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Does the "New Economy" Measure up to the Great Inventions of the Past?

Robert J. Gordon

A widespread belief seems to be emerging, at least in the popular press, that the U.S. economy is in the throes of a fundamental transformation, one which is wiping out the 1972–95 productivity slowdown, along with inflation, the budget deficit, and the business cycle. A typical recent comment, in a *Wall Street Journal* article, claimed that "when it comes to technology, even the most bearish analysts agree the microchip and Internet are changing almost everything in the economy" (Ip, 2000). Or as an article in *Fortune* (June 8, 1998, pp. 86–87) magazine put it, "The [computer] chip has transformed us at least as pervasively as the internal combustion engine or electric motor." Alan Greenspan (1999) appears to be among the technological enthusiasts. He recently stated: "A perceptible quickening in the pace at which technological innovations are applied argues for the hypothesis that the recent acceleration in labor productivity is not just a cyclical phenomenon or a statistical aberration, but reflects, at least in part, a more deep-seated, still developing, shift in our economic landscape." The true enthusiasts treat the New Economy as a fundamental industrial revolution as great or greater in importance than the concurrence of inventions, particularly electricity and the internal combustion engine, which transformed the world at the turn of the last century.

There is no dispute that the U.S. economy is awash in computer investment, that productivity has revived, and that the late 1990s were extremely good years for the U.S. economy. Indeed, Robert M. Solow has now declared obsolete his 1987 paradox that "we can see the computer age everywhere but in the productivity statistics" (Uchitelle, 2000). However, room remains for a degree of skepticism.

■ *Robert J. Gordon is Stanley G. Harris Professor in the Social Sciences, Northwestern University, Evanston, Illinois, and Research Associate, National Bureau of Economic Research, Cambridge, Massachusetts. His e-mail address is ⟨rjg@northwestern.edu⟩ and his website is ⟨http://faculty-web.at.northwestern.edu/economics/gordon⟩.*

Does the "New Economy" really merit treatment as a basic industrial revolution of a magnitude and importance equivalent to the great inventions of the late nineteenth and early twentieth century? These earlier changes, particularly electricity and the internal combustion engine, but also including chemicals, movies, radio, and indoor plumbing, set off 60 years between roughly 1913 and 1972 during which multifactor productivity growth was more rapid than ever before or since, and during which everyday life was transformed.

The skeptic's case begins with a close examination of the recent productivity revival. While the aggregate numbers are impressive, the productivity revival appears to have occurred primarily within the production of computer hardware, peripherals, and telecommunications equipment, with substantial spillover to the 12 percent of the economy involved in manufacturing durable goods.[1] However, in the remaining 88 percent of the economy, the New Economy's effects on productivity growth are surprisingly absent, and capital deepening has been remarkably unproductive. Moreover, it is quite plausible that the greatest benefits of computers lie a decade or more in the past, not in the future. The paper then explores some of the intrinsic limitations of the computer in general and the Internet in particular for affecting productivity and the quality of life when evaluated in comparison with the great inventions of the past.

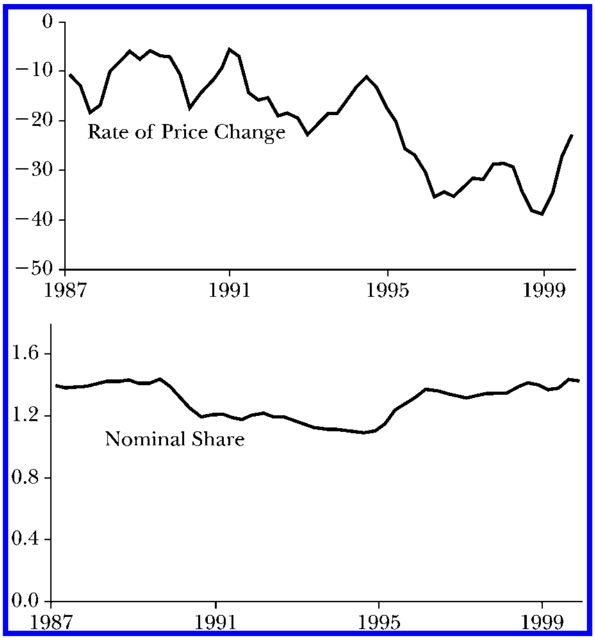
Dissecting the Revival in U.S. Productivity Growth

Since computer prices have been declining at rapid rates for the last 50 years, the phrase "New Economy" must mean that something more and different has happened in the last few years. Indeed, as shown in the top frame of Figure 1, at the end of 1995 there was an acceleration of the rate of price change in computer hardware (including peripherals) from an average rate of −14.7 percent during 1987–95 to an average rate of −31.2 percent during 1996–99. These growth rates do not mean that the prices of computers as listed on store shelves and websites literally fell by this amount. In the U.S. national accounts, computer prices since 1986 have been measured by the "hedonic" regression technique, in which the prices of a variety of models of computers are explained by the quantity of computer characteristics and by the passage of time. Thus, "decline in computer prices" actually means "a decline in the prices of computer attributes like a given level of speed, memory, disk drive access speed and capacity, presence and speed of a CD-ROM, and so on." Indeed, computers have seemed perhaps the ideal application for the hedonic regression technique since the work of Chow (1967).

One way to get a feel for the dramatic impact of this price decline is to consider the ratio of performance-to-price that is implicit in the BEA's calculations. From the fourth quarter of 1993 to the fourth quarter of 1999, the performance of a

[1] In 1996, current dollar value-added in durable manufacturing was 11.6 percent of current dollar output in the nonfarm private business sector. See *Economic Report of the President*, February 1999, Tables B-10 and B-12.

Figure 1
Final Sales of Computers and Peripherals, Four-quarter Rate of Price Change and Nominal Share in Nonfarm Nonhousing Business GDP, 1987–99



computer at a given price rose by a factor of 5.2. Improvements in performance-price ratios for individual computer components are substantially larger, by a factor of 16.2 for computer processors, 75.5 for RAM, and 176.0 for hard disk capacity.[2] The driving force behind the greater rate of price decline was an acceleration in the rate of technological progress; apparently, the time cycle of Moore's Law, which has historically held that the price of computing power falls by half every 18 months, shortened from 18 months to about 12 months at this time.[3]

Most of the discussion in this paper will follow the lead of Figure 1 by focusing on computer hardware, rather than the universe of computer hardware, software, and telecommunications equipment, because the government deflators for software and telecommunications equipment exhibit implausibly low rates of price decline (Jorgenson and Stiroh, 2000). These adjustments for the "true" price of computer performance are essential, since over the period since 1987, spending on computers stagnated at around 1.3 percent of the nonfarm private business economy, as shown in the bottom frame of Figure 1. Within the computer industry, the productivity gains involve greater amounts of computer speed and other capabilities from the same amount of total spending.

[2] See "Computers, then and now," *Consumer Reports*, May 2000, p. 10, where the published reported comparisons in 1999 dollars have been converted to nominal dollars using the Consumer Price Index.
[3] This judgement is based on a conversation between Gordon Moore and Dale W. Jorgenson, related to the author by the latter.

This acceleration in the price decline of computers since 1995 has been accompanied by a revival of productivity growth in the aggregate economy which is impressive in comparison with the American historical record dating back more than a century. Table 1 compares rates of output, input, and productivity growth achieved in the American economy during the four years 1995–99 as compared with three long earlier intervals: 1870–1913, 1913–1972, and 1972–1995.[4] The top line of the table shows the real growth rate of (nonfarm, nonhousing) output over these time periods.

Lines 2–6 show growth rates of inputs and productivity. Lines 2–3 show the growth rate of output for labor and capital, respectively. Line 4 is the growth rate of capital per hour worked. Line 5 shows the growth rate of output per hour or labor productivity, which can be calculated in the table by subtracting the growth rate of labor hours in line 2 from the growth rate of output in line 1. Line 6 is multifactor productivity growth, which is productivity growth based on a weighted average of several inputs, in this case labor and capital, with weights based on the share of each input in total income. The growth in output per hour (line 5) can be split up into multifactor productivity growth (line 6) and the contribution of capital deepening, which in turn is the growth in capital per hour (line 4) multiplied by capital's share of income, which is roughly one-third. Thus, the growth rate of output per hour minus one-third the growth rate of capital per hour equals multifactor productivity.[5]

Lines 6–9 repeat this exercise, but are based on alternative input concepts which are adjusted for changes in composition of the inputs. For example, the growth in labor input is adjusted for changes in the dimensions of age, sex, and educational attainment. The shift in capital input is adjusted for the change in capital spending from structures to equipment, and from longer-lived equipment

[4] The record compiled for 1870–1996 in Table 1 is based on Gordon (2000b), which merges data from Kendrick (1961) with BEA and BLS data for the postwar period and develops estimates for labor and capital composition to carry the postwar BLS composition adjustments back from 1948 to 1870.

[5] The concepts can be related by considering a production function:

$$y = m + bh + (1 - b)k,$$

where y is the growth rate of output, m is the growth rate of multifactor productivity growth, b is the elasticity of output with respect to labor input, h is the growth rate of labor input, $1 - b$ is the elasticity of output with respect to capital input (implicity invoking constant returns to scale), and k is the growth rate of capital input. Thus, output growth is the sum of productivity growth and of the separate contributions of labor and capital input, weighted by the elasticity of output growth to each input. Now rewrite the equation as

$$y - h = m + (1 - b)(k - h).$$

Growth in output per hour $(y - h)$ is now equal to growth in multifactor productivity plus the contribution of "capital deepening," which is the elasticity of output with respect to capital $(1 - b)$ times the growth rate of the capital-labor ratio $(k - h)$.

Table 1

Growth Rates of Output, Inputs, and Multifactor Productivity, Selected Intervals, 1870–1999

	1870–1913	*1913–1972*	*1972–1995*	*1995–1999*
1. Output (*y*)	4.42	3.14	2.75	4.90
Without Composition Adjustment to Inputs				
2. Labor Hours (*h*)	3.24	1.28	1.71	2.25
3. Capital (*k*)	4.16	2.07	2.98	4.87
4. Capital per Hour (*k-h*)	0.92	0.79	1.27	2.62
5. Output per Hour (*y-h*)	1.18	1.86	1.04	2.65
6. Multifactor productivity growth (*m*)	0.77	1.60	0.62	1.79
With Composition Adjustment to Inputs				
7. Labor Hours (*h*)	3.73	1.72	2.09	2.71
8. Capital (*k*)	4.22	2.76	4.04	5.58
9. Capital per hour (*k-h*)	0.49	1.04	1.95	2.87
10. Output per Hour (*y-n*)	0.69	1.42	0.66	2.19
11. Multifactor productivity growth (*m*)	0.47	1.08	0.02	1.25

Sources: 1870–1995. Lines 1–6 from Gordon (2000b), Table 1. Lines 7–11 from Gordon (2000b), Table 6. 1995–1999. All data are taken from Oliner and Sichel (2000) and are transformed as follows. Output (line 1): Table 1, line 1. Labor hours (line 2): Table 1, line 7, divided by 0.67, the implicit share of labor. Capital (line 3): Composition-adjusted capital (see below for source of line 7) minus 0.71, which is the difference between the growth of capital services and capital stock in Jorgenson and Stiroh (2000, Tables 1 and 2, column 1). MFP (line 6): Output growth minus input growth, using weights of 0.67 and 0.33 on labor and capital, respectively. Labor hours (line 7): Table 1, line 7 plus line 8, divided by 0.67, the implicit share of labor. Capital (line 8): Table 1, line 2 plus line 6, divided by 0.33, the implicit share of capital. MFP (line 11): Table 2, line 9.

like railroad locomotives to shorter-lived equipment like computers.[6] These composition-adjusted estimates should be viewed as the preferred measures of the growth rates of labor and capital input. However, the estimates in lines 2–6 that exclude the composition adjustments are useful for comparability with other unadjusted quarterly data, some of which will be explored later in this paper.

In past writing, I have pointed to the historical patterns summarized through 1995 in the first three columns and have suggested that the basic question about historical productivity growth should not be "Why was growth was so slow after 1972?" but rather "Why was growth was so fast during the golden years 1913–72?" I have attributed the outstanding performance of the golden years to the role of the great inventions of the late nineteenth and early twentieth century mentioned in the introduction and discussed further below.

Upon first examination, the data for 1995–99 are consistent with the beginning of a new golden age of productivity growth. Either with or without composition

[6] Likewise, housing is excluded to retain comparability with Table 2 below. Adjustments for labor composition were pioneered by Griliches (1960) and Denison (1962), and for capital composition by Jorgenson and Griliches (1967). Similar adjustments are incorporated in the official BLS series on multifactor productivity that currently covers 1948–97, and detailed annual data are available through 1998 in Jorgenson and Stiroh (2000).

adjustments, multifactor productivity growth during 1995–99 exceeded that in the golden age from 1913–1972. Capital deepening during 1995–99 proceeded at an extraordinary rate. The overall acceleration in output per hour, combining multifactor productivity growth and the impact of capital deepening, is more than a full percentage point per year when 1995–99 is compared to the 1972–95 slowdown period.

