of the post-1995 productivity acceleration to two types of factors: structural factors, which include competition and innovation; and cyclical demand, which include consumer behavior and the stock market bubble. The problem of isolating the impact of IT has not yet been eliminated.

However, some researchers still show evidence that investment in computers has increased productivity slightly. The studies around 1994 and 1995 report excess returns on IT capital. Using different assumptions of excess returns on computer investment, Oliner and Sichel (1994) show a contribution of 0.38% per year from 1984 to 1991, while Jorgenson and Stiroh (1995) report a slightly higher contribution of 0.38%-0.52% per year from 1979 to 1992.

Ib. Consumer Surplus and Economic Growth

Productivity is the most commonly used method of measuring the economic impact of IT. However, we can benefit from the examination of some other indicators. Consumer surplus and economic growth offer us two different ways to look at the impact of IT. There is far less controversy using these indicators. Most researchers agree that IT has made a positive contribution to consumer surplus and economic growth.

Consumers always benefit from price reductions in merchandise prices. When computer prices are declining exogenously, profit-maximizing firms are substituting computer systems for other input factors such as labor or space for inventories. Lower prices of computers and other inputs shift marginal cost curves downward. Low marginal costs result in more output, lower prices and higher profits.

Hitt and Brynjolfsson (1986, 1994a) look for associations between IT spending and various business performance measures. Although they document IT's positive impact on output and consumer surplus, they do not find a significant positive correlation between IT spending and performance measures other than output.

Bresnahan (1986) was the first to look at benefits from computer price declines. Assuming the benefits of price declines go to consumers and using a hedonic price index, he finds that consumer surplus was five or more times computer expenditure in the late 1960s in the financial sector. Brynjolfsson (1995) estimates economy-wide consumer surplus to be around three times computer expenditure in 1987, using assumptions similar to Bresnahan's.

Jorgenson and Stiroh (1995) embark on a comprehensive growth accounting exercise, and discover the contribution of computers and peripherals decreased from the 1979-1985 period to the 1985-1992 period. This is probably because the nominal investment in computers did not increase much between 1985 and 1992. From other data sources and using different methodologies, other researchers found a less than 1% contribution of computers to economic growth (Brynjolfsson and Yang, 1996). In fact, in 1993, when GDP grew by $173 billion, computers' contribution was $29 billion, while the contribution of other capital was $46 billion. The unexplained residual's contribution was $40 billion. Jorgenson called this "a pretty hefty contribution" from computers.

In a more recent study, Jorgensen and Stiroh (2000b) decomposed the effect of IT investment on growth and productivity data in the United States, in an attempt to assess whether the development of IT is a positive, temporary shock (as argued by Gordon (1989)) or whether it has caused a permanent improvement in U.S. growth prospects. They looked at output growth, and average labor productivity growth (ALP). They found that output growth increased by 1.72% from 1995-1999, but only 28.9% of that was due to IT production (however, IT production did double relative to the 1990-1995 period). In other words, more than 70% of increased output growth can be attributed to non-IT products.

II. Industry-level

IIa. Cross-Industry Productivity

While earlier studies failed to identify the positive effects of IT, subsequent analysis found encouraging results. In addition, results are somewhat different between the manufacturing and service sectors. Measurement problems are more acute in services than in manufacturing, partly because many service transactions are idiosyncratic, and therefore not subject to statistical aggregation. In addition, industrial classifications sometimes seem arbitrary in service sectors. Therefore, research results in manufacturing often show stronger effects than studies of service sectors. Before 1970, service and manufacturing productivity growth rates were comparable, but since then growth paths have diverged significantly. From 1953 to 1968, labor productivity growth in services averaged 2.56% vs. 2.61% in manufacturing. From 1973 to 1979, the respective figures became 0.68% vs. 1.53% (Baily, 1986). In response to these diverging trends, Gordon and Baily (1989) and Griliches (1994, 1995) suggest that measurement errors in U.S. statistics systematically understate service productivity growth relative to manufacturing productivity growth. From the 1970s to the mid-1990s, services have dramatically increased as a share of total employment and to a lesser extent, as a share of total output. This has been taken as indirect evidence of poor IT productivity because services use up to 80% of computer capital.

Siegel and Griliches (1992) use industry and establishment data from a variety of sources to examine several biases in conventional productivity estimates. They find a positive simple correlation between an industry's level of investment in computers and its multifactor productivity growth during the 1980s. In 1994, by controlling two errors (measurement error from computer price and quantity and ignorance of the goal of using computer to improve quality), Siegel (1994) again finds a positive and significant relationship between multifactor productivity growth and computer investment. He also finds computer investment positively correlates with labor quality. This conclusion was later supported by Brynjolfsson and Hitt (1994), Berndt and Morrison (1995), and Berman, Bound and Griliches (1994).

