International Department Working Paper Series 00-E-1

Increased Labor productivity and IT Investment in the United States

Yoshihito SAITO
yoshihito.saitou@boj.or.jp

International Department
Bank of Japan

C.P.O. BOX 203 TOKYO
100-8630 JAPAN

(This paper was originally published in Japanese in *the Bank of Japan Monthly Bulletin* on February 2000.)

Increased Labor Productivity and IT Investment in the United States

June 2000

Yoshihito SAITO[1]

International Department, Bank of Japan

Summary

1. The US economy has been booming for almost nine consecutive years after hitting bottom in March 1991. It is often said that this long period of economic expansion is due to the enhanced productivity of the overall US economy through the active use of computers and the Internet to realize labor saving, inventory reductions, and sales network expansion. However, labor productivity, which is obtained by dividing real GDP by labor input, grew only about 1.5% on average annually until the mid-1990s. Thus, it has been argued that the quantitative contribution of information technology (IT) investment to economic growth by reinforcing the supply side of the economy cannot be confirmed (which has been called the "IT Paradox").

2. However, data since 1996 shows that labor productivity growth has risen to an average 2.5% annually. This is partly due to the comprehensive revision of GDP statistics released on October 1999, whereby software expenses are now recorded as value added. This pushed up GDP figures, since the growth in IT investment is directly reflected in GDP growth. However, even excluding the upward effect occasioned by the comprehensive revision of GDP statistics, labor productivity improvement became prominent in the latter half of the 1990s.

---

[1] Global Economic Research Division, International Department, Bank of Japan
(e-mail: yoshihito.saitou@boj.or.jp).

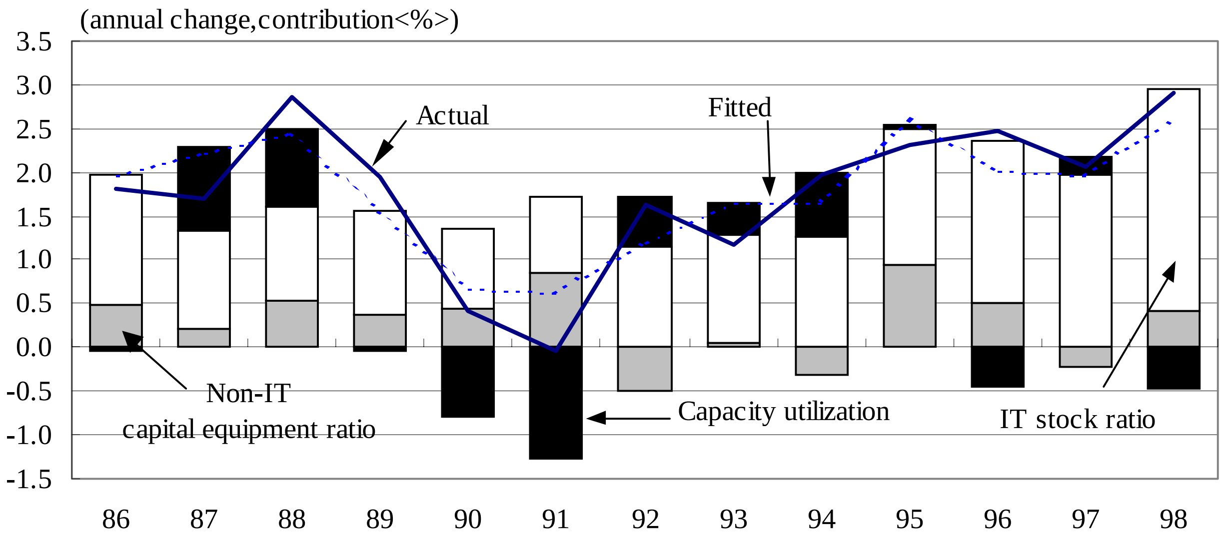
Key terms: Productivity, Information Technology, IT paradox
JEL classification: D20, L10, N10, O30, O40