This performance is undeniably impressive. Yet there are two skeptical questions to be raised. First, when examined closely, it turns out that a major fraction of the revival in multifactor productivity growth has occurred within the part of the economy engaged in producing computers and peripherals, and within the rest of the durable manufacturing sector, which together comprise only about 12 percent of the private business economy. This raises the question of how far the New Economy actually reaches into the remaining 88 percent of economic activity. Second, the period from 1995 to 1999 is much shorter than the earlier three time periods and during at least part of that time, it seemed clear even to many of the New Economy optimists that output growth was running at a faster pace than the sustainable long-term growth trend. The idea that productivity varies procyclically dates back to Hultgren (1960) and "Okun's Law" (Okun, 1962) and was first interpreted by Oi (1962), who described labor as a "quasi-fixed factor" that adjusts only partially during cyclical swings of output. If output was growing faster than trend, then productivity was also growing faster than trend, and some part of the productivity revival recorded in Table 1 was transitory rather than permanent.

My recent research on the cyclical analysis of labor productivity in Gordon (2000c) updates the earlier results of Gordon (1993). In my econometric specification, the change in the growth of actual hours relative to the hours trend is explained by changes in its own lagged values and by changes in the growth of output relative to trend. Hours growth lags behind output growth and responds by roughly 0.75 of the output change; thus growth in output per hour exhibits a temporary acceleration when hours are lagging behind output changes, and in addition increases by roughly 0.25 of any excess in output growth relative to trend.[7]

Several decompositions between trend and cyclical productivity growth are displayed in Table 2. The first column refers to the aggregate economy, which in this case means the nonfarm private business sector including computers. Of the actual 2.75 percent annual growth of output per hour between 1995:Q4 and 1999:Q4, 0.50 percentage point are attributed to a cyclical effect and the remaining 2.25 points to trend growth. This is 0.83 points faster than the 1972–95 trend, as shown in lines 4 and 5. How can this acceleration be explained? A small part on

[7] I set the hours trend at a rate consistent with a nonaccelerating inflation rate of unemployment (NAIRU) in the fourth quarter of 1999 of 5.0 percent. Moreover, it is assumed that actual and trend output were equal in the later stages of upswings in 1954:Q1, 1963:Q3, 1972:Q2, 1978:Q2, 1987:Q3 and 1995:Q4. The task is to determine the optimal output trend after 1995:Q4. The decomposition of the recent productivity acceleration between cycle and trend is accomplished by specifying a value for the hours growth trend and then conducting a grid search to find the output growth trend that optimizes the fit of the equation. The regression equation is estimated for the period 1954:Q1–1999:Q4, and the growth in trend output is varied to minimize the root-mean-squared error over 1996:Q1–1999:Q4.

Table 2
Decomposition of Growth in Output Per Hour, 1995:4–1999:4, into Contributions of Cyclical Effects and Structural Change in Trend Growth
(*percentage growth rates at annual rate*)

	Nonfarm Private Business	*NFPB Excluding Computer Hardware Manufacturing*	*NFPB Excluding Durable Manufacturing*
1. Actual Growth	2.75	2.30	1.99
2. Contribution of Cyclical Effect	0.50	0.51	0.63
3. Growth in Trend (line 1–line 2)	2.25	1.79	1.36
4. Trend, 1972:2–1995:4	1.42	1.18	1.13
5. Acceleration of Trend (line 3–line 4)	0.83	0.61	0.23
6. Contribution of Price Measurement	0.14	0.14	0.14
7. Contribution of Labor Quality	0.05	0.05	0.05
8. Structural Acceleration in Labor Productivity (line 5–line 6)	0.64	0.42	0.04
9. Contribution of Capital Deepening	0.33	0.33	0.33
10. Contribution of MFP Growth in Computer and Computer-Related Semiconductor Manufacturing	0.29	0.19	—
11. Structural Acceleration in MFP (line 7–lines 8 through 10)	0.02	−0.10	−0.29

Sources and notes: Actual and trend growth and contribution of price measurement (lines 1–6): Gordon (2000c), Tables 1 and 2. Lines 6, 9, and 10 are from Oliner and Sichel (2000), in each case comparing their growth rates for 1995–99 with a weighted average of 1973–90 and 1990–95. The table and line sources from Oliner and Sichel are as follows: Labor quality (line 7): Table 2, line 8. Capital deepening (line 9): Table 2, line 2. MFP growth in computers and computer-related semiconductors (line 10): Table 4, line 5. Comparing Table 4, lines 2 and 5, of the total effect of 0.29, 0.10 is due to computers (and hence is omitted from column 2 in our Table 2) and the remaining 0.19 is due to computer-related semiconductor manufacture.

lines 6 and 7 is attributed to changes in price measurement methods and to a slight acceleration in the growth of labor quality.[8] The remaining 0.64 points can be directly attributed to computers. The capital-deepening effect of faster growth in capital relative to labor in the aggregate economy accounts for 0.33 percentage points of the acceleration (all due to computers), and an acceleration of multifac-

[8] The price measurement effect consists of two components. While most changes in price measurement methods in the CPI have been backcast in the national accounts to 1978, one remaining change—the 1993–94 shift in medical care deflation from the CPI to the slower-growing PPI—creates a measurement discontinuity of 0.09 percent. The fact that other measurement changes were carried back to 1978 rather than 1972 creates a further discontinuity of 0.05 when the full 1972–95 period is compared to 1995–99. The acceleration in labor quality growth is taken from Oliner and Sichel (2000, Table 2) and reflects the same compositional changes discussed in connection with Table 1 above; labor quality growth during 1972–95 was held down by a compositional shift toward female and teenage workers during the first half of that period.

tor productivity growth in computer and computer-related semiconductor manufacturing account for almost all of the rest.[9]

A different way of assessing the role of computers is displayed in the second column of Table 2. Here we carry out the same set of calculations, but in this case we subtract output and hours in computer hardware manufacturing (but not computer-related semiconductor manufacturing) from the nonfarm private business economy. In this calculation, the structural acceleration of labor productivity on line 8 is 0.42 percentage points, compared to 0.64 for the first column. Again, the impact of capital deepening has created a genuine revival in growth in output per hour in the non-computer economy, and the contribution of the computer sector is reduced. But in either case, spillover effects on multifactor productivity in the noncomputer economy are absent (column 1) or slightly negative (column 2).

The third column of Table 2 carries out these calculations yet again, but this time excludes all durable goods manufacturing from hours worked and output. The starting growth rate in the first line is a much lower 1.99 percent. A slightly larger cyclical effect is subtracted, leaving an acceleration in trend on line 5 of only 0.23 percent. The cyclical effect is slightly larger here because between 1995 and 1999, there is no increase in the capacity utilization rate in manufacturing nor any acceleration in hours of growth in manufacturing. The cyclical effects in the economy over this time occur entirely outside of manufacturing, which accounts for the higher cyclical effect in this column. Almost all of the acceleration in productivity trend can be explained by price measurement and labor quality, leaving a structural acceleration in output per hour growth of only 0.04 percent. As a result, after taking capital deepening into account, line 11 shows a *substantial structural deceleration* in multifactor productivity growth in the economy outside of the durable goods manufacturing sector.

From the fourth quarter of 1995 to the fourth quarter of 1999, the annual growth of output per hour was 1.33 percentage points faster than from 1972:Q2 to 1995:Q4 (as shown in Table 2, column 1, lines 1 and 4). The analysis here argues that .50 percentage points of that increase is a cyclical effect (column 1, line 2); .19 points of that increase results from changes in measurement of prices and labor quality; .33 points is the capital deepening from greater investment in computers; .29 points is the acceleration of multifactor productivity growth in manufacturing computers; .27 points is the acceleration in multifactor productivity growth in manufacturing other types of durable goods; and −.29 percent is a *deceleration* in trend productivity growth in the economy outside of durable goods manufacturing.

How credible is this decomposition? It depends on the accuracy of the cyclical adjustment; it would take a reduction in the cyclical effect in the right-hand column of Table 2 by .29 points (from .63 to .34) to eliminate the basic conclusion that trend productivity growth outside of durables has decelerated. Yet a cyclical effect

[9] In the Oliner-Sichel decomposition on which line 9 is based, computers account for all of the acceleration in the capital-deepening effect, and the additional acceleration attributable to semiconductors and telecommunications is exactly canceled out by a *deceleration* of capital deepening for all other types of equipment and structures (Oliner and Sichel, 2000, Table 2, lines 2 through 7).

of the magnitude estimated here is not unprecedented or unusual. Labor hiring always lags behind surges in output, and we would expect productivity to exhibit temporary growth in response to the astonishing 7.3 percent growth rate of nonfarm business output in the last half of 1999. At the end of 1999 the level of nonfarm business output per hour was 2.0 percent above trend, a smaller cyclical deviation than occurred in 1966, 1973, and 1992.[10]

These results imply that computer investment has had a near-zero rate of return outside of durable manufacturing. This is surprising, because 76.6 percent of all computers are used in the industries of wholesale and retail trade, finance, insurance, real estate, and other services, while just 11.9 percent of computers are used in five computer-intensive industries within manufacturing, and only 11.5 percent in the rest of the economy (McGuckin and Stiroh, 1998, Table 1, p. 42). Thus, three-quarters of all computer investment has been in industries with no perceptible trend increase in productivity. In this sense the Solow computer paradox survives intact for most of the economy, and the need to explain it motivates the rest of this paper.

How the Great Inventions Helped Us Escape from the Bad Old Days

The First Industrial Revolution began largely in Britain and extended from about 1760 to 1830. But despite the list of innovations of this time period—the steam engine, the power loom, and so on—multifactor productivity grew at a snail's pace in the nineteenth century. As Brad De Long (2000) has observed: "Compared to the pace of economic growth in the 20th century, all other centuries—even the 19th . . . —were standing still."[11] The Second Industrial Revolution took place simultaneously in Europe and the United States and can be dated roughly 1860 to 1900. This is the revolution of electricity, the internal combustion engine, and so on, and it led to the golden age of productivity growth from 1913 to 1972.

The question at hand is whether the role of the computer and Internet are likely to constitute a Third Industrial Revolution, with lasting productivity gains comparable to the second one. One might object that this comparison does not include the entirety of technological advance of the 1990s; for example, a broader perspective that included biology, pharmaceuticals, and medical technology might lead to a more sympathetic comparison of recent progress with the Second Industrial Revolution. But in common discourse, the New Economy is certainly more about computers than pharmaceuticals. Moreover, if one starts down the road of comparing changes in life expectancy, the yearly rate of increase in life expectancy at birth during 1900–50, resulting in substantial part from the inventions of the

[10] Compared to the 2.0 percent ratio in 1999:Q4, larger log ratios of actual to trend productivity in the nonfarm business sector occurred in 1966:Q1 (3.0 percent), 1973:Q1 (2.3 percent), and 1992:Q4 (2.2 percent).
[11] Quoted in "A Century of Progress," *Economist*, April 15, 2000, p. 86.

Second Industrial Revolution, was 0.72 percent per year, *triple* the 0.24 percent annual rate during 1950–95 (Nordhaus, 1999, Figure 3). Thus, it seems unlikely that taking gains in life expectancy into account will elevate the possible Third Industrial Revolution relative to the second one.

Life in the "Bad Old Days"

To understand the profound sense in which the great inventions of the Second Industrial Revolution altered the standard of living of the average American resident, we begin with a brief tour of some of the less desirable aspects of living in the late nineteenth century. An eye-opening introduction to the conditions of that era is provided in a little-known book by Otto Bettman (1974), the founder of the famed Bettman photographic archive, and I paraphrase and quote from that book in the next four paragraphs.

The urban streets of the 1870s and 1880s were full not just of horses but pigs, which were tolerated because they ate garbage. In Kansas City, the stench of patrolling hogs was so penetrating that Oscar Wilde observed, "They made granite eyes weep." The increasing production of animal waste caused pessimistic observers to fear that American cities would disappear like Pompeii—but not under ashes. Added to that was acrid industrial smog, sidewalks piled high with kitchen slops, coal dust, and dumped merchandise, which became a liquid slime after a rain. All of this was made worse in the summer, which was almost as unbearable outdoors as inside, especially with the heavy clothes of the day. Rudyard Kipling said of Chicago, "Having seen it, I desire urgently never to see it again. Its air is dirt." Added to putrid air was the danger of spoiled food—imagine meat and poultry hung unrefrigerated for days, spoiled fruit, bacteria-infected milk, and so on. Epidemics included yellow fever, scarlet fever, and smallpox. Many hospitals were deathtraps.

Before the invention of electricity, urban streets were a chaotic jungle of horse-drawn conveyances of all types, made even more congested in winter by horse-drawn snowplows that did little more than move the snow out of the way of the trolleys by dumping it on the sidewalks. Rural life was marked by isolation, loneliness, and the drudgery of fireplace cooking and laundry done by muscle-power. Travel between cities on railroads was surprisingly dangerous; in 1890, railroad-connected accidents caused 10,000 deaths.

In 1882, only 2 percent of New York City's houses had water connections. Urban apartments were crowded, damp, airless, and often firetraps. Even middle-class apartment buildings were little more than glorified tenements. In the slums as many as eight persons shared a single small room.

Coal miners, steel workers, and many others worked 60-hour weeks in dirty and dangerous conditions, exposed to suffocating gas and smoke. Danger was not confined to mines or mills; in 1890 one railroad employee was killed for every 300 employed. Sewing in a sweatshop might have been the most oppressive occupation for women, but was not as dangerous as soap-packing plants or the manual stripping of tobacco leaves.