Jorgensen and Stiroh (2000a) break down the U.S. economy into 37 industries (35 private industries, private households and general government), and identify the contribution of each industry to aggregate productivity growth. They conclude that many industries made important positive contributions to Total Factor Productivity (TFP) growth, while others showed negative productivity growth that pulled down the aggregate. This heterogeneity is lost in relying exclusively on the aggregate production function, so they turn to each industry individually. First, they determine that computer hardware plays a rapidly increasing role as a source of economic growth. Declining IT prices and years of sustained economic growth have spurred massive investments not only in computer and communications equipment, but also in new software that harnesses and enhances the productive capacity of that equipment. In addition, the falling prices of IT goods and services have reduced overall U.S. inflation—for the years 1994 to 1998, by an average of 0.5 percentage points a year, or from 2.3 percent to 1.8 percent. The rates of decline in IT prices accelerated through the 1990s—from about 1 percent in 1994, to nearly 5 percent in 1995, and an average of 8 percent for the years 1996 to 1998. One reason why IT contributes greatly to economic growth is the reduction in computer hardware prices. Substantial price declines in computer hardware are currently contributing to a reduction of U.S. inflation at an annual rate of 0.5% per year. Such reductions in inflation for a given amount of growth in output imply proportionately higher real growth and account for higher productivity when divided by inputs. Thus, most of the productivity growth comes from an increased real investment in computer hardware and declines in their quality adjusted prices. Furthermore, new investments in IT are helping to generate higher rates of U.S. labor productivity growth.

IIb. Software Industry

The technologies for acquiring, storing, processing, and transmitting information are collectively referred to as "information technology" and include both hardware and software components. Hardware producers in the U.S., with the notable exception of IBM, have received a diminishing share of their revenues from software production. Moreover, although all software is complementary in demand with hardware, some software may raise the level of hardware demand more than others, and one can expect that hardware producers are more active in these areas than in other areas.

Software production (SIC 7371 programming services, 7373 integrated computer systems) is classified as a "business service" in the U.S. income and product accounts, and should be distinguished from software that is sold as a product (SIC 7372). A second important distinction is the division of output between intermediate and final goods. In this report, software is an intermediate good, employed by businesses in the production of other goods and services or sold for the same purposes to other enterprises. A third important distinction is between software and the production of other economic commodities. The potential profits from widespread sales of particular software products have encouraged the entry of a third group of producers, independent software vendors (ISVs). For users, the presence of ISVs offers an alternative to internal production.

The Stanford Computer Industry Project Software Study (1995) proposes dividing software establishments into four categories: software products publishers and related firms, systems specification and design services, programming and support services, and in-house software services (software not sold outside the firm developing it). Most firms conduct their primary operations in only one of these categories, as the categories differentiate products vs. services, systems specification and design vs. programming, and software developed for sale vs. in-house use.

The first category, software products publishing, includes companies such as Microsoft, Nintendo, Novell, Oracle and Lotus. These firms produce software products sold to millions of customers. Systems specification and design services covers establishments that are involved in planning and consulting with businesses seeking new software systems. These firms also design and test software systems. The third category, programming, involves firms that write, test or maintain software, but are not software publishers or systems providers. These firms deal exclusively with software code. In-house software development accounts for all of the software developed by firms across industries, exclusively for use within their respective firm. This category is the most difficult to quantify, and will be the one that presents the most problems with data collection. The Stanford Study outlines a market-based system that reclassifies the software industry according to the way end products are used. The five main categories are software products publishers, customized software development services, systems specification services, in-house operations software, and embedded software. The authors of the Stanford study believe this classification would provide useful data on the software industry.

The software industry has grown from selling primarily to businesses, to selling to businesses and consumers. It is difficult to measure the impact of software on the economy, because so much of it is written in-house. Software is used across industries and in many areas of operation within firms, including manufacturing, customer service, and accounting. Companies still write and maintain most of this software themselves. This means that a large portion of a company's software-related costs do not involve purchasing software from an outsider, and do not appear in standard economic data.

Software is also an intermediate or embedded good in many of today's modern products, ranging from airplanes and automobiles to cellular phones and consumer appliances. This software is developed in-house, and does not appear in economic data for the software industry because it is not sold separately as software. The software industry is therefore underestimated because both operational and embedded software are unreported.

The literature on software productivity measurement is varied. Walston and Felix (IBM Systems Journal, 1977) estimate software productivity in terms of the number of lines of code produced per person-hour. However, labor hours covered the complete development project, and not simply the coding phase. Scacchi (1995) proposes a new method to measure software productivity by constructing a software productivity modeling and simulation system. Software has been persistently identified as a "bottleneck" in the growth of information technology markets and as a drag on the realization of productivity gains from utilization of information technology. The growth of the cost share of software has been linked to the "craft production" techniques in the software industry that allegedly cannot match the pace of hardware performance improvement. The purported result is rapidly escalating costs of IT due to the "bottleneck" of increasing software costs, a consequence that may help explain the low measured productivity gains from investments in IT. Institutional reforms have been directed at sources of cost growth, particularly the development and maintenance costs of internally produced software.