3. This paper examines some factors that have been contributing to the recent improvement in productivity, among which IT investment is our major interest. First, by decomposing real GDP into several factors, we verify that technological innovation actually contributes significantly to economic growth. It is found that capital stock and labor input are not enough to fully explain enhanced real GDP growth in the 1990s. Rather, factors other than the above, namely "Total Factor Productivity", have been found to account for roughly half of economic growth in the latter half of the 1990s. It is also thought that the effect of the substitution of capital stock for labor input is not a major cause of the increase in labor productivity, because the capital equipment ratio did not rise to any significant degree.

From this analysis, it becomes apparent that "technological innovations" that enhances output per unit of capital equipment and per unit of labor became increasingly conspicuous during the late 1990s, consequently contributing considerably to real GDP growth.

4. It has been confirmed that the recent increase in labor productivity led by technological innovation is mainly because of IT investments. It is estimated that about 80% of the increase in labor productivity since 1995 has been induced by the increase in the ratio of IT stock to the total capital stock.

Regression of Labor Productivity (all industries)



Note: see Chart 13 for details.

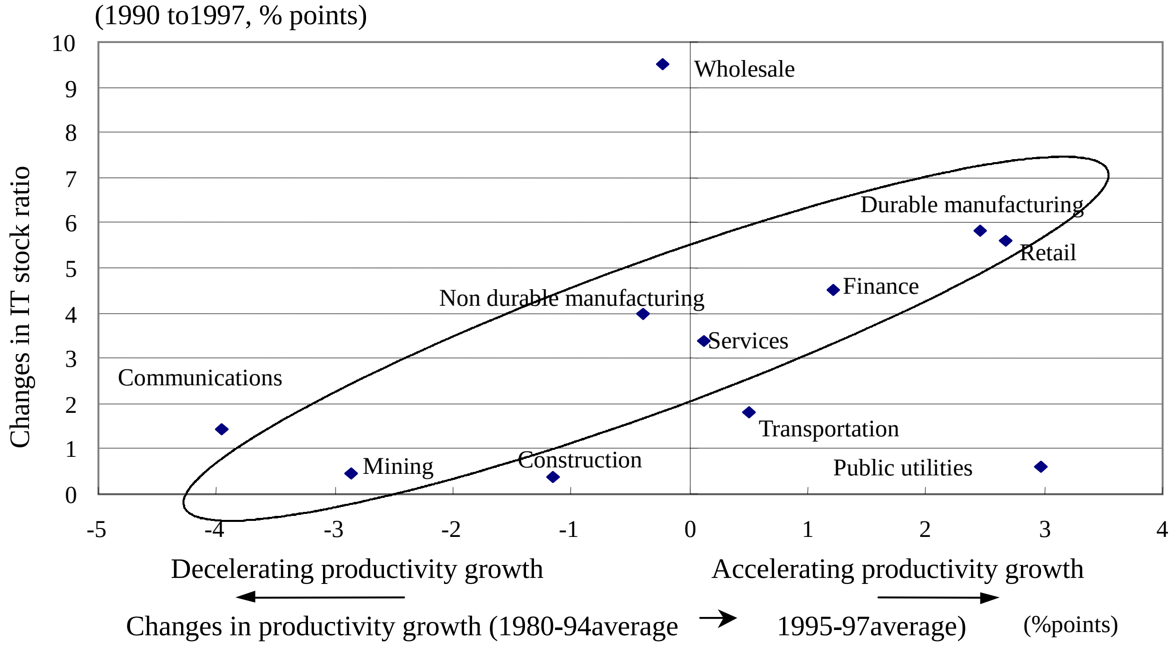
5. The fact that active IT investment has led to an increase in productivity partly reflects the improved efficiency of computers and networks. More importantly, synergies emanating from IT stock have increased the productivity of other capital stock and labor, which eventually lead to technological innovation.