The Great Inventions

Into this world of the late nineteenth and early twentieth century came a set of great inventions which can be usefully grouped into five "clusters." Each of these clusters had a primary breakthrough invention that occurred during the period 1860–1900. For specific chronologies of these inventions as they developed, see Bunch and Hellemans (1993) or the website of the "Greatest Engineering Achievements of the 20th Century" recently released by the National Academic of Engineering at ⟨http://www.greatachievements.org⟩.

The first great invention in the "Group of Five" is electricity, including both electric light and electric motors. In the opening decades of the twentieth century, electric motors revolutionized manufacturing by decentralizing the source of power and making possible flexible and portable tools and machines. After a somewhat longer lag, electric motors embodied in consumer appliances eliminated the greatest source of drudgery of all, manual laundry; refrigeration virtually eliminated food spoilage; and air conditioning made summers enjoyable and opened the southern United States for modern economic development (David, 1990).[12]

Sharing the title with electricity for the most important invention that had its main diffusion in the twentieth century is the internal combustion engine, which made possible personal autos, motor transport, and air transport. Grouped in this category are such derivative inventions as the suburb, highway, and supermarket. Gradually eliminated or greatly reduced were many of the ills of the late nineteenth century, from manure to unplowed snow to rural isolation.

The third group of great inventions includes petroleum, natural gas, and various processes which "rearrange molecules," including chemicals, plastics, and pharmaceuticals. Some of these inventions were spontaneous and others were induced by the demands of motor and air transport. They helped to reduce air pollution created by industrial and heating uses of coal, and they made possible many new and improved materials and products, as well as conquering illness and prolonging life.

The fourth cluster consists of the complex of entertainment, communication, and information innovations. This set of inventions that made the world smaller can be traced back to the telegraph (1844) and includes the telephone (1876), phonograph (1877), popular photography (1880s and 1890s), radio (1899), motion pictures (1881 to 1888), and television (1911). Television is the only one of these innovations that was diffused into the popular marketplace after World War II.

Perhaps the most tangible improvement in the everyday standard of living, besides electric light, came through the rapid spread after 1880 of running water, indoor plumbing, and urban sanitation infrastructure. Mokyr and Stein (1997, p. 146) credit Louis Pasteur's germ theory of disease for the great decline in mortality in the four decades prior to World War I, long before the invention of

[12] See Oi (1997) for an insightful analysis of the effect of air conditioning on productivity.

antibiotics, although in part the development of indoor plumbing was independent of the germ theory and dates to the invention of the indoor flush toilet.

These five clusters of inventions, in turn, created an increase in per capita income and wealth during the golden years of productivity growth from 1913–72 that allowed an improvement in living standards even in those aspects of consumption where inventions did not play a major role, particularly the ability of families to afford many more square feet of shelter (and in the suburbs more land surrounding that shelter) than in 1880.

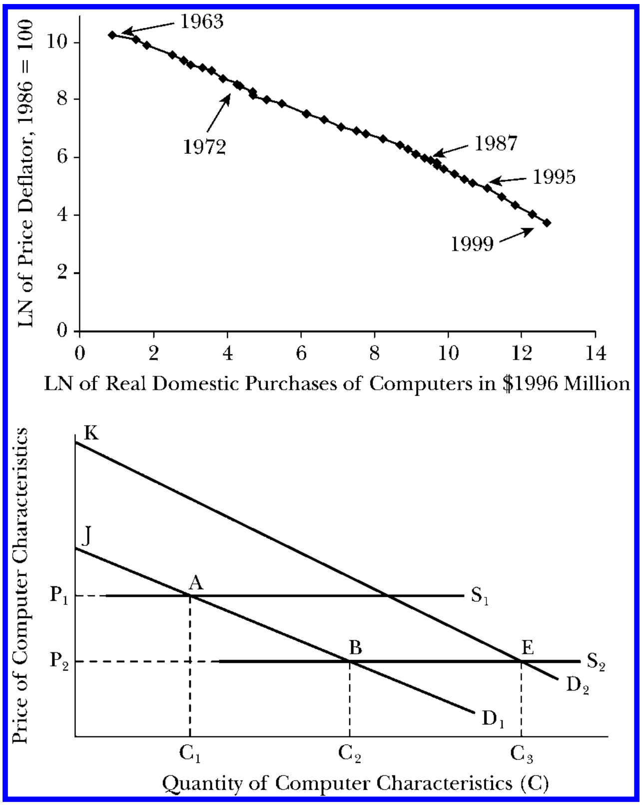
Will the information revolution spawned by the computer create as great a change in living conditions as the major inventions of the late nineteenth and early twentieth century? At an intuitive level, it seems unlikely. For instance, we might gather together a group of Houston residents and ask: "If you could choose only one of the following two inventions, air conditioning or the Internet, which would you choose?" Or we might ask a group of Minneapolis residents, "If you could choose only one of the following two inventions, indoor plumbing or the Internet, which would you choose?" But there are deeper reasons, rooted in basic principles of economics like diminishing returns, as to why, half a century from now, it is unlikely that historians and economists will look back at the present surge in computer investment as the harbinger of a Third Industrial Revolution.

The Declining Cost of Computer Power and the Pervasiveness of Diminishing Returns

There are a number of differences between the computer and the great inventions of the Second Industrial Revolution, but perhaps the largest difference is the unprecedented rate of decline in the price of computer power. Although the price decline of computing power has accelerated from 1995–99 as opposed to the period from 1987–94, as shown earlier in Figure 1, over the last five decades these rapid rates of price decline are standard. The rate of price change has varied over time, but rapid price declines also occurred during the 1950–80 interval dominated by the mainframe computer and the 1980–95 interval dominated by the transition from mainframe to personal computer applications prior to the invention of the Internet. Indeed, existing computer price deflators fail to take account of the radical decline in the price per calculation that occurred in the transition from mainframes to personal computers, which have been studied only separately, not together. Gordon (1990, p. 239) calculates that the annual rate of price decline between 1972 and 1987 would have been 35 percent per annum, rather than 20 percent per annum, if this transitional benefit had been taken into account. From this perspective, the technological advance created by the New Economy of the last five years may be less significant than it at first appears.

The top frame of Figure 2 shows the implicit price deflator for computers on the vertical axis, and real expenditures for computers and peripherals on the

Figure 2
Real Gross Domestic Purchases of Computers and Peripherals and its Price Deflator, 1963–99



Source: Unpublished series provided by Christian Ehemann of the Bureau of Economic Analysis.

horizontal axis.[13] This set of points of price and quantity for given years has an intuitive supply and demand interpretation: there has been an outward shift of the supply curve for computers, driven by technological advance, happening at a rate much faster than the upward shift in the demand for computer services. In fact, the story is often told with a theoretical diagram like the bottom frame of Figure 2, in which the supply curve slides steadily downwards from S_1 to S_2 with no shift in the demand curve at all, as in Brynjolfsson (1996, p. 290), Gordon (1990, p. 46) and Sichel (1997, p. 17). The supply curves in this graph have been drawn as horizontal lines, both to simplify the subsequent discussion of consumer surplus and because

[13] Domestic purchases in Figure 2 includes consumption, investment, and government expenditures on computers and peripherals. This differs from final sales of computers (the subject of Figure 1 and the middle column of Table 2) by excluding net exports (which are strongly negative). Final sales are relevant to issues involving domestic output and productivity in the computer sector, while domestic purchases are relevant for issues involving the domestic demand for computers.

there is no evidence of a rising marginal cost of producing additional computer speed, memory, and other characteristics at a given level of technology.

The shape of the graph offers evidence that the demand curve has not shifted much or at all. If there had been a discontinuous rightward shift in the demand curve for computer hardware, the slope of the price-quantity relationship in the top frame of Figure 2 should flatten noticeably, as the rate of increase of quantity accelerates relative to the rate of decline in price, but it does not. The rate of change of price and quantity both accelerate after 1995 (as indicated by the greater price declines and quantity increases between annual observations) but the slope becomes steeper rather than flatter. This pattern suggests that while the pace of technological change has speeded up in the last few years, the relationship between supply and demand is not qualitatively different than earlier advances in the computer industry.

The data on the price and quantity of computer characteristics have previously been used to "map out" the demand curve (Brynjolfsson, 1996, p. 290). In fact, the slope of the price-quantity relationship was appreciably flatter during 1960–72 and 1972–87 than during 1987–95 or 1995–99. If the demand curve has not shifted, the inverse of these slopes is the price elasticity of demand, namely −2.03, −1.97, −1.64, and −1.36 in these four intervals, which can be compared with Brynjolfsson's (1996, p. 292) estimated price elasticity of −1.33 over the period 1970–89. The apparent decline in the price elasticity is the counterpart of the fact that the nominal share of computer hardware expenditures in the total economy (which implicitly holds income constant) rose rapidly before 1987 but barely increased at all after that year, and this shift in the price-quantity slope is consistent with the view that the most important uses of computers were developed more than a decade into the past, not currently.

A second distinguishing feature of the development of the computer industry, after the decline in price, is the unprecedented speed with which diminishing returns set in. While computer users steadily enjoy an increasing amount of consumer surplus as the price falls, the declining point of intersection of the supply curve with the fixed demand curve implies a rapid decline in the marginal utility or benefit of computer power. Since Gary Becker's (1965) seminal article on the economics of time, household production has been viewed as an activity which combines market goods and time. The fixed supply of time to any individual creates a fundamental limitation on the ability of exponential growth in computer speed and memory to create commensurate increases in output and productivity. As Zvi Griliches once said, "The cost of computing has dropped exponentially, but the cost of thinking is what it always was."[14]

In performing two of the activities that were revolutionized by the personal computer, namely word processing and spreadsheets, I cannot type or think any faster than I did with my first 1983 personal computer that contained 1/100th of the memory and operated at 1/60th of the speed of my present model. The capital

[14] The full remark continued, "That's why we see so many articles with so many regressions and so little thought." This comment was passed on to me by Jack Triplett.

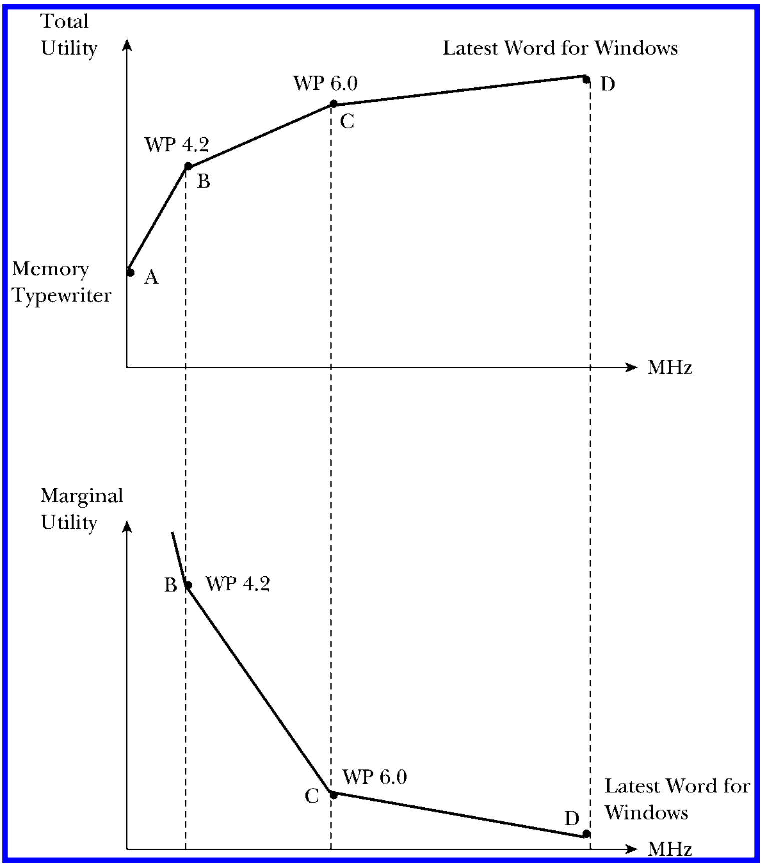
stock with which I work has increased by a factor of almost 30, according to the hedonic price methodology, yet my productivity has hardly budged, occasionally benefitting for a few seconds when I can jump from the beginning to the end of a 50-page paper much faster than in 1983. A price index that declines at 25 percent per year for 17 years reaches a level of 1.4 in 2000 on a base of 1983 equals 100. This implies that my present $1000 computer represents $70,100 in 1983 prices, or 28 times the $2500 that I spent in 1983 on my first computer net of peripherals. As a result, there has been an exponential rate of decline in my output-to-capital ratio, and an equally sharp decline in the marginal productivity of computer capital.

The computer hardware and software industries are certainly not unique in running into some form of diminishing returns. Numerous industries have run into barriers to steady growth in productivity, most notably the airline industry when jet aircraft reached natural barriers of size and speed, and the electric utility industry when turbogenerator/boiler sets reached natural barriers of temperature and pressure. The apparent dearth of productivity growth in the construction and home maintenance industry reflects that electric portable power tools could only be invented once and have been subject to only marginal improvements in recent decades.