III. Firm-level

IIIa. Firm Productivity

In the service sectors, many studies report disappointing evidence about the capability of IT. For example, Brand and Duke (1982) used BLS data to show that moderate productivity growth had already occurred in banking. Franke (1987) finds that IT investment was associated with a sharp drop in capital productivity and stagnation in labor productivity, but remains optimistic about the future potential of IT. Strassmann (1990) concludes, "there is no relation between spending for computers, profits and productivity." Harris and Katz (1991) and Bender (1986) find a positive relationship between IT expense ratios and various performance ratios although at times the relationship is quite weak.

Starting around 1993, more rigorous studies with larger samples appeared at the firm level. Many studies found that IT investments contribute to firm productivity, and show higher gross marginal returns than non-IT investments. By comparing the studies at the firm-level published through the mid-1990s, Brynjolfsson and Yang (1996) observe an interesting trend in the results of those studies: the use of longer and more recent datasets tends to generate evidence of IT's positive effect on firm performance. In addition, the research results in manufacturing often show stronger effects than studies of services, probably because of the better measurement in the manufacturing sector.

Using a production function approach, Brynjolfsson and Hitt (1993) find that for the service firms in their sample, gross marginal product averaged over 60 percent per year. They show the contribution of IT to output is as high in the service as in the manufacturing sector. A survey in Brynjolfsson and Hitt (1994) discloses that reengineering work would help firms increase their productivity.

Research in manufacturing generally finds higher returns to IT investment than in the services, though some studies show otherwise (for instance, in Loveman (1994) IT investments added nothing to output). Loveman (1994) provides some of the first econometric evidence of a potential problem when he examines data from 60 business units. Barua and Mukhpadhyay (1991) trace Loveman's results back a step by looking at IT's effect on intermediate variables such as capacity utilization, inventory turnover, product quality, relative price and new product introduction, rather than output. Using the same dataset, they find that IT had a positive relationship with three of these five intermediate measures of performance. Dudley and Lasserre (1989), and Weill (1992) come to similar conclusions by examining different datasets in the manufacturing sectors.

According to Oliner and Sichel (1994), the user cost of computer capital averaged 36.6% per year from 1970-92, while that of other types of capital was 15.4%. In addition, one needs to account for the adjustment or hidden costs of IT investment. These types of costs are easier to ignore than other obvious costs. On the other hand, IT capital is highly productive. One important extension by Lichtenberg (1995) is that he reports the marginal rate of substitution between IT and non-IT workers. Evaluated at the sample mean, it is 6:1. That means one IT worker substitutes for six non-IT workers. Managers have incentive to invest in IT by this high return despite these "hidden" costs. This provides one reason for the seemingly negative relationship between IT investment and economy-wide productivity.

Gilchrist, Gurbaxani and Town (2001) focus on the manufacturing companies in their study sample and show that IT has a substantial and contemporaneous impact on labor productivity and multifactor productivity (MFP) growth in the durable goods sector, which exceeds the impact that would be predicted by its factor share, while in the non-durable goods sector, the returns that accrue primarily to labor productivity via capital deepening are consistent with the IT factor share. Moreover, these returns correlate with decentralized computing architectures, suggesting that the diffusion and networking of computing throughout the organization contributes substantially to the payoff.

Starting at the firm level leads us to a closer look at the economic impact of IT. Complementary management practices are playing an important role to the level of returns to IT investment achieved by firms. There is a great deal of variance among firms in returns to IT investments while average returns are high. Unfortunately, firm-level studies so far have not shown a clear link from IT investment to profitability. Once factors such as incomplete accounting of complementary investments, high rates of obsolescence, and one accounts for risk adjustments, the returns to IT investments are likely to be more accurate, so we can see the relationship between IT investment and profitability more clearly.

IIIb. Firm Structure and Office Productivity

Beede and Montes (1997) did statistical analyses of 46 industries that showed large variations across industries in the size, sign, and statistical significance of the elasticities of auxiliary unit shares with respect to IT capital stock shares. They found no economy-wide trends associated with IT. Because there is so much variation among industries to rely on estimates obtained from pooling industry data, for the most part, sectoral trends are scarce. Only in transportation sector industries do the sign and statistical significance suggest that IT related changes are similar across industries. Ultimately, the enormous variation revealed by their results suggests that one cannot make economy-wide generalizations about the effects of IT. However, combined with company size distribution data and anecdotal evidence, their results suggest that economies of scale—gained from using IT to reduce coordination and monitoring costs—influence firm size and structure. They attribute the difference across industries to the variation in firm size distribution across industries prior to the IT revolution. One reason why the effects of IT appear to manifest themselves so differently across industries is variation in firm size distribution across industries prior to the IT revolution.

Brynjolfsson and Hitt (1998) use the firm fixed-effect productivity model to determine that productivity growth is higher in longer time periods. This suggests that a firm-specific factor is involved when IT investment occurs and that the long term benefits are not just returns from IT investment, but from a system of technological and organizational changes. Short term returns represent direct effects of IT investment, while long term returns also include related investment in organizational changes. Analysis of 800 large firms by Brynjolfsson and Hitt (2000) suggests that the ratio of intangible assets to IT assets may be 10 to 1. Further, an increase of $1 of investment in computer capital, results in an increase of $10 of financial market valuation. A categorization of start-up costs of a software firm showed that average spending on computer hardware accounted for less than 4% of start-up costs of $20.5 million, while software license and development were another 16 percent of total costs. The remaining costs included hiring internal and outside consultants to help design new business processes and to train workers in the use of the system.