To verify this point, the relationship between IT stock and productivity was analyzed using productivity data for various industries. The following became apparent as a result:

a) In the retail, durable goods manufacturing (especially industrial machinery and electronic machinery), and financial industries, both the ratio of IT stock to non-IT stock and growth rate of labor productivity accelerated in the late 1990s. It can be said that (1) these industries have benefited from the fruit of IT innovation and (2) competition with foreign companies has been intense and a reduction in labor costs has been indispensable.

b) In the service sector, labor productivity is relatively low due to its labor-intensive nature. However, in some industries like business services, productivity improvements occasioned by aggressive IT investment stand out.

Correlation between IT stock and Labor Productivity (all industries)



Note: see Chart 19 for details.

c) Labor saving was the original aim of IT investment. However, it is noteworthy that the productivity gains have generated new business opportunities, expanding US employment significantly in the retail and service areas since the mid-1990s. This expansion took place supported by an entrepreneurial friendly environment and a highly flexible labor market. Another notable change during this period is the increasing proportion of highly skilled jobs stemming from accelerated IT investment.

6. Most US companies are expected to continue IT investment. This is due to the decline in price of IT goods in comparison with employment cost and increased competition with foreign economies. Yet, a higher proportion of low skilled workers in some industries such as construction and the possibility of a shortage in the supply of skilled labor in the economy may be potential obstacles to a further increase in IT investment.

7. In the process of improving labor productivity after recovering from the recession in the early 1990s, the US economy has benefited from IT innovation. The background to this success is as follows:

a) The penetration of corporate governance that ceaselessly demanded the accurate evaluation of risk and return for each business.

b) The increased competitiveness of financial and capital markets, which enabled the efficient supply of risk capital.

c) Extensive restructuring and reengineering of business processes that enable the efficient use of limited capital and human resources.

The experience of the US, where productivity of the overall economy was enhanced through eliminating structural problems while expanding IT investment, is a meaningful lesson for Japan and European countries.

1. Labor Productivity in the US

The US economy has been booming for almost nine consecutive years after hitting bottom in March 1991. One notable characteristic of current expansion is the acceleration of labor productivity growth. Labor productivity in the non-farm business sector showed average annual growth of only about 1.5% from the late 1980s to early 1990s (Chart 1). There has been a lot of controversy among economists on this phenomenon where an increase in IT investment did not lead to an expected improvement in aggregate productivity. This is often referred to as the "IT paradox". (discussed later). However, since 1996, the increase in productivity has become conspicuous: from the first quarter of 1996 to the third quarter of 1999, average growth reached 2.5%, almost hitting 3% after 1998.

When breaking down labor productivity of the non-farm business sector into manufacturing and non-manufacturing industries (Chart 2)[2], the accelerated increase in the manufacturing industry is prominent: 3.1% annually during 1990 to 1994. However, during 1995 to 1998, productivity jumped to 4.4% on an annual basis. Although the productivity increase in the non-manufacturing industry is lower compared to manufacturing industry, there has also been a considerable improvement.

Generally, labor productivity shows a strong growth at the beginning of an economic recovery mainly due to the recovery in the capacity utilization rate. However, in the later stage of expansion, growth slows down because of the increase in employment. Past experience confirmed this trend (Chart 3), where the growth rate of labor productivity slowed down as the economy achieved a long-term expansion. However, the current economic boom is quite different from the past, in that the increase in labor productivity is accelerating as economic expansion becomes prolonged.

In line with the benchmark revision of GDP statistics announced in October 1999, labor productivity statistics have also been revised. This revision[3] of GDP statistics[4]

---

[2] Figures for manufacturing industry are released by the US Department of Labor. Figures for non-manufacturing industry are the author's estimation from non-farm business sector and manufacturing sector data.