What makes diminishing returns particularly important in understanding the computer paradox is the sheer pace at which computer users are sliding down the computer demand curve to ever-lower marginal utility uses. Word processing offers an example of this point. The upper frame in Figure 3 conjectures a total utility curve for word processing, plotted against the speed of the computer measured in mHz. Plotted are successive improvements starting at point A with the memory typewriter, which eliminated much repetitive retyping. At point B comes the early slow DOS personal computer with WordPerfect 4.2. Much faster computer speeds allowed the development of WordPerfect 6.0 for DOS, with a fully graphical WYSIWYG interface, as at point C. Further order-of-magnitude increases in speed bring us today's state of the art at point D, Windows 98 with the latest version of Microsoft Word. Yet look at how the curve flattens out. The real revolution in word processing came at the beginning, by ending repetitive retyping and by allowing revisions to be inserted while the rest of the document would automatically reformat itself. The productivity enhancement of WYSIWYG was minor in comparison, and what was contributed by the final step to the latest version of Word for Windows, beyond some ease of training for novice users, escapes me. As the computer industry has developed, the steady decline in the prices of computer characteristics has fueled the development of increasingly complex software with high requirements for speed and memory required by graphical point-and-click interfaces that yield increasingly small increments of true functionality. The race between hardware capability and software requirements has been aptly summed up in the phrase, "What Intel giveth, Microsoft taketh away."

The bottom frame of Figure 3 replots the same relationship with marginal utility on the vertical axis. This is the demand curve for computers which is drawn on the simplified assumption that word processing is the only use of computers, but the point can be made in multiple dimensions. As the diagram is drawn, a large part

Figure 3
A Total and Marginal Utility Curve for Word Processing



of the consumer surplus occurred in going from A to B to C, and further gains are relatively small.[15]

When investment in computers was failing to provide much (or any) measurable increase in productivity from the 1970s up into the early 1990s, one response from economists was that the productivity gains would arrive eventually. Perhaps the most noteworthy formulation of this argument was by David (1990), who argued that it had taken electric light and electric motors some decades to diffuse after their invention in the 1870s, so that their productivity benefits did not arrive until the opening decades of the 21st century. Perhaps, David argued, the productivity gains from computers would follow a similar pattern.

But the fact of extreme diminishing returns in computers argues against the David (1990) delay hypothesis. The reason that electric light and electric motors

[15] Even *Business Week*, normally enthusiastic about the benefits of the New Economy, admits that the latest increments in chip speed offer "a lot of speed you can't really use. . . a speedier chip won't make you type faster or think faster." See Wildstrom (1999, p. 23).

took time to diffuse is that initially they were very expensive and didn't work very well. But computers provided powerful benefits early on. Many of the industries that are the heaviest users of computer technology—like airlines, banks, and insurance companies—began in the 1960s and 1970s with mainframe technology and still perform the most computation-intensive activities on mainframes, often using personal computers as smart terminals to access the mainframe database. Personal computers are a secondary step in the evolution of computer technology, made practical by decreasing costs of computer power. The Internet is yet another step in the evolution of computer technology, also made possible by decreasing costs of computer power. In this sense, computers have been around for almost 50 years. Instead of waiting for the productivity boost to arrive, it is more plausible that the main productivity gains of computers have already been achieved.

A final reason that computers run into diminishing returns is that there are real limitations to the replacement of human beings by computers. To be sure, some of the output of computers is, in principle, as productivity-enhancing as that of electric motors or motorized transport. Numerically controlled machine tools, robots, and other computer-driven machinery have some of the same potential for productivity improvement as the earlier great inventions and doubtless account for the robust rate of productivity growth apparent in much of the durable manufacturing sector. The use of ever-faster computers and peripherals to churn out securities transactions, bank statements, and insurance policies has enhanced productivity growth in the finance/insurance sector. Just as the motor car enormously increased personal mobility and flexibility, so the computer has spawned inventions whose main output is convenience, perhaps most notably the automatic teller machine in the banking industry, but now also beginning to include various Internet-based services.

However, computers are actually less pervasive in the economy than is generally thought, because some tasks are resistant to replacement of human beings by computers. Commercial aircraft will always need two human pilots, no matter how advanced the avionics in the cockpit. Trucks will always need at least one driver. In manufacturing, some critical functions have proven to be resistant to automation, such as the connecting of tubes and wires when an auto chassis is "married" to the body.[16] By their nature, many services involve in-person contact between clients and practitioners, whether doctors, nurses, dentists, lawyers, professors, investment bankers, management consultants, bartenders, wait staff, bus boys, flight attendants, barbers, or beauticians. Many other services require in-person contact between an object and the practitioner, such as grocery cashiers, grocery baggers, parking lot attendants, valet parkers, auto repair, lawn maintenance, restaurant chefs, hotel housekeepers, and almost every type of maintenance of homes and

[16] Ford engineers explained to a group of National Bureau of Economic Research economists (including this author) touring a plant in Lakewood, Ohio, on November 1, 1996, that the "marriage" would be the last operation in automobile assembly to be fully automated. In another tour with some of the same economists at the Toyota plant in Georgetown, Kentucky, on April 3, 1998, officials explained their aversion to automation and replacing humans with robots: "Our philosophy is *kaizan* (continuous self-improvement), and machines cannot *kaizan*."

machines. Computers are a relatively large share of capital in business, health, legal, and educational services, but in each of these the contribution of capital to productivity growth is relatively small. No matter how powerful the computer hardware and how user-friendly the software, most functions provided by personal computers, including word processing, spreadsheets, and database management, still require hands-on human contact to be productive, and that need for human contact creates diminishing returns for the productivity impact of the computer.

The Positive and Negative Sides of the Internet

The accelerated rate of price decline in computer attributes has been accompanied since 1995 by the invention of the Internet, by which I really mean the widespread public use of the web using web browsers. In perhaps the most rapid diffusion of any invention since television in the late 1940s and early 1950s, by the end of the year 2000 the percentage of American households hooked up to the Internet will have reached 50 percent.[17] Although the New Economy was defined at the beginning of this paper as the apparent acceleration around 1995 in the rate of technical progress in information technology broadly conceived, most of the optimistic interpretations of this development point to the Internet, or more specifically the invention of web browsers, as the central development that warrants calling the present era a new Industrial Revolution. In terms of the supply and demand diagram in Figure 2, it might seem that the Internet represents an expansion of possibilities that should shift the demand curve rightwards and raise consumer surplus substantially in exactly the same way that supermarkets and superhighways raised the consumer surplus associated with the invention of the automobile. But as noted earlier in the discussion of Figure 2, there is little evidence that the demand curve has shifted in this way. Why have the productivity effects of the Internet been so moderate?

A useful starting point is the way in which Barua et al. (1999) divide the "Internet economy" into four "layers:" 1) the Internet infrastructure layer; 2) the Internet applications layer; 3) the Internet intermediary layer; and 4) the Internet commerce layer. The first layer consists of hardware manufacturers, including IBM, Dell, HP, Cisco, Lucent, Sun, and many others, all included in either the computer hardware or telecommunications hardware industries. As we have seen above in Table 2, this sector accounts for the largest single component of the post-1995 productivity growth acceleration, both the direct effect of faster multifactor growth in computer hardware (including computer-related semiconductors) and the indirect capital-deepening effect of the investment boom in information technology.

[17] This projection is made by Henry Harteveldt, Senior Analyst at Forrester Research, in communications with the author. The misleading data of Cox and Alm (1999, Figure 8.1, p. 162) suggests that it took more than 25 years for television to reach 50 percent household penetration, but dating from the first commercial TV station in 1947 this penetration rate was reached in only seven years. See Kurian (1994, series R105 divided by A335).

There is little debate about the dynamism of this sector, but rather about the uses to which this exponentially exploding quantity of computer power is being put.

The second layer consists of software, consulting, and training, and includes such companies as Microsoft and its competitors. The impact of this sector is potentially substantial, since producers' durable equipment investment in software in 1999 was $143.3 billion, almost 50 percent larger than such investment in computer and peripheral hardware. The main debate concerning the productivity of this layer is whether the BEA software deflators decline too slowly to capture the increased capability of the software being produced as part of this massive investment effort. However, as shown by Jorgenson and Stiroh (2000), the outcome of the debate over the software deflators has almost no impact on the question of how this sector of the Internet economy affects productivity in the rest of the economy. The reason is that using alternative software deflators with radically faster rates of price decline has two offsetting effects from the point of view of productivity calculations: capital inputs grow faster, but total output grows faster, too. Overall, there is more capital deepening and a higher share of the productivity acceleration accounted for by the software industry, but no change in any conclusions about spillovers from software to the rest of the economy.

The third and fourth layers of the Internet economy consist of providers of intermediate goods and consumption goods. Many aggregators, portals, and content providers, like Yahoo and Travelocity, sell information and services both to business firms and to consumers. To the extent that e-commerce is provided by one business to another, it is an intermediate good and not directly relevant for computing the productivity of final output in the noncomputer economy. In this sense, we do not need to debate whether business-to-business e-commerce is a fruitful invention. If the development of more efficient links in the supply chain reduces costs and allows the elimination of people and paper in the chain of intermediate transactions, then we should see the payoff in faster productivity growth in the noncomputer economy. So far this payoff has appeared in other parts of durable manufacturing, but not in rest of the economy. Thus our primary remaining question concerns the benefits of the Internet economy in the provision of final goods.

The consumer benefits of the Internet are familiar. Perhaps the most important single consumer benefit at present, also now used universally within business firms, is e-mail. The use of the Internet for e-mail long predated the invention of web browsers, and the hardware and software requirements for straight e-mail, as opposed to e-commerce, are very small. The benefits of e-commerce also include the provision of vast amounts of free information that was formerly expensive or inconvenient to obtain, including travel and sports schedules, hotel descriptions, maps, directions, news, security prices, and even entire encyclopedias. When items are purchased over the web rather than obtained for free, selection is often much better than at traditional bricks and mortar stores, and prices even net of shipping costs are often lower. Auctions on sites like e-Bay provide a new mechanism that allows the flea market to spread from local communities and neighborhoods to a worldwide community of potential buyers and sellers. According to Smith, Bailey and Brynjolfsson (1999), "[E]arly research suggests that electronic markets are more efficient than conventional markets with respect to price levels, menu costs, and price elasticity . . . although several studies find significant price dispersion in Internet markets."

If e-commerce contributes to holding down prices of goods traded in the noncomputer part of the economy, then this will provide an additional factor holding down inflation in addition to the direct impact of the falling prices of computer hardware discussed earlier. However, the low prices of many consumer web vendors have resulted in unsustainable financial losses financed temporarily—but surely not permanently!—by venture capitalists and stockholders. In 1999, it was common for well-known e-commerce companies to have losses that were 20 percent, 50 percent, or even more than 100 percent of sales revenues (Bulkeley and Carlton, 2000, p. A4). It remains to be seen how much the web reduces consumer prices once stockholders begin to require that e-commerce vendors actually earn profits (Byron, 2000).

The enormous variety of products and services available on the Internet, both for free and for pay, might seem to be an invention worthy of comparison with the great inventions of the past. Yet the mere fact that new products and services are being developed is not sufficient for an Industrial Revolution, which requires that the extent of improvements must be greater than in the past. In Triplett's insightful critique (1999, pp. 326–27), the enthusiastic retelling of anecdotes about the New Economy ignores the distinction between arithmetic numbers and logarithmic growth rates. If an economy has 10 products and invents a new one, the growth rate is 10 percent. If many years later the economy has 100 products, it must invent 10 new ones to grow at the same rate and invent 12 or 13 to register a significant increase in the growth rate. Today's U.S. real GDP is more than 40 times greater than in 1880, but does anyone think that today we are inventing 40 times as many important products as in the few decades that yielded the invention of electricity, the telephone, motion pictures, the phonograph, the indoor toilet, and the many others discussed above? No current development in communications has achieved a change in communication speed comparable to the telegraph, which between 1840 and 1850 reduced elapsed time per word transmitted by a factor of 3000 (from 10 days to 5 minutes for a one-page message between New York and Chicago), and the cost by a factor of 100 (Sichel, 1997, p. 127). The excitement of today's web access, taken in historical perspective, does not measure up to the first live electronic contact with the outside world achieved as radio spread in the early 1920s and television in the late 1940s.

The contribution of the Internet to productivity is not the same as its contribution to consumer welfare. For consumers, the new combination of home personal computers and web access provides a valuable invention: Why else would Internet access reach a 50 percent household penetration rate only six years after the invention of web browsers? But here again, as for computers in general, the vast variety of Internet products collides with the fixed quantity of time available to each household member. Inevitably, much Internet use represents a substitution from other forms of entertainment. Internet games replace hand-held games. Downloaded Internet music replaces purchased CDs. Internet pornography replaces purchased or rented adult videos. Other forms of Internet entertainment and surfing for information replace hours previously spent watching television, reading books, or shopping. New evidence of diminishing returns is now emerging. Use of personal computers and of the Internet is declining among newer purchasers who paid less for their machines and appear to value them less, and apparently only two-thirds of computer owners who subscribe to Internet services actually use them (Clark, 1999). As Herbert Simon once said: "A wealth of information creates a poverty of attention."[18]

The essential question raised by the earlier productivity decomposition is to explain why the New Economy in general and the Internet in particular have failed to boost multifactor productivity growth outside of the durable manufacturing sector. What explains the apparent contradiction between this unimpressive productivity performance and the eagerness with which millions of business firms and consumers have purchased business and home computers, as well as Internet infrastructure, spawning whole new industries and creating vast wealth? This conflict is highlighted by findings in microeconomic cross-section studies, discussed by Brynjolfsson and Hitt in this symposium, that the gross rate of return on investment in computers substantially exceeds investments in other areas.