Dedrick, Gurbaxani and Kraemer (2001) stress the dual roles of IT capital. They consider this as one key difference between IT capital and other forms of capital in an organization. First, like other types of capital, IT is used directly as a production technology, as in the case of a bank's transaction processing system. On the other hand, one can view IT as an especially potent technology that has a significant impact on the costs of coordinating economic activity both within and between organizations. In other words, IT enables fundamental changes in business processes and organizational structures that can enhance both labor productivity and multifactor productivity.

Jorgenson and Stiroh (2000b) examine both output growth and average labor productivity (ALP) growth. Decomposing output growth into growth of hours worked and ALP growth shows that each area contributed almost equally during the 1995-1999 period. Out of the 1.72% increase in output growth, 1.98% was due to hours worked while 2.11% was due to ALP growth. ALP can further be decomposed into capital deepening (growth in capital input per hours worked), improvements in labor quality (using workers with higher marginal products), and total factor productivity (TFP) growth. As mentioned above, ALP contributed 2.11% to output growth from 1995-1999. Out of the 2.11% contribution to output growth from 1995-1999, 0.89% is due to IT capital deepening, and 0.50% is due to IT total factor productivity growth. Therefore, IT contributed two-thirds of ALP growth (1.39% out of 2.11%).

IIIc. Firm-level Studies and Organizational Transformation

"Macromed" (a medical company pseudonym) is an example of an IT intensive production process. Its investment in computer-integrated manufacturing coincided with other major organizational changes including elimination of piece rates, giving workers decision rights, process workflow innovations, etc. Baxter ASAP lets hospitals electronically order supplies directly from wholesalers. Its implementation of an electronic data interchange, Internet-based procurement system reduced cost and time by eliminating paper work and errors. The new technology and new supply chain organization improved efficiency for both Baxter and other hospitals, resulting in $10-$15 million of cost savings per year, incremental product sales, and reduction of logistics costs (which consumes 30% of hospital budgets). Dell has implemented a consumer-driven build-to-order business model, rather than the traditional build-to-stock model of selling computers through retail stores, which gives Dell as much as a 10% advantage in production costs (Brynjolfsson and Hitt (1999)).

Roach (1987) focuses on information workers, regardless of industry, to analyze productivity. He cites statistics indicating that output per production worker grew by 16.9% between the 1970s and 1986, while output per information worker decreased by 6.6%. He concluded there was low office productivity. Roach concentrates mainly on the service sectors. He argues that IT is an effective substitute for labor in most manufacturing industries, but has paradoxically been associated with bloating information worker employment in services, especially finance. However, Berndt and Morrison (1991 and 1995) also found such a paradox in the manufacturing sectors (1991, 1995). Although their studies manifest a significant difference between the productivity of IT capital and other types of capital for a majority of the 20 industry categories, they find that IT capital correlates with significantly increased demand for skilled labor.

Bresnahan, Brynjolfsson and Hitt (2000) reach the conclusion that skilled labor is complementary with the cluster of three firm changes: information technology, new work organization, and new products and services. They find that information technology is a source of increased demand for skilled labor and rising wage inequality. They also find that organizational changes due to technical change have a larger effect on skills than raw technical change. The complementarities among organizational change, information technology, and improvements in the output market together have a major effect on the demand for skilled labor. Thereby, the wage gap between skilled labor and unskilled labor may increase.

Capturing the impact of Information Technology is difficult to do. We can feel the impact around us, but find it difficult to measure. Different methodologies and metrics yield different results. Even now, the debate about the productivity paradox has not calmed down. Jorgensen (2001) does not hypothesize whether IT is a temporary or permanent shock to the United States economy. Instead, he suggests many areas in which research must still be conducted, such as industry level decomposition of growth, and distinguishing between IT-producing and IT-using firms. On the labor front, he wonders whether skilled workers are complementary to IT and unskilled workers' substitutes, or whether technical change due to IT is skill biased and thus increases the wage differential between skilled and unskilled workers. Internationally, growth evidence of the "new economy" does not exist among other leading industrialized nations. Jorgensen believes this may be due to the absence of constant quality price indexes in the national income accounts of other countries.

4. Scenario in Connecticut

According to Steve Clement (CTC), the software-producing industry in Connecticut has increased by 64% since 1992, to 1143 firms. Out of the fifty fastest growing technology companies in the state over the past five years, 36% were software producers. Further, the software industry has fared well in terms of employment, which has grown by 60% since

1992, while employment has declined in other sectors of the economy. Even though the software industry in Connecticut contributes only 0.8% of total employment, it contributes more than proportionately to GSP (1.3% of total GSP). The average size of a software company in Connecticut is 11-12 employees. Connecticut however, ranks last in the growth of technology-based start-ups. Since the 1990s, according to CTC, high-technology start-ups have increased by only 5% in Connecticut (CASE Reports, Vol.13, no.1, 1998).