[3] NIPA (National Income and Product Accounts) Statistics

[4] See ANNEX for further details on the benchmark revision of GDP statistics.

incorporated changes in the treatment of software that had been purchased or self developed, which previously was regarded as an “input to production” and thus counted as part of GDP. This resulted in upward revision of real GDP and labor productivity, especially in the 1990s when software expenditures rapidly increased (changes caused by the revision : + 0.3% points in the 1980s, + 0.6% points in the 1990s. <Chart 4>).[5]

2. Background to the Labor Productivity Increase in US

In this section, various factors that are likely to have led to an increase in labor productivity are examined; (1) changes in the capital equipment ratio, (2) economic cycle which led to a decrease in average cost, and (3) technological innovation embodied as an increase in Total Factor Productivity, TFP.

(1) Capital equipment ratio

Capital equipment ratios (=capital stock/number of employment) for manufacturing and non-manufacturing industries are shown in Chart 5. In manufacturing industry, active investment in plant and equipment and a continuous reduction in employment have constantly pushed up the capital equipment ratio. On the other hand, in non-manufacturing industry, the ratio has leveled off since the 1980s due to the rapid growth in the share of labor intensive sectors such as service industries.

This increasing gap in the capital equipment ratio may explain the higher growth of labor productivity in the manufacturing industry than in non-manufacturing industry. We should note that, in manufacturing industry, labor productivity is likely to be overestimated because of the active use of outside labor which is not counted as employment in manufacturing industry; outside labor is counted as employment in non-manufacturing industry[6]. Taking this into consideration, the gap between manufacturing and non-manufacturing industries is likely to narrow.

---

[5] Labor productivity is calculated by dividing output by labor input. Output calculation is based on GDP statistics. Output of the non-farming sector is calculated by subtracting output of the government, farm, and non-profit organization sectors from GDP (share of non-farm sector in total GDP was about 76%<1996>).

[6] If manufacturing industry uses outside labor, output is included in manufacturing industry, while labor input is counted in the service sector.

However, the capital equipment ratio of manufacturing industry has not exceeded the trend in recent years. Therefore, the increase in the capital equipment ratio cannot be the main cause for the increase in labor productivity.

(2) Cyclical factor and technological innovation

Next, real GDP growth is decomposed into four factors: (1) capital stock[7], (2)labor force, (3) economic cyclical factor such as utilization of capital and labor, and (4) Total Factor Productivity (TFP).[8]

Using a Cobb-Douglas production function, it is estimated that[9]GDP growth since 1995 is largely due to TFP (Chart 6). Real GDP growth from 1995 to 1998 averaged 3.8%, while the contribution of TFP was just under 50% (1.8%). The contribution of the rise in the utilization of both capital and labor combined during this period as the business cycle factor was limited to 0.2%.[10] This was due to relatively stable capacity utilization. Since estimation was based on a homogeneous Cobb-Douglas production function, there is a problem that increasing returns that can usually be observed during economic expansion cannot be captured; a part of the cyclical factor can not be excluded from TFP.[11] However, the fact that TFP shows the largest increase in the past

---

[7] In statistics on capital stock, "Fixed Reproducible Tangible Wealth in the United States" released by the US Department of Commerce (the most recent issue was published in September 1998 for 1997), software stock is not included in capital stock. However, to achieve consistency with revised GDP statistics, software capital stock is estimated and added to capital stock.

[8] In principle, economic growth is considered to be achieved by the increase in resource input and technological innovation. As technological innovation is difficult to observe, it is generally calculated by subtracting the quantitative change in input, such as capital and labor, from real GDP growth, "remaining difference". Yet, some attention is needed to interpret the "remaining difference", as it incorporates not only technological innovation, but also the business cycle and other factors.

[9] A Cobb-Douglas production function is used.

[10] Gordon[1999] has decomposed productivity growth into factors attributable to the economic trend and those attributable to the business cycle using econometric techniques. The outcome shows that with respect of labor productivity growth of 2.17% during the fourth quarter 1995 to first quarter 1999, factors attributable to the business cycle are estimated to account for 0.30%, whereas factors attributable to the economic trend, 1.85%.