At least four factors may play a role in resolving the conflict: market-share protection, recreation of old activities rather than creation of new activities, duplicative activity, and consumption on the job.

First, the need to protect market share against competitors explains much of the investment and maintenance expense of websites. Barnes and Noble and Borders would have been content to play a dominant role in the retailing of books, but were forced by competition from Amazon to become "clicks and mortar" organizations by developing their own websites that duplicated much of their previous retail activity and most of what Amazon had already pioneered. More generally, computers are used extensively to provide information aimed at taking customers, profits, or capital gains away from other companies. This is a zero-sum game involving redistribution of wealth rather than the increase of wealth, yet each individual firm has a strong incentive to make computer investments that, if they do not snatch wealth away from someone else, at least act as a defensive blockade against a hostile attack. This may be at the heart of the apparent contradiction between the Brynjolfsson-Hitt micro evidence on the high returns to computer investment and the failure of computers to spark a productivity growth revival outside of durable manufacturing; the high payoff to computers for individual firms may reflect redistributions to computer-using firms from firms that use computers less intensively. There is a "keeping up with the Joneses" aspect of

[18] This quotation was related to me by Hal Varian.

hardware and software purchase motivated by competition, employee satisfaction, and employee recruitment.[19]

Second, much Internet content is not truly new, but rather consists of pre-existing forms of information now made available more cheaply and conveniently. Internet surfing of airline schedules provides a lower cost, although not necessarily faster, method of obtaining information already available in airline timetables, from the printed Official Airline Guide, and from travel agents. Obtaining stock quotes and performing trades on the web does not represent the invention of a new activity but rather a reduction in cost of performing an old activity. In contrast, the great inventions of the late nineteenth century created truly new products and activities.

A third factor subtracting from productivity is the duplicative aspect of the Internet. Much e-commerce is an alternative to mail-order catalog shopping (another invention of the 1870s, whose development is summarized in Gordon, 1990, pp. 419–23). Just as Wanamaker's and Macy's department stores began to issue catalogs to supplement their existing retail operations in the early 1870s, so currently Land's End, Spiegel's, and many other catalog operators have supplemented their existing operations with websites in the late 1990s. Yet the catalogs have not disappeared; the full cost of printing and mailing the catalogs is still incurred, but on top of that must be expended many millions on developing and maintaining duplicative websites. While it is cheaper to take an order from a web customer than with a human worker answering a phone, much of the rest of the transaction involves the same physical input of labor in building and stocking warehouses, selecting items from warehouse shelves, packing them, and shipping them. The brown UPS trucks are thriving with e-commerce, but each truck still requires one driver. In fact, far from reducing or eliminating the use of paper, the electronic age seems to multiply paper. As the president of one dot-com recently said: "For getting attention in a professional way, paper still matters. Nobody even asks anymore if paper is going away."[20]

An example closer to home for economists is the added cost to academic societies of developing websites to provide information already available in their printed journals. The Econometric Society now provides duplicate announcements of most of its activities through the back pages of its journal and through its website, and it like other societies is under increasing pressure to provide the contents of its journal and even papers given at its regional meetings to its members on the web without any additional fee. It costs money to develop and maintain these websites. Economists gain a consumer surplus in having more convenient access to research, but convenience for professors is not a final

[19] There seems to be a deeper contradiction between the macro and micro evidence that has not yet been resolved. For instance, in a study of multifactor productivity growth and computer capital across a number of industries, Stiroh (1998) finds: "For all computer-using sectors . . . the average growth rate of multifactor productivity fell while [computer] capital grew."

[20] The speaker is the president of NowDocs.com, as quoted by Doan (2000, p. 140). On the growth in paper usage, see also "Bad News for Trees" (1998).

good. The final product, education and research, is affected little if at all by the ease of access of references.[21]

Finally, productivity on the job may be impaired by the growing use of business computers with continuous fast web access for consumption purposes. One research service found that people spend more than twice as much time online at the office as they do at home, and that web users at the office take advantage of high-speed connections to access entertainment sites more frequently at work than at home. In fact the most-visited site from the office is eBay, and three financial trading sites are not far behind (Farrell, 2000, p. A1). The media have gleefully reported that a large fraction of on-line equity trading is happening at the office, not at home (for instance, Bennett, 2000; "Workers Leaving Water Cooler for Internet," 1999). Employers are so disturbed by the continuing use of office computers for personal e-mail that the number of companies using "surveillance software" to monitor their employees' e-mail usage is "soaring" (Guernsey, 2000, p. C1).

A final response from the New Economy optimists to the skeptics is that computers have added greatly to output, but that many of the benefits of computers have been mismeasured. While it is doubtless true that certain benefits of the current technology are not fully captured in national income accounts, a great many of the benefits should be captured. The heaviest uses of computers are in industries that provide mainly or entirely intermediate goods, especially wholesale trade, finance, many parts of the insurance industry, business services, and legal services. If computers truly raised the output of these intermediate industries in unmeasured ways, then the benefits should show up in the output of final goods industries that exhibit higher output in relation to their undermeasured inputs. Yet this spillover from intermediate to final goods industries is just what cannot be found in the official data on output and productivity growth, at least outside of the durable manufacturing sector.

Moreover, the presence of unmeasured outputs is certainly not new. Personal computers and the Internet have doubtless created consumer surplus, but so did most of the great inventions of the past. Indeed, it is quite plausible that the additional consumer surplus from present technologies is less than the amount from diffusion of the great inventions during the golden age of productivity growth from about 1913 to 1972.

Conclusion

The New Economy, defined as the post-1995 acceleration in the rate of technical change in information technology together with the development of the

[21] In a related investigation of the payoff for academic research of information technology, Hamermesh and Oster (1997) find that articles with co-authors working at long distance from each other actually have fewer citations than other articles; that is, "a greater ease of overcoming distance does not enhance productivity" (p. 18). They interpret the rise in long-distance co-authorship as mainly a consumption good as academic friends find it easier to work together.

Internet, has been both a great success and a profound disappointment. The New Economy has created a dynamic explosion of productivity growth in the durable manufacturing sector, both in the manufacturing of computers and semiconductors and of other types of durables. This productivity explosion has boosted the economy's rate of productivity growth and created enormous wealth in the stock market. Also, by helping to hold down inflationary pressures in the last few years, the New Economy allowed the Federal Reserve to postpone the tightening of monetary policy for several years in the face of a steadily declining unemployment rate. However, the New Economy has meant little to the 88 percent of the economy outside of durable manufacturing; in that part of the economy, trend growth in multifactor productivity has actually *decelerated*, despite a massive investment boom in computers and related equipment.

The fundamental limitation on the contribution to productivity of computers in general and the Internet in particular occurs because of the tension between rapid exponential growth in computer speed and memory on the one hand and the fixed endowment of human time. Most of the initial applications of mainframe and personal computers have encountered the rapid onset of diminishing returns. Much of the use of the Internet represents a substitution from one type of entertainment or information-gathering for another.

In assessing the importance of the New Economy and the Internet as an invention, we have applied a tough test. To measure up, the New Economy had to equal the great inventions that constitute what has been called the Second Industrial Revolution. Internet surfing may be fun and even informational, but it represents a far smaller increment in the standard of living than achieved by the extension of day into night achieved by electric light, the revolution in factory efficiency achieved by the electric motor, the flexibility and freedom achieved by the automobile, the saving of time and shrinking of the globe achieved by the airplane, the new materials achieved by the chemical industry, the first sense of live two-way communication achieved by the telephone, the arrival of live news and entertainment into the family parlor achieved by radio and then television, and the enormous improvements in life expectancy, health, and comfort achieved by urban sanitation and indoor plumbing.

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References

"Bad News for Trees." 1998. *Economist.* December 19, pp. 123–26.

Barua, Anitesh, Jon Pennell, Jay Shutter and Andrew B. Whinston. 1999. "Measuring the Internet Economy: An Exploratory Study." Working paper, June 10. Updated versions available at ⟨http://crec.bus.uteexas.edu⟩.

Basu, Susanto. 1996. "Procyclical Productivity: Increasing Returns or Cyclical Utilization?" *Quarterly Journal of Economics.* 111:4, pp. 719–51.

Becker, Gary S. 1965. "A Theory of the Allocation of Time." *Economic Journal.* 75:3, pp. 493–517.

Bennett, Johanna. 2000. "Placing Stock Trades While at the Office Adds a Little Risk." *Wall Street Journal.* March 15, p. B10D.

Bettmann, Otto L. 1974. *The Good Old Days—They Were Terrible!* New York: Random House.

Bresnahan, Timothy F. and Robert J. Gordon, eds. 1997. *The Economics of New Goods.* Chicago: University of Chicago Press for NBER.

Brynjolfsson, Erik. 1996. "The Contribution of Information Technology to Consumer Welfare." *Information Systems Research.* September, 7:3, pp. 281–300.

Brynjolfsson, Erik and Lorin M. Hitt. 1996. "Paradox Lost? Firm-level Evidence on the Returns to Information Systems Spending." *Management Science.* April 42:4, pp. 541–58.

Brynjolfsson, Erik, Lorin M. Hitt and Shinkyu Yang. 2000. "Intangible Assets: How the Interaction of Computers and Organizational Structure Affects Stock Market Valuations," presented at AEA meetings, Boston, January.

Bulkeley, William M. and Jim Carlton. 2000. "E-Tail Gets Derailed, How Web Upstarts Misjudged the Game." *Wall Street Journal.* April 5, pp. A1, A4.

Bunch, Bryan and Alexander Hellemans. 1993. *The Timetables of Technology: A Chronology of the Most Important People and Events in the History of Technology.* New York: Touchstone.

Byron, Christopher. 2000. "Balance Due: In the Hunt for Elusive Profits, Consumer Web Sites will be the First Casualties." *Fortune.* February 21, pp. 104–8.

Checkland, S. G. 1987. "Industrial Revolution," in *The New Palgrave: A Dictionary of Economics.* John Eatwell, Murray Milgate and Peter Newman, eds. London: Macmillan, pp. 811–15.

Chow, Gregory C. 1967. "Technological Change and the Demand for Computers.'' *American Economic Review.* December 57, pp. 1117–1130.

Clark, Don. 1999. "Survey Finds PC Usage in Homes Has Dropped." *Wall Street Journal.* June 21, p. B7.

Cortada, James W. 1993. *Before the Computer: IBM, NCR, Burroughs, and Remington Rand and the Industry They Created, 1865–1956.* Princeton: Princeton University Press.

Cox, W. Michael and Richard Alm. 1999. *Myths of Rich and Poor.* New York: Basic Books.

David, Paul A. 1990. "The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox." *American Economic Review* (Papers and Proceedings), 80:2, pp. 355–61.

Denison, Edward F. 1962. *The Sources of Economic Growth in the United States and the Alternatives Before Us.* New York: Committee for Economic Development, Supplementary Paper no. 13.

Doan, Amy. 2000. "Paper Boy." *Forbes.* February 21, p. 140.

Dudley, Leonard. 1999. "Communications and Economic Growth." *European Economic Review.* 43, pp. 595–619.

Farrell, Greg. 2000. "Online Time Soars at Office; Not All Surfing Work-Related." *USA Today.* February 18, p. A1.

Flamm, Kenneth. 1997. *More for Less: The Economic Impact of Semiconductors.* Washington: Semiconductor Industry Association, December.

Gordon, Robert J. 1990. *The Measurement of Durable Goods Prices.* Chicago: University of Chicago Press for NBER.

Gordon, Robert J. 1993. "The Jobless Recovery: Does It Signal a New Era of Productivity-Led Growth?" *Brookings Papers on Economic Activity.* 24:1, pp. 271–316.

Gordon, Robert J. 1997. "The Time-Varying NAIRU and its Implications for Economic Policy. *Journal of Economic Perspectives.* Winter, 11:1, pp. 11–32.

Gordon, Robert J. 1998. "Foundations of the Goldilocks Economy: Supply Shocks and the Time-Varying NAIRU." *Brookings Papers on Economic Activity.* 29:2, pp. 297–333.

Gordon, Robert J. 1999. "U.S. Economic Growth Since 1870: One Big Wave?" *American Economic Review* (Papers and Proceedings). 89:2, pp. 123–28.

Gordon, Robert J. 2000a. *Macroeconomics,* eighth edition. Reading MA: Addison-Wesley.

Gordon, Robert J. 2000b. "Interpreting the 'One Big Wave' in U.S. Long-term Productivity Growth," in *Productivity, Technology, and Economic Growth.* Bart van Ark, Simon Kuipers and Gerard

Kuper, eds. Amsterdam: Kluwer Publishers, forthcoming.

Gordon, Robert J. 2000c. "Has the New Economy Rendered the Productivity Slowdown Obsolete?" Unpublished working paper, Northwestern University, September.