The Connecticut Employment and Training Commission (CETC) undertook to produce a long-range strategic plan for IT workforce development. As a result, the Office of Workforce Competitiveness (OWC) asked the Battelle Memorial Institute to undertake the analysis of IT workforce development called for in the legislation. Connecticut is highly specialized in IT occupations. Not only does one find specialization across software and computer service industries, but historically in manufacturing and insurance industries as well. Connecticut has historical strengths in IT-using rather than IT-producing industries, but the recent trends suggest that there has been slower growth in IT-using industries compared to the national average and faster growth in IT-producing and newly formed businesses compared to national average. The Battelle study methodology constituted a comparison of national IT occupational trends vis-à-vis state trends; detailed interviews with senior executives of Connecticut IT-related companies; interviews across educational institutions; and, benchmarking analysis of key states and lessons learned. The focus of the study was to identify weaknesses of the state to attract IT workers and improve capabilities in existing industries.

According to the Battelle study, at the national level, a tight labor market has emerged for IT workers with a unique set of labor market dimensions. Demand for IT workers is growing, about 1.6 million in 2000 with half of available positions remaining unfilled. Companies with 50-99 employees will absorb 70 per cent of the demand and have the highest skill gap. BLS reports that IT employment will grow from 2.2 million in 1998 to a projected level of 3.9 million in 2007, a growth rate of 77 % in ten years. The net new workers required between 1998 and 2008 will be over two million workers or 200,000 skilled IT workers annually. The annual wage growth for IT occupations is 6% compared to 3.9 % for all occupations. The U.S. Department of Commerce identified several constraints with respect to the supply of adequate IT workers. Some of the key problems that exist across the nation are short product life cycles and frequent paradigm shifting developments, poor management practices, changing nature of work-relationship (contractors rather than long-term employees), and a preference for young compared to old IT workers.

Connecticut: There are over 62,000 IT workers across 13 occupations, which is 3.8 percent of Connecticut's total workforce. This is higher than the national average of 3 percent, but lower compared to Maryland, Massachusetts and Virginia, which are leading IT states. Connecticut is above the national average in three IT related skill sets (engineering, mathematical and natural science managers; system analysts and electronic and electrical technicians), typically found in research, manufacturing and data processing industries. Connecticut stands out in the number of IT workers found in insurance, aircraft, manufacturing, pharmaceutical, and electric services industries. Almost 10 percent of all life insurance workers in the nation work in Connecticut, but over 16 percent of IT workers in life insurance are in Connecticut. Similarly, Connecticut's share of employment in aircraft manufacturing is 10 percent, but it employs 16 percent of the IT employees in that industry. The national IT employment share in the ship building industry is only 6 percent, while Connecticut employs 34.3 percent of IT employees of that industry. The pharmaceutical industry in Connecticut, representing 8.4 percent of the nation's IT workers in this industry, employs only 2.8 percent of all pharmaceutical workers. Regionally, the Hartford metro area has the largest number of IT workers in the state, but the Stamford-Norwalk metro area has the highest fraction of its workforce in IT occupations. Regional Financial Associates (RFA, now known as Economy.com) identified 39 detailed industries as key IT-related sectors because more than 7 percent of their workers are in IT occupations, and they have a high level of IT-related equipment investments, exceeding 20 percent. RFA makes the following distinction:

> *"IT-producing industries are engaged in activities that facilitate the use of information, while IT-using industries are engaged in activities that intensively use information in their production process."*

RFA identified 13 IT-producing industries including manufacturers of hardware and providers of software and computer services, and 26 IT-using industries in CT. Connecticut's share in IT-using industries is 26 percent greater than that found for the nation as a whole, but it has a lower economic specialization in IT-producing industries than the nation as a whole. Connecticut is nearly seven times more concentrated in the insurance industry than the nation as a whole. However, over the last five years, while IT-using industries are growing nationally at a rate of 4.2 percent, they are growing at only 2.6 percent in Connecticut. Although the composition of IT-producing industries (4% of Connecticut 's total workforce) is less than the national average of 4.2 percent, these industries are growing at 9.7 percent, a rate faster than the national average growth rate of 8.8 percent. Finally, in Connecticut, newly formed business establishments accounted for over 20 percent of IT-producing industry employment, compared to 16 percent nationally. However, this is not a perfect measure of new business formation because IT is a dynamic industry. The Battelle Study concludes that there is greater economic specialization in IT-producing industries at the sub-state level, specifically in the Danbury and Stamford regions that are above the national average in the concentration of IT-producing industries, though still lower than other leading regions of the nation.