Griliches, Zvi. 1960. "Measuring Inputs in Agriculture: A Critical Survey." *Journal of Farm Economics.* 42:5, pp. 1411–33.

Greenspan, Alan. 1999. "The American Economy in a World Context." At the 35th Annual Conference on Bank Structure and Competition, Federal Reserve Bank of Chicago, May 6, 1999, at ⟨http://www.federalreserve.gov/boarddocs/speeches/1999/19990506.htm⟩.

Guernsey, Lisa. 2000. "You've Got Inappropriate Mail: Monitoring of Office E-mail is Increasing," *New York Times.* April 5, pp. C1, C10.

Hamermesh, Daniel S. and Sharon M. Oster. 1997. "Tools or Toys? The Impact of High Technology on Scholarly Productivity." Manuscript, November.

Hultgren Thor. 1960. "Changes in Labor Cost During Cycles in Production and Business." Occasional Paper 74. New York: National Bureau of Economic Research.

Ip, Greg. 2000. "Market on a High Wire." *Wall Street Journal.* January 18, p. C1.

Jorgenson, Dale W. and Zvi Griliches. 1967. "The Explanation of Productivity Change." *Review of Economic Studies.* 34:3, pp. 249–83.

Jorgenson, Dale W. and Kevin J. Stiroh. 2000. "Raising the Speed Limit: U. S. Economic Growth in the Information Age." *Brookings Papers on Economic Activity.* 31:1, pp. 125–211.

Katz, Lawrence F. and Alan B. Krueger. 1999. "The High-Pressure U. S. Labor Market of the 1990s." *Brookings Papers on Economic Activity.* 30:1, pp. 1–65.

Kendrick, John. 1961. "Productivity Trends in the United States.'' Princeton: Princeton University Press for the NBER.

Kurian, George Thomas. 1994. *Datapedia of the United States, 1790–2000.* Lanham MD: Bernan Press.

McGuckin, Robert H. and Kevin J. Stiroh. 1998. "Computers Can Accelerate Productivity Growth." *Issues in Science and Technology.* Summer, pp. 41–48.

Mokyr, Joel. 1997. "Are We Living in the Middle of an Industrial Revolution?" *Federal Reserve Bank of Kansas City Economic Review.* Second Quarter, pp. 31–43.

Mokyr, Joel and Rebecca Stein. 1997. "Science, Health, and Household Technology: The Effect of the Pasteur Revolution on Consumer Demand," in *The Economics of New Goods.* Timothy F. Bresnahan and Robert J. Gordon, eds., pp. 143–200.

Nordhaus, William D. 1997. "Do Real-Output and Real-Wage Measures Capture Reality? The History of Lighting Suggests Not," in *The Economics of New Goods.* Timothy J. Bresnahan and Robert J. Gordon, eds., pp. 29–66.

Nordhaus, William D. 2000. "The Health of Nations: The Contribution of Improved Health to Living Standards," in *The Economic Value of Medical Research.* Kevin Murphy and Robert Topel, eds. Chicago: University of Chicago Press, forthcoming.

Oi, Walter Y. 1962. "Labor as a Quasi-Fixed Factor." *Journal of Political Economy.* December, 70:4, pp. 538–55.

Oi, Walter Y. 1997. "The Welfare Implications of Invention," in *The Economics of New Goods.* Timothy J. Bresnahan and Robert J. Gordon, eds., pp. 109–41.

Okun, Arthur M. 1962. "The Gap between Actual and Potential Output." *Proceedings of the American Statistical Association.* Reprinted in *Problems of the Modern Economy.* Edmund S. Phelps, ed. New York: Norton, 1965.

Oliner, Stephen D. and Daniel E. Sichel. 2000. "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?" Working paper, Federal Reserve Board, February.

Schlesinger, Jacob M. and Yochi J. Dreazen. 2000. "Inflation Shows Signs of Stirring as Forces Restraining it Wane." *Wall Street Journal.* April 17, p. A1.

Sichel, Daniel E. 1997. *The Computer Revolution: An Economic Perspective.* Washington: Brookings.

Smith, Michael D., Joseph Bailey and Erik Brynjolfsson. 1999. "Understanding Digital Markets: Review and Assessment," *Understanding the Digital Economy.* Erik Brynjolfsson and Brian Kahin, eds. Cambridge: MIT Press.

Staiger, Douglas, James H. Stock and Mark W. Watson. 1997. "The NAIRU, Unemployment, and Monetary Policy." *Journal of Economic Perspectives.* Winter, 11, pp. 33–49.

Stiroh, Kevin J. 1998. "Computers, Productivity and Input Substitution." *Economic Inquiry.* April, 36:2, pp. 175–91.

Triplett, Jack E. 1999. "The Solow Computer Paradox: What do Computers do to Productivity?" *Canadian Journal of Economics.* April, 32:2, pp. 309–34.

Uchitelle, Louis. 2000. "Economic View: Productivity Finally Shows the Impact of Computers." *New York Times.* March 12, section 3, p. 4.

Wildstrom, Stephen H. 1999. "Pentium III: Enough Already?" *Business Week.* March 22, p. 23.

"Workers Leaving Water Cooler for Internet." 1999. *New York Times.* May 20, p. A1.

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1. Md. Shahiduzzaman, Khorshed Alam. 2014. Information technology and its changing roles to economic growth and productivity in Australia. *Telecommunications Policy* **38**:2, 125-135. [CrossRef]
2. Marlies Van der Wee, Sofie Verbrugge, Bert Sadowski, Menno Driesse, Mario Pickavet. 2014. Identifying and quantifying the indirect benefits of broadband networks for e-government and e-business: A bottom-up approach. *Telecommunications Policy* . [CrossRef]
3. Elsadig Musa Ahmed, Rahim Ridzuan. 2013. The Impact of ICT on East Asian Economic Growth: Panel Estimation Approach. *Journal of the Knowledge Economy* **4**:4, 540-555. [CrossRef]
4. Harald Edquist. 2013. Can double deflation explain the ICT growth miracle?. *Economics Letters* **121**:2, 302-305. [CrossRef]
5. Jin-Liao He, Hans Gebhardt. 2013. Space of Creative Industries: A Case Study of Spatial Characteristics of Creative Clusters in Shanghai. *European Planning Studies* 1-18. [CrossRef]
6. Claudio Mattalia. 2013. Embodied technological change and technological revolution: Which sectors matter?. *Journal of Macroeconomics* **37**, 249-264. [CrossRef]
7. Kul B. Luintel, Mosahid Khan, Konstantinos Theodoridis. 2013. On the robustness of R&D. *Journal of Productivity Analysis* . [CrossRef]
8. Alain Herscovici. 2013. Economic Growth, Technical Progress and Labor Productivity. *International Journal of Innovation in the Digital Economy* **2**:1, 35-47. [CrossRef]
9. Fabio Canova, David Lopez-Salido, Claudio Michelacci. 2013. The Ins and Outs of Unemployment: An Analysis Conditional on Technology Shocks *. *The Economic Journal* **123**:569, 515-539. [CrossRef]
10. Hyun-Joon Jung, Kyoung-Youn Na, Chang-Ho Yoon. 2013. The role of ICT in Korea's economic growth: Productivity changes across industries since the 1990s. *Telecommunications Policy* **37**:4-5, 292-310. [CrossRef]
11. Alain HerscoviciEconomic Growth, Technical Progress and Labor Productivity 208-220. [CrossRef]
12. Robert C. Feenstra,, Benjamin R. Mandel,, Marshall B. Reinsdorf,, Matthew J. Slaughter. 2013. Effects of Terms of Trade Gains and Tariff Changes on the Measurement of US Productivity Growth. *American Economic Journal: Economic Policy* **5**:1, 59-93. [Abstract] [View PDF article] [PDF with links]
13. Baoline Chen, Peter A. Zadrozny. 2013. Further model-based estimates of US total manufacturing production capital and technology, 1949–2005. *Journal of Productivity Analysis* **39**:1, 61-73. [CrossRef]
14. Der-Fang Hung. 2013. Sustained Competitive Advantage and Organizational Inertia: The Cost Perspective of Knowledge Management. *Journal of the Knowledge Economy* . [CrossRef]
15. M. Cardona, T. Kretschmer, T. Strobel. 2013. ICT and productivity: conclusions from the empirical literature. *Information Economics and Policy* . [CrossRef]
16. Karen A. Murdock. 2012. Entrepreneurship policy: Trade-offs and impact in the EU. *Entrepreneurship & Regional Development* **24**:9-10, 879-893. [CrossRef]
17. Zhiqing Dong, Linhui Wang. 2012. The technical structure and origins of productivity growth: evidence from industry-level panel data of China's manufacturing industry. *Asian Journal of Technology Innovation* **20**:2, 257-275. [CrossRef]
18. Yen-Chun Chou, Benjamin B.M. Shao, Winston T. Lin. 2012. Performance evaluation of production of IT capital goods across OECD countries: A stochastic frontier approach to Malmquist index. *Decision Support Systems* **54**:1, 173-184. [CrossRef]
19. Geraldine Ryan, Edward ShinnickKnowledge and Intellectual Property Rights 1313-1320. [CrossRef]

20. Matthew Smith. 2012. The Coming of Age of Information Technologies and the Path of Transformational Growth. *Review of Political Economy* **24**:4, 663-665. [CrossRef]
21. Fredrik Eng-Larsson, Karl-Johan Lundquist, Lars-Olof Olander, Sten Wandel. 2012. Explaining the cyclic behavior of freight transport CO2-emissions in Sweden over time. *Transport Policy* **23**, 79-87. [CrossRef]
22. Nicholas Oulton. 2012. Long term implications of the ICT revolution: Applying the lessons of growth theory and growth accounting. *Economic Modelling* **29**:5, 1722-1736. [CrossRef]
23. Prasanna Tambe, Lorin M. Hitt. 2012. The Productivity of Information Technology Investments: New Evidence from IT Labor Data. *Information Systems Research* **23**:3-part-1, 599-617. [CrossRef]
24. Sumanjeet Singh. 2012. Digital Divide in India. *International Journal of Innovation in the Digital Economy* **1**:2, 1-24. [CrossRef]
25. Murillo Campello, John R. Graham. 2012. Do stock prices influence corporate decisions? Evidence from the technology bubble. *Journal of Financial Economics* . [CrossRef]
26. Kevin J. Lansing. 2012. Speculative growth, overreaction, and the welfare cost of technology-driven bubbles. *Journal of Economic Behavior & Organization* **83**:3, 461-483. [CrossRef]
27. Sumanjeet SinghDigital Divide in India 106-130. [CrossRef]
28. Aikaterini KokkinouInnovation Policy, Competitiveness, and Growth 854-868. [CrossRef]
29. Aikaterini KokkinouInnovation Policy, Competitiveness, and Growth 854-868. [CrossRef]
30. P.W. Daniels. 2012. Service industries at a crossroads: some fragile assumptions and future challenges. *The Service Industries Journal* **32**:4, 619-639. [CrossRef]
31. Landon Kleis, Paul Chwelos, Ronald V. Ramirez, Iain Cockburn. 2012. Information Technology and Intangible Output: The Impact of IT Investment on Innovation Productivity. *Information Systems Research* **23**:1, 42-59. [CrossRef]
32. Richard G Anderson, Kevin L Kliesen. 2012. How Does the FOMC Learn About Economic Revolutions? Evidence from the New Economy Era, 1994–2001. *Business Economics* **47**:1, 27-56. [CrossRef]
33. Jeff E. BiddleAir Conditioning, Migration, and Climate-Related Wage and Rent Differentials **28**, 1-41. [CrossRef]
34. Kunsoo Han, Robert J. Kauffman, Barrie R. Nault. 2011. Research Note —Returns to Information Technology Outsourcing. *Information Systems Research* **22**:4, 824-840. [CrossRef]
35. Hwan-Joo Seo, Young Soo Lee, HanSung Kim. 2011. The determinants of export market performance in OECD service industries. *The Service Industries Journal* 1-12. [CrossRef]
36. Ryo Horii. 2011. Wants and past knowledge: Growth cycles with emerging industries. *Journal of Economic Dynamics and Control* . [CrossRef]
37. Andrea Ollo-López, M. Elena Aramendía-Muneta. 2011. ICT impact on competitiveness, innovation and environment. *Telematics and Informatics* . [CrossRef]
38. Sophia P. Dimelis, Sotiris K. Papaioannou. 2011. Technical Efficiency and the Role of ICT: A Comparison of Developed and Developing Countries. *Emerging Markets Finance and Trade* **47**:0, 40-53. [CrossRef]
39. S. Moshiri, W. Simpson. 2011. Information technology and the changing workplace in Canada: firm-level evidence. *Industrial and Corporate Change* . [CrossRef]
40. Seo Hwan-Joo, Lee Young Soo, Kim HanSung. 2011. Does international specialization in producer services warrant sustainable growth?. *The Service Industries Journal* **31**:8, 1279-1291. [CrossRef]
41. O. Ejermo, A. Kander. 2011. Swedish business research productivity. *Industrial and Corporate Change* . [CrossRef]

42. Wensheng Kang. 2011. Housing price dynamics and convergence in high-tech metropolitan economies. *The Quarterly Review of Economics and Finance* . [CrossRef]

43. Nina Czernich, Oliver Falck, Tobias Kretschmer, Ludger Woessmann. 2011. Broadband Infrastructure and Economic Growth*. *The Economic Journal* **121**:552, 505-532. [CrossRef]

44. Harald Edquist. 2011. CAN INVESTMENT IN INTANGIBLES EXPLAIN THE SWEDISH PRODUCTIVITY BOOM IN THE 1990s?. *Review of Income and Wealth* no-no. [CrossRef]

45. Sonali Bhattacharya. 2011. Innovation in India: A Path to Knowledge Economy. *Journal of the Knowledge Economy* . [CrossRef]

46. Anja Lambrecht, Katja Seim, Catherine Tucker. 2011. Stuck in the Adoption Funnel: The Effect of Interruptions in the Adoption Process on Usage. *Marketing Science* **30**:2, 355-367. [CrossRef]

47. Esteban Alfaro Cortés, José-Luis Alfaro Navarro. 2011. Do ICT Influence Economic Growth and Human Development in European Union Countries?. *International Advances in Economic Research* **17**:1, 28-44. [CrossRef]

48. Laure Turner, Herve Boulhol. 2011. Recent trends and structural breaks in the US and EU15 labour productivity growth. *Applied Economics* 1-16. [CrossRef]

49. Wensheng KangMissing-Data Imputation in Nonstationary Panel Data Models **27**, 235-251. [CrossRef]

50. Simon van Norden. 2011. Current trends in the analysis of Canadian productivity growth. *The North American Journal of Economics and Finance* **22**:1, 5-25. [CrossRef]

51. Concetta Castiglione. 2011. Technical efficiency and ICT investment in Italian manufacturing firms. *Applied Economics* 1-15. [CrossRef]

52. Erdal Aydin, Semih Kavaklioglu. 2011. A Study of Superiority of E-Trade Compared to Traditional Methods of Commerce in Overcoming Crises: Case Study of kitapix.com. *Procedia - Social and Behavioral Sciences* **24**, 123-137. [CrossRef]

53. Linda S. Niehm, Keila Tyner, Mack C. Shelley, Margaret A. Fitzgerald. 2010. Technology Adoption in Small Family-Owned Businesses: Accessibility, Perceived Advantage, and Information Technology Literacy. *Journal of Family and Economic Issues* **31**:4, 498-515. [CrossRef]

54. Douglas Cumming, Sofia Johan. 2010. The Differential Impact of the Internet on Spurring Regional Entrepreneurship. *Entrepreneurship Theory and Practice* **34**:5, 857-883. [CrossRef]

55. Elsadig Musa Ahmed. 2010. Information and Communications Technology Effects on East Asian Productivity. *Journal of the Knowledge Economy* **1**:3, 191-201. [CrossRef]

56. Sonali Bhattacharya. 2010. Knowledge Economy in India: Challenges and Opportunities. *Journal of Information & Knowledge Management* **09**:03, 203-225. [CrossRef]

57. Simon Commander, Rupert Harrison, Naercio Menezes-Filho. 2010. ICT and Productivity in Developing Countries: New Firm-Level Evidence from Brazil and India. *Review of Economics and Statistics* 110301164542093. [CrossRef]

58. Liming Wang, Jinghai Zheng. 2010. China and the changing landscape of the world economy. *Journal of Chinese Economic and Business Studies* **8**:3, 203-214. [CrossRef]

59. Geraldine Ryan, Edward ShinnickKnowledge and Intellectual Property Rights 489-496. [CrossRef]

60. Saida Habhab-RaveThe Policy of Uses of ICTs in Developing Countries 745-762. [CrossRef]

61. HARALD EDQUIST. 2010. Does hedonic price indexing change our interpretation of economic history? Evidence from Swedish electrification. *The Economic History Review* **63**:2, 500-523. [CrossRef]

62. Ky-hyang Yuhn, Seung R. Park. 2010. Information Technology, Organizational Transformation and Productivity Growth: An Examination of the Brynjolfsson-Hitt Proposition. *Asian Economic Journal* **24**:1, 87-108. [CrossRef]

63. Sophia P Dimelis, Sotiris K Papaioannou. 2010. FDI and ICT Effects on Productivity Growth: A Comparative Analysis of Developing and Developed Countries. *European Journal of Development Research* **22**:1, 79-96. [CrossRef]

64. Bernard C. Beaudreau. 2010. The dynamo and the computer: an engineering perspective on the modern productivity paradox. *International Journal of Productivity and Performance Management* **59**:1, 7-17. [CrossRef]

65. B. Charlene Henderson, Kevin Kobelsky, Vernon J. Richardson, Rodney E. Smith. 2010. The Relevance of Information Technology Expenditures. *Journal of Information Systems* **24**:2, 39. [CrossRef]

66. Davide Gualerzi, Edward Nell. 2010. Transformational Growth in the 1990s: Government, Finance and High-tech. *Review of Political Economy* **22**:1, 97-117. [CrossRef]

67. Shane GreensteinInnovative Conduct in Computing and Internet Markets **1**, 477-537. [CrossRef]

68. Francesco Venturini. 2009. The long-run impact of ICT. *Empirical Economics* **37**:3, 497-515. [CrossRef]

69. Richard R. John. 2009. Who Were the Gilders? And Other Seldom-Asked Questions about Business, Technology, and Political Economy in the United States, 1877–1900. *The Journal of the Gilded Age and Progressive Era* **8**:04, 474-480. [CrossRef]

70. Mark Setterfield. 2009. An index of macroeconomic performance. *International Review of Applied Economics* **23**:5, 625-649. [CrossRef]

71. Ian Keay. 2009. Resource Specialization and Economic Performance: A Canadian Case Study, 1970–2005. *Canadian Public Policy* **35**:3, 291-313. [CrossRef]

72. Elena Ketteni. 2009. Information technology and economic performance in U.S industries. *Canadian Journal of Economics/Revue canadienne d'économique* **42**:3, 844-865. [CrossRef]

73. Roya (Roghieh) Gholami, Xiaojia Guo, M $^{\rm a}$. Dolores AÑÓn HigÓn, Sang-Yong Tom Lee. 2009. Information and Communications Technology (ICT) International Spillovers. *IEEE Transactions on Engineering Management* **56**:2, 329-340. [CrossRef]

74. Christopher H. Wheeler. 2009. Technology and industrial agglomeration: Evidence from computer usage. *Papers in Regional Science* **88**:1, 43-62. [CrossRef]

75. Neeraj Mittal, Barrie R. Nault. 2009. Research Note —Investments in Information Technology: Indirect Effects and Information Technology Intensity. *Information Systems Research* **20**:1, 140-154. [CrossRef]

76. Jessica Crowe. 2008. Economic Development in the Nonmetropolitan West: The Influence of Built, Natural, and Social Capital. *Community Development* **39**:4, 51-70. [CrossRef]

77. STEVEN PENNINGS, ROD TYERS. 2008. Increasing Returns, Financial Capital Mobility and Real Exchange Rate Dynamics*. *Economic Record* **84**, S141-S158. [CrossRef]

78. Nathalie Chusseau, Michel Dumont, Joël Hellier. 2008. EXPLAINING RISING INEQUALITY: SKILL-BIASED TECHNICAL CHANGE AND NORTH–SOUTH TRADE. *Journal of Economic Surveys* **22**:3, 409-457. [CrossRef]

79. R. R. John. 2008. Telecommunications. *Enterprise and Society* **9**:3, 507-520. [CrossRef]

80. Alice Shiu, Pun-Lee Lam. 2008. Causal Relationship between Telecommunications and Economic Growth in China and its Regions. *Regional Studies* **42**:5, 705-718. [CrossRef]

81. RAOUF BOUCEKKINE, PATRICIA CRIFO. 2008. HUMAN CAPITAL ACCUMULATION AND THE TRANSITION FROM SPECIALIZATION TO MULTITASKING. *Macroeconomic Dynamics* **12**:03. . [CrossRef]

82. Jinghai Zheng. 2008. On Chinese productivity studies. *Journal of Chinese Economic and Business Studies* **6**:2, 109-119. [CrossRef]
83. Robert Hutchinson. 2008. Knowledge and Control: A Marxian Perspective on the Productivity Paradox of Information Technology. *Rethinking Marxism* **20**:2, 288-304. [CrossRef]
84. Michelle C. Baddeley. 2008. STRUCTURAL SHIFTS IN UK UNEMPLOYMENT 1979–2005: THE TWIN IMPACTS OF FINANCIAL DEREGULATION AND COMPUTERIZATION. *Bulletin of Economic Research* **60**:2, 123-157. [CrossRef]
85. K. Stiroh. 2008. Information Technology and Productivity: Old Answers and New Questions. *CESifo Economic Studies* **54**:3, 358-385. [CrossRef]
86. 2008. Book Reviews. *Journal of Economic Literature* **46**:1, 151-193. [Abstract] [View PDF article] [PDF with links]
87. Harald Hagemann. 2008. Consequences of the new information and communication technologies for growth, productivity and employment. *Competitiveness Review: An International Business Journal incorporating Journal of Global Competitiveness* **18**:1/2, 57-69. [CrossRef]
88. ROBERT INKLAAR. 2007. Cyclical Productivity in Europe and the United States: Evaluating the Evidence on Returns to Scale and Input Utilization. *Economica* **74**:296, 822-841. [CrossRef]
89. ISSOUF SOUMARÉ. 2007. EQUILIBRIUM WITH EXCESSIVE HOLDINGS CONSTRAINT: AN APPLICATION TO DC PENSION PLANS. *International Journal of Theoretical and Applied Finance* **10**:07, 1159-1190. [CrossRef]
90. R EDGE, T LAUBACH, J WILLIAMS. 2007. Learning and shifts in long-run productivity growth#. *Journal of Monetary Economics* **54**:8, 2421-2438. [CrossRef]
91. James A. Kahn, Robert W. Rich. 2007. Tracking the new economy: Using growth theory to detect changes in trend productivity#. *Journal of Monetary Economics* **54**:6, 1670-1701. [CrossRef]
92. Sunil Mithas, Jonathan Whitaker. 2007. Is the World Flat or Spiky? Information Intensity, Skills, and Global Service Disaggregation. *Information Systems Research* **18**:3, 237-259. [CrossRef]
93. Zhuo (June) Cheng, Barrie R. Nault. 2007. Industry Level Supplier-Driven IT Spillovers. *Management Science* **53**:8, 1199-1216. [CrossRef]
94. J MADSEN. 2007. Technology spillover through trade and TFP convergence: 135 years of evidence for the OECD countries#. *Journal of International Economics* **72**:2, 464-480. [CrossRef]
95. Anna Giunta, Francesco Trivieri. 2007. Understanding the determinants of information technology adoption: evidence from Italian manufacturing firms. *Applied Economics* **39**:10, 1325-1334. [CrossRef]
96. Z MENG, S LEE. 2007. The value of IT to firms in a developing country in the catch-up process: An empirical comparison of China and the United States. *Decision Support Systems* **43**:3, 737-745. [CrossRef]
97. Alexander J. Field. 2007. The origins of US total factor productivity growth in the golden age. *Cliometrica* **1**:1, 63-90. [CrossRef]
98. Ian Keay. 2007. The Engine or the Caboose? Resource Industries and Twentieth-Century Canadian Economic Performance. *The Journal of Economic History* **67**:01. . [CrossRef]
99. Barry L. Bayus, Wooseong Kang, Rajshree Agarwal. 2007. Creating Growth in New Markets: A Simultaneous Model of Firm Entry and Price. *Journal of Product Innovation Management* **24**:2, 139-155. [CrossRef]
100. K MOTOHASHI. 2007. Firm-level analysis of information network use and productivity in Japan. *Journal of the Japanese and International Economies* **21**:1, 121-137. [CrossRef]
101. Orlando Gomes. 2007. Investment in organizational capital. *Managerial and Decision Economics* **28**:2, 107-113. [CrossRef]