The Milken Institute reports that Connecticut is one of the top three states in the nation in its readiness for the knowledge-based New Economy. The Corporation for Enterprise Development has rated Connecticut third of 50 states in its Development Report Card (DRC) for transformation to a Digital Economy. The state ranks 24th in households with computers, 20th in digital infrastructure and 27th in the 1999-2000 Digital State Survey overall final ranking. Furthermore, the annual survey by the Connecticut Business and Industry Association found that 54% of the state's small and mid-sized companies are using the Internet, while 15% plan to launch a web site in 2001 (Rubin Systems / META Group, 2001). The sample and methodology used are however, not clearly defined in arriving at these conclusions.

The U.S. Department of Commerce also releases state rankings regarding IT employment. Their latest rankings use 1998 employment data and rank Connecticut among the top 10 states in many key IT occupational categories, in both Worker Intensity (IT workers / total workforce) and Average Wage. The study suggests that the IT industry is large in Connecticut relative to other states, as well as compared to the nation as a whole (U.S. Department of Commerce, 2000).

In a recent study, CTC analyzed the role of technology-based industries for the Connecticut economy (CTC (1997)). Their study uses the 172 industry classifications (at the four-digit SIC level) from the County Business Patterns data, which they regrouped into 51 broader classifications for use with ES202 data. Because the 4-digit SIC data may reveal specific company information, CTC aggregated the ES202 data to the 3-digit level. These 51 major industries encompass all the 172 industries in the previous data set and serve as a basis for comparing Connecticut with other states. Their first level of analysis examines technology sectors within the Connecticut economy and makes a comparison to sectors within the overall economy. Their second level of analysis traces employment, payroll and business formation from 1990-96 in Connecticut. According to the CTC report (1997), technology companies account for one-sixth of the total jobs and one-quarter of the total payroll in the state. In technology-based industries, wages per employee increased 16.9% between 1990 and 1996, far faster than 10.1% for the entire private sector. Connecticut's employment in technology-based industries is 15.8% of the private sector employment, above the national average of 11.7%. Compared to other states, Connecticut ranked 4^{th} in the percentage of technology business—that is, 7.6% of all Connecticut firms are technology firms as compared to 6.0% in the U.S. overall. The data shows that the Aircraft and Aircraft Engines and Parts sectors are by far the largest technology-based employers of any industry in Connecticut, followed by pharmaceuticals and utilities. Of the top ten highest paying technology-based industries, only one belongs to manufacturing, the rest belong to the Pharmaceuticals, Industrial Chemicals and Software and Computer Service sectors.

The Connecticut Economic Resource Center (CERC) details the state of the IT sector in Connecticut, describes IT-related occupations, and analyzes IT occupational demand in Connecticut (CERC (2001)). CERC analyzes occupational demand through want ads, forecasts, and vacancy rates. In addition, their forecast includes both high and low scenario employment forecasts. CERC forecasts IT occupations to the year 2010, by taking the Connecticut Department of Labor (DoL) forecast to the year 2008, and extrapolating to 2010. CERC forecasts only the occupation of computer operators to decline. CERC forecasts both a high and low scenario by creating a 10% bandwidth around the year 2010 DoL forecast. CERC labels additional forecasts as BLS, RFA and NU. The BLS forecast uses national Bureau of Labor Statistics forecasts and assumes national growth rates would occur in Connecticut. The RFA forecast derives from Economy.com projections on employment in IT-producing and IT-using industries. The NU forecast applies the RFA forecast to a Northeast Utilities forecast of total Connecticut employment. Based on the alternate scenarios, Connecticut IT employment will fall in the range from 79,643 to 107,061 for the year 2010.

CERC conducted a survey of 334 IT-using (65%) and IT-producing (35%) firms to examine current IT employment vacancies. Vacancies were concentrated in programming, web-based and e-commerce areas. According to CTC, employment in the broad software industry (SIC code 737) has grown by 20% in the 1990s outpacing all other industries. Firms compensate the average software employee at a rate 37% higher than the average Connecticut employee. Software company output per employee from is three times the national average or nearly $160,000 per year.

A significant barrier to continued IT growth is the scarcity of qualified personnel moving into the field. One reason for this is that Computer and Information Sciences degrees from colleges and universities are down 40% since 1998. CERC analyzes the impact of the IT industry on the local economy and finds:

1) the fraction of workforce for which the IT industry accounts, including the number of IT employees as a percentage of local employment;

2) the local wages in the IT industry based on the median and average wage of IT workers and the median and average wage of workers in the IT industry;

3) the total income of IT employees and IT industry employees compared to the area total, median, and other industries; and,

4) the degree to which IT has increased the ability and likelihood of people to run extra businesses out of their homes.

We conclude several things from our broad overview of the IT literature. While much has been written in the economic literature on the contribution of IT investment to productivity ***growth***, few venture to measure the impact of out-sourced, in-house, and embedded software production on productivity ***levels***. Several studies estimate the output elasticity of IT (see Stiroh (2002)). Some studies have attempted to analyze the impact of technology in a dynamic setting. Others compare the IT sector in Connecticut to other states across the nation. No study combines IT employment and productivity gains in a dynamic impact analysis. Our study is unique in both the dynamic model (REMI) we use and in the method by which we measure the various contributions of the IT sector to the Connecticut economy.