102. Andrew Atkeson, Patrick J. Kehoe. 2007. Modeling the Transition to a New Economy: Lessons from Two Technological Revolutions. *American Economic Review* **97**:1, 64-88. [Abstract] [View PDF article] [PDF with links]
103. Francesco Daveri, Andrea Mascotto. 2006. THE IT REVOLUTION ACROSS THE UNITED STATES. *Review of Income and Wealth* **52**:4, 569-602. [CrossRef]
104. Marcin Piatkowski. 2006. Can Information and Communication Technologies Make a Difference in the Development of Transition Economies?. *Information Technologies and International Development* **3**:1, 39-53. [CrossRef]
105. David L. Dickinson. 2006. On-the-job leisure as a cause of asymmetric observed-effort distributions. *Managerial and Decision Economics* **27**:6, 435-444. [CrossRef]
106. Kenneth Carlaw, Les Oxley, Paul Walker, David Thorns, Michael Nuth. 2006. BEYOND THE HYPE: INTELLECTUAL PROPERTY AND THE KNOWLEDGE SOCIETY/KNOWLEDGE ECONOMY. *Journal of Economic Surveys* **20**:4, 633-690. [CrossRef]
107. Ana Aizcorbe. 2006. Why Did Semiconductor Price Indexes Fall So Fast in the 1990s? A Decomposition. *Economic Inquiry* **44**:3, 485-496. [CrossRef]
108. Jonathan Perraton. 2006. Heavy Constraints on a "Weightless World"?. *American Journal of Economics and Sociology* **65**:3, 641-691. [CrossRef]
109. Elsadig Musa Ahmed. 2006. ICT and Human Capital Role in Achieving Knowledge-Based Economy: Applications on Malaysia's Manufacturing. *Journal of Information & Knowledge Management* **05**:02, 117-128. [CrossRef]
110. Shyamal K. Chowdhury. 2006. Investments in ICT-capital and economic performance of small and medium scale enterprises in East Africa. *Journal of International Development* **18**:4, 533-552. [CrossRef]
111. ALEXANDER J. FIELD. 2006. Technological Change and U.S. Productivity Growth in the Interwar Years. *The Journal of Economic History* **66**:01. . [CrossRef]
112. Raouf Boucekkine, Blanca Martinez, Cagri Saglam. 2006. The Development Problem under Embodiment. *Review of Development Economics* **10**:1, 42-58. [CrossRef]
113. Robert W. Fairlie. 2006. The Personal Computer and Entrepreneurship. *Management Science* **52**:2, 187-203. [CrossRef]
114. Harald Edquist, Magnus HenreksonTechnological Breakthroughs and Productivity Growth **24**, 1-53. [CrossRef]
115. ELLIS CONNOLLY, KEVIN J. FOX. 2006. THE IMPACT OF HIGH-TECH CAPITAL ON PRODUCTIVITY: EVIDENCE FROM AUSTRALIA. *Economic Inquiry* **44**:1, 50-68. [CrossRef]
116. A MASHAL. 2006. Impact of Investment in Information Technology on Bank Productivity and Profitability: Evidence from Jordan. *Research in Accounting in Emerging Economies* **7**, 245-257. [CrossRef]
117. Lois Labrianidis, Thanassis Kalogeressis. 2006. The digital divide in Europe's rural enterprises. *European Planning Studies* **14**:1, 23-39. [CrossRef]
118. Chinkook Lee. 2005. Information Technology for the Food Manufacturing Industry. *Journal of International Food & Agribusiness Marketing* **17**:2, 165-193. [CrossRef]
119. Alfred Kleinknecht, C.W.M. Naastepad. 2005. The Netherlands: Failure of a neo-classical policy agenda. *European Planning Studies* **13**:8, 1193-1203. [CrossRef]
120. Robert Inklaar, Mary O'Mahony, Marcel Timmer. 2005. ICT AND EUROPE's PRODUCTIVITY PERFORMANCE: INDUSTRY-LEVEL GROWTH ACCOUNT COMPARISONS WITH THE UNITED STATES. *Review of Income and Wealth* **51**:4, 505-536. [CrossRef]

121. Mary O'Mahony, Michela Vecchi. 2005. Quantifying the Impact of ICT Capital on Output Growth: A Heterogeneous Dynamic Panel Approach. *Economica* **72**:288, 615-633. [CrossRef]
122. Ajit Singh, Jack Glen, Ann Zammit, Rafael De-Hoyos, Alaka Singh, Bruce Weisse. 2005. Shareholder Value Maximisation, Stock Market and New Technology: Should the US Corporate Model be the Universal Standard? 1. *International Review of Applied Economics* **19**:4, 419-437. [CrossRef]
123. E OZ. 2005. Information technology productivity: in search of a definite observation. *Information & Management* **42**:6, 789-798. [CrossRef]
124. Andrea Micocci. 2005. Uncertainty in Market Economies. *International Review of Sociology* **15**:1, 35-49. [CrossRef]
125. Kym Thorne. 2005. Designing virtual organizations? Themes and trends in political and organizational discourses. *Journal of Management Development* **24**:7, 580-607. [CrossRef]
126. Andreas Hornstein, Per Krusell, Giovanni L. ViolanteChapter 20 The Effects of Technical Change on Labor Market Inequalities **1**, 1275-1370. [CrossRef]
127. Boyan Jovanovic, Peter L. RousseauChapter 18 General Purpose Technologies **1**, 1181-1224. [CrossRef]
128. Yvon Fauvel, Alain Guay, Alain Paquet. 2005. Les neuf vies de la courbe de Phillips américaine : réincarnations ou résilience ?. *L'Actualité économique* **81**:4, 665. [CrossRef]
129. Stephen D. Oliner, Daniel E. Sichel. 2005. Les technologies de l'information et la productivité : situation actuelle et perspectives d'avenir. *L'Actualité économique* **81**:1-2, 339. [CrossRef]
130. Gilbert Cette, Jacques Mairesse, Yusuf Kocoglu. 2005. Effets de la diffusion des technologies de l'information sur la croissance potentielle et observée. *L'Actualité économique* **81**:1-2, 203. [CrossRef]
131. Dean Parham. 2005. Les gains de productivité au moyen de l'usage des technologies de l'information : l'expérience australienne. *L'Actualité économique* **81**:1-2, 143. [CrossRef]
132. Dale W. JorgensonChapter 10 Accounting for Growth in the Information Age **1**, 743-815. [CrossRef]
133. Tim Dixon. 2005. The impact of information and communications technology on commercial real estate in the new economy. *Journal of Property Investment & Finance* **23**:6, 480-493. [CrossRef]
134. Tony Buxton, Gerry Kennally. 2004. Economic policy, the new economy and the social rate of return to R&D in UK manufacturing. *Economics of Innovation and New Technology* **13**:7, 655-670. [CrossRef]
135. Michael Devaney. 2004. Government Subsidized Academic Research: Economic and Ethical Conflicts. *Journal of Academic Ethics* **2**:3, 273-285. [CrossRef]
136. Walter W. Powell, Kaisa Snellman. 2004. The Knowledge Economy. *Annual Review of Sociology* **30**:1, 199-220. [CrossRef]
137. K Takase. 2004. The impact of IT investment on energy: Japan and US comparison in 2010. *Energy Policy* **32**:11, 1291-1301. [CrossRef]
138. Jaime Marquez. 2004. Productivity, investment, and current accounts: Reassessing the evidence. *Review of World Economics* **140**:2, 282-301. [CrossRef]
139. Arthur Diamond. 2004. Zvi Griliches's contributions to the economics of technology and growth. *Economics of Innovation and New Technology* **13**:4, 365-397. [CrossRef]
140. Dean Parham. 2004. Sources of Australia's Productivity Revival. *Economic Record* **80**:249, 239-257. [CrossRef]
141. George R G Clarke. 2004. Effect of Enterprise Ownership and Foreign Competition on Internet Diffusion in the Transition Economies. *Comparative Economic Studies* **46**:2, 341-370. [CrossRef]
142. Nirvikar SinghDigital Economy . [CrossRef]

143. Francesco Daveri, Olmo Silva. 2004. Not only Nokia: what Finland tells us about new economy growth. *Economic Policy* **19**:38, 117-163. [CrossRef]

144. P.W. DANIELS. 2004. Reflections on the "Old" Economy, "New" Economy, and Services. *Growth and Change* **35**:2, 115-138. [CrossRef]

145. C Gust. 2004. International comparisons of productivity growth: the role of information technology and regulatory practices. *Labour Economics* **11**:1, 33-58. [CrossRef]

146. A Razin. 2003. Trade openness, investment instability and terms-of-trade volatility. *Journal of International Economics* **61**:2, 285-306. [CrossRef]

147. Erik Brynjolfsson, Lorin M. Hitt. 2003. Computing Productivity: Firm-Level Evidence. *Review of Economics and Statistics* **85**:4, 793-808. [CrossRef]

148. Mark Setterfield, Kristen Leblond. 2003. The phillips curve and US macroeconomic performance during the 1990s. *International Review of Applied Economics* **17**:4, 361-376. [CrossRef]

149. Thomas N. Hubbard. 2003. Information, Decisions, and Productivity: On-Board Computers and Capacity Utilization in Trucking. *American Economic Review* **93**:4, 1328-1353. [Abstract] [View PDF article] [PDF with links]

150. Daniel V. Rainey, Kenneth L. Robinson, Ivye Allen, Ralph D. Christy. 2003. Essential Forms of Capital for Sustainable Community Development. *American Journal of Agricultural Economics* **85**:3, 708-715. [CrossRef]

151. Abdur Chowdhury. 2003. Information technology and productivity payoff in the banking industry: evidence from the emerging markets. *Journal of International Development* **15**:6, 693-708. [CrossRef]

152. P.D.F. STRYDOM. 2003. WORK AND EMPLOYMENT IN THE INFORMATION ECONOMY. *South African Journal of Economics* **71**:1, 1-20. [CrossRef]

153. Charles Kenny. 2003. The Internet and Economic Growth in Less-developed Countries: A Case of Managing Expectations?. *Oxford Development Studies* **31**:1, 99-113. [CrossRef]

154. Jan Marc Berk. 2003. New Economy, Old Central Banks?. *Economic Notes* **32**:1, 1-35. [CrossRef]

155. Jacques Mairesse. 2003. In Memoriam: Zvi Griliches. *Econometric Reviews* **22**:1, xi-xv. [CrossRef]

156. J Core. 2003. Market valuations in the New Economy: an investigation of what has changed. *Journal of Accounting and Economics* **34**:1-3, 43-67. [CrossRef]

157. Ronald S. Batenburg, Werner Raub, Chris SnijdersCONTACTS AND CONTRACTS: DYADIC EMBEDDEDNESS AND THE CONTRACTUAL BEHAVIOR OF FIRMS **20**, 135-188. [CrossRef]

158. Robert J. Gordon. 2003. Deux siècles de croissance économique : l'Europe à la poursuite des États-Unis. *Revue de l'OFCE* **84**:1, 9. [CrossRef]

159. G Silverberg. 2002. The discrete charm of the bourgeoisie: quantum and continuous perspectives on innovation and growth. *Research Policy* **31**:8-9, 1275-1289. [CrossRef]

160. Kevin J. Stiroh. 2002. Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?. *American Economic Review* **92**:5, 1559-1576. [Citation] [View PDF article] [PDF with links]

161. Nathan S. Balke, Mark E. Wohar. 2002. Low-Frequency Movements in Stock Prices: A State-Space Decomposition. *Review of Economics and Statistics* **84**:4, 649-667. [CrossRef]

162. Daniel S. Hamermesh, Sharon M. Oster. 2002. TOOLS OR TOYS? THE IMPACT OF HIGH TECHNOLOGY ON SCHOLARLY PRODUCTIVITY. *Economic Inquiry* **40**:4, 539-555. [CrossRef]

163. Karl Whelan. 2002. Computers, Obsolescence, and Productivity. *Review of Economics and Statistics* **84**:3, 445-461. [CrossRef]

164. Vernon W. Ruttan. 2002. Can Economic Growth Be Sustained? A Post-Malthusian Perspective. *Population and Development Review* **28**:1, 1-12. [CrossRef]

165. STEPHEN REDDING. 2002. Reviews. *THE ECONOMIC JOURNAL* **112**:477, F153-F155. [CrossRef]

166. Stephen Malpezzi. 2002. Urban regulation, the "new economy," and housing prices. *Housing Policy Debate* **13**:2, 323-349. [CrossRef]

167. Raouf Boucekkine, David de la Croix, Yiannis Vailakis. 2002. Technological Shocks and IT Revolutions. *Recherches économiques de Louvain* **68**:1, 75. [CrossRef]

168. Michael T Kiley. 2001. Computers and growth with frictions: aggregate and disaggregate evidence. *Carnegie-Rochester Conference Series on Public Policy* **55**:1, 171-215. [CrossRef]

169. Susanto Basu, John G. Fernald, Matthew D. Shapiro. 2001. Productivity growth in the 1990s: technology, utilization, or adjustment?. *Carnegie-Rochester Conference Series on Public Policy* **55**:1, 117-165. [CrossRef]

170. John Reenen. 2001. The New Economy: Reality and Policy. *Fiscal Studies* **22**:3, 307-336. [CrossRef]

171. Morris M. Kleiner. 2001. Intensity of management resistance: understanding the decline of unionization in the private sector. *Journal of Labor Research* **22**:3, 519-540. [CrossRef]

172. Nicholas Crafts, Mary O'Mahoney. 2001. A Perspective on UK Productivity Performance. *Fiscal Studies* **22**:3, 271-306. [CrossRef]

173. Phillip Anthony O'Hara. 2001. Recent changes to the IMF, WTO and SPD: emerging global mode of regulation or social structure of accumulation for long wave upswing?. *Review of International Political Economy* **10**:3, 481-519. [CrossRef]

174. Martin Neil Baily,, Robert Z. Lawrence. 2001. Do We Have a New E-conomy?. *American Economic Review* **91**:2, 308-312. [Citation] [View PDF article] [PDF with links]

175. Robert E. Litan,, Alice M. Rivlin. 2001. Projecting the Economic Impact of the Internet. *American Economic Review* **91**:2, 313-317. [Citation] [View PDF article] [PDF with links]

176. JOHN FREEBAIRN. 2001. SOME MARKET EFFECTS OF E-COMMERCE. *The Singapore Economic Review* **46**:01, 49-62. [CrossRef]

177. Marc van Wegberg, Arjen van WitteloostuijnStrategic management in the new economy: Modern information technologies and multichannel contact strategies **18**, 263-304. [CrossRef]