References and Bibliography

Association of Governments, San Diego, "What are Industry Clusters?"

Baily, Martin Neil (1986), "What has Happened to Productivity Growth?" *Science*, Vol. 234: 443-451

Bakos, Yannis (1996). "Information technology spending and economic productivity": A review of The Trouble with Computers by Thomas K. Landauer, *Journal of Economic Literature*, (September).

Barua, A., Kriebel, C. and Mukhopadhyay, T. (1991), "Information Technology and Business Value: An Analytic and Empirical Investigation," *University of Texas at Austin Working Paper*, (May).

Battelle Study (2001), "Information technology workforce strategy for the state of Connecticut."

Beede, David N. and Montes, Sabrina L. (1997), "Information Technology's Impact on Firm Structure: A Cross-Industry Analysis" (March).

Bender, D.H. (1986), Financial Impact of Information Processing, Vol. 3(2), 22-32.

Berndt, Ernst R. (1991), The Practice of Econometrics: Classic and Contemporary, Addison-Wesley Reading, MA.

Berndt, Ernst R. and Malone, Thomas W. (1995): "Information Technology and the Productivity Paradox: Getting the Questions Right: Guest Editor's Introduction to Special Issue," *Economics of Innovation and New Technology*, Vol. 3, 177-182.

Beyers, William B. and Nelson, Peter B. (1998), "The Economic Impact of Technology-Based Industries in Washington State in 1997," (for the Technology Alliance).

Blake, Ives (1994), "Probing the Productivity Paradox," *Management Information Systems Quarterly*.

Bond Stephen and Cummings Jason, *Brookings Papers on Economic Activity*, fall 2000.

Brand, H. and Duke, J. (1982), "Productivity in Commercial Banking: Computers Spur the Advance," *Monthly Labor Review*, Vol. 105, 19-27, (December).

Bresnahan, Timothy F. (1986), "Measuring Spillovers from Technical Advance: Mainframe Computers in Financial Services," *American Economic Review* 76(4), (September).

Bresnahan, Timothy F., Brynjolfsson, Erik and Hitt, Lorin M. (2000), "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-level Evidence" *Quarterly Journal of Economics*, forthcoming.

Brynjolfsson, Erik and Hitt, Loran (2000), "Beyond Computation: IT, Organizational Performance and Business Performance," MIT.

Brynjolfsson, Erik and Hitt, Loran (1998), "Beyond the Productivity Paradox," MIT, (June).

Brynjolfsson, Erik and Hitt, Loran (1994), "Creating Value and Destroying Profits?" MIT, (December).

Brynjolfsson Erik and Yang Shinkyu (1999), "The Intangible Costs and Benefits of Computer Investments: Evidence from Financial Markets," MIT, December.

Brynjolfsson, Erik and Yang, Shinkyu (1996), "Information Technology and Productivity: A Review of the Literature. MIT Sloan School of Management," *Advances in Computers,* Academic Press, Vol.43, pp. 179-214.

CASE Reports (1998), "In search of 'critical mass': Software industry outpaces other economic sectors as experts seek ways to nurture future growth." 13, no. 1.

Connecticut Economic Resource Center (2001), "Information Technology Occupations in Connecticut," (January).

Connecticut Technology Council (1997), "The Role of Technology in the Connecticut Economy," (May).

Crowston, Kevin and Treacy, M.E. (1986), "Assessing the Impact of Information Technology on Enterprise Level Performance," *MIT Center for Information Systems Research Working Paper*, No. 143, (October).

Debrick, Jason, Gurbaxani, Vijay and Kraemer, Kenneth L, (2001), "Information Technology and Productivity Growth at the Firm and Country Level," (August).

Dubley, L. and Lasserre, P. (1989), "Information as a Substitute for Inventories," *European Economic Review*, Vol. 31: 1-21.

Edward, Steinmueller W. (1995), "The U.S. Software Industry: An Analysis and Interpretive History," Maastricht Economic Research Institute in Innovation and Technology (Paper in progress), (March).

Franke, Richard H. (1987), "Technological Revolution and Productivity Decline: Computer Introduction in the Financial Industry," *Technological Forecasting and Social Change*, Vol. 31, 143-154.

Gilchrist, Simon; Vijay Gurbaxani and Robert Town (2001). "Productivity and PC revolution." Center for Research on Information Technology and Organizations, (April).

Gordon, Robert J. (2000), "Does the 'New Economy' Measure up to the Great Inventions of the Past?" *Journal of Economic Perspectives*, Vol. 14.

Gordon, Robert J. and Baily, M. N. (1989), "Measurement Issues and the Productivity Slowdown in Five Major Industrial Countries," International Seminar on Science, Technology and Economic Growth, Paris, France.

Griliches, Zvi (1994), "Productivity, R&D, and Data Constraints," *American Economic Review,* 84(1).

Griliches, Zvi (1995), "Comments on Measurement Issues in Relating IT Expenditures to Productivity Growth," *Economics of Innovation and New Technology*, Vol. 3, 317-321.

Harris, S.E. and Katz, J.L. (1991), "Organizational Performance and Information Technology Investment Intensity in the Insurance Industry," *Organizational Science*, Vol. 2 (3), 263-296.

Hitt, Lorin and Brynjolfsson, Erik (1994a), "Three Faces of IT Value: The Theory and Evidence," *The Proceedings of the Fifteenth International Conference on Information Systems*, (December).

Hitt, Lorin and Brynjolfsson, Erik,(1994b), "Creating Value and Destroying Profits? Three Measures of Information Technology's Contributions," http://ccs.mit.edu/papers/CCSWP183.htm, (December).

Ives, Blake (1994), "Probing the Productivity Paradox," *Management Information System Quarterly*, Vol. 18, no. 2, (June).

Jorgensen, Dale W. (2001), "Information Technology and the U.S. Economy," *American Economic Review*, March, 91 (1), 1-32.

Jorgenson, Dale W. and Stiroh, Kevin J. (2000a), "Industry-level productivity and competitiveness between Canada and the United States, U.S. Economic growth at the industry level," *American Economic Review*, May, Vol. 90 no. 2.

Jorgenson, Dale W. and Stiroh, Kevin J. (2000b), "Raising the Speed Limit: U.S. Economic Growth in the Information Age," Federal Reserve Bank of New York, (May).

Jorgenson, Dale W. and Stiroh, Kevin J. (1995), "Computers and Growth," *Economics of Innovation and New Technology*, Vol. 3, 295-316.

Landauer, Tomas K. (1995), The trouble with Computers, The MIT Press, Cambridge, MA.

Lichtenberg, Frank R. (1995), "The Output Contributions of Computer Equipment and Personal: A Firm-level Analysis," *Economics of Innovation and New Technology*, Vol. 3: 201-217.

Loveman, Gary W. (1994), "An Assessment of the Productivity Impact of Information Technologies," in Allen, Thomas J. and Scott Morton, Michael S. (eds.), Information Technology and the Corporation of 1990s: Research Studies, Oxford University Press, pp. 84-110.

McKinsey Global Institute (2001), "US Productivity Growth 1995-2000: Understanding the Contribution of Information Technology Relative to Other Factors (Executive Summary)," (October).

Oliner, Stephen D. and Sichel, Daniel E. (1994), "Computers and Output Growth Revisited: How Big is the Puzzle?" *Brookings Papers on Economic Activity*, 1994(2), 273-334.

Oliner, Stephen D.and Sichel, Daniel E. (2000), "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?" *Journal of Economic Perspectives*, fall, Vol. 14.

Roach, Stephen S. (1987), "America's Technology Dilemma: A Profile of the Information Economy," Morgan Stanley Special Economic Study, (April).

Roach, Stephen S. (1991), "Services under Siege: the Restructuring Imperative," *Harvard Business Review,* 39(2) 82-92, (September-October).

Rubin Systems / META Group (2001), "Connecticut Rank in IT."

Scacchi, Walt (1995), "Understanding Software Productivity," in Advances in Software Engineering and Knowledge Engineering, D. Hurley (ed.), Vol. 4, 37-40.

Siegel, Donald (1994), "The Impact of Computers on Manufacturing Productivity Growth: A Multiple-Indicators, Multiple-Causes Approach," *SUNY at Stony Brook Working Paper*, (May).

Siegel, Donald and Griliches, Zvi (1992), "Purchased Services, Outsourcing, Computers, and Productivity in Manufacturing," in Griliches et al (eds.), Output Measurement in the Service Sectors, University of Chicago Press.

Steinmueller, Edward W. (1995), "The U.S. Software Industry: An Analysis and Interpretive History" in The International Computer Software Industry, Oxford University press (forthcoming).

Stiroh, Kevin J. (2002), "Reassessing the Impact of IT in the Production Function: A Meta-Analysis," Federal Reserve Bank of New York, (November).

Stiroh, Kevin J. (2001), "Investing in Information Technology: Productivity Payoffs for U.S. Industries," Federal Reserve Bank of New York, (June).

Stiroh, Kevin J. (2001), "The Economic Impact of Information Technology," Federal Reserve Bank of New York, (June).

Strassmann, P.A. (1990), The Business Value of Computers: An Executive's Guide, New Canaan, CT, Information Economics Press.

The City of Seattle Department of Information Technology and the Citizens' Telecommunications and Technology Advisory Board Information (2000), "Technology Indicators for a Healthy Community."

U.S. Department of Commerce (2001), Digital Economy 2000, (June).

US Department of Commerce (2000), "The Digital Work Force: State Data & Rankings," (September).

Weill, Peter (1992), "The Relationship Between Investment in Information Technology and Firm Performance: A Study of the Value Manufacturing Sector," *Information Systems Research*, 3(4), 307-333.

Stanford Computer Industry Project Software Study (1995) "Revising the Classification of the Software Industry," memo to Office of Management and Budget.

Walton and Felix (1977), "A Method of Programming Measurement and Estimation," *IBM Systems Journal*, 16(1), 54-65.