[11] There is also the possibility of an improvement in the quality of capital stock and labor (described later), which is captured as an increase in TFP. Fernald and Basu [1999] pointed out four points as the underlying reasons for productivity to exhibit a

30 years implies that the contribution of technological innovation to GDP growth is significant.

In addition to the abov e estimation, “Multifactor Productivity Statistics” released by the US Department of Labor shows the recent increase in TFP. In these statistics, Total Factor Productivity is calculated by dividing output by labor input and capital stock.[12] This is almost equivalent to the sum of TFP, obtained by the production function approach, and business cycle factors. This data also confirms the acceleration of TFP growth in recent years (Chart 7).

The fact that productivity growth is led by technological innovation is also verified by comparing labor productivity and capital productivity (Chart 8). Even if labor productivity grows, if capital productivity is slowing down at the same time, this cannot be regarded as technological innovation. Actually, from the 1970s to early 1980s, labor productivity showed a small increase while capital productivity plunged. However since the mid-1980s, both labor productivity and capital productivity have increased. Furthermore, since the mid-1990s, capital productivity has been growing and labor productivity rapidly accelerating. As the capital equipment ratio has not increased, it can be said that the recent increase in labor productivity has not been brought about at the sacrifice of a slowdown in capital productivity. Rather, productivity growth is more likely to have been induced by technological innovation.

3. Increase in Labor Productivity Led by IT Investment

Next, we examine the effect of the rapid increase in IT stock on productivity growth.

In US Department of Commerce statistics, real IT stock[13] increased about 40% during the three years from the end of 1994 to the end of 1997. The increase in computer stock

---

trend similar to that of the economic cycle: (1) technological innovation tends to track the business cycle, (2)increasing returns under imperfect competition, and (3) capacity utilization shows a similar trend to the business cycle.

[12] Labor and capital weights are calculated based on income share of labor and capital within the GDP on total cost basis.

[13] IT stock as defined by the US Department of Commerce is the total of (1)computers, (2) photocopy machines, (3) communication equipment, and (4) other office equipment.

was especially remarkable, growing about 2.7 times.[14] As a result, the share of IT stock to total capital stock rose to about 13% by the end of 1997.

It should be noted that the above figures do not include software, which came to be categorized as capital stock as a result of the revision of GDP statistics in October 1999. Real IT stock based on software investment data increased by about 25% if software stock is included. As a result, the share of IT stock to total capital stock is estimated to be about 16% (Charts 9 and 10).[15]

Some empirical research shows that the marginal productivity of IT stock is higher than that of non-IT stock. For example, Brynjolfsson and Hitt [1996] analyzed 380 companies making IT investments during 1987 and 1991, and found that the marginal return on IT stock was 81% annually; 67.0% on a net basis when depreciation is subtracted, while the marginal return on non-IT stock was 6.3%. Also Shinozaki [1996] showed that the marginal productivity of IT stock was 48.1% on a net basis, considerably higher than for non-IT capital stock which was 12.0% (Chart 12).

As the proportion of IT stock with higher marginal productivity increases to overall production resources, productivity is enhanced on a macro basis. To confirm this point quantitatively, we made a regression on labor productivity by (1) the capital equipment ratio of non-IT stock, (2) the IT stock ratio (=IT stock/non-IT stock), and (3) the capacity utilization rate(Chart 13) .[16]

---

[14] IT stock on a nominal basis increased only about 15% from 1994 to 1997. The drop in prices have contributed to the remarkable increase in the IT stock on a real basis.

[15] According to the US Department of Commerce [1998], the IT industry market (gross national income of the industry) has posted around 10% annual growth in recent years. Also, its share within the whole economy has reached around 8% (Chart 11).

[16] This estimation is based on a Cobb-Douglas production function, which includes IT stock as a production factor (note that values for α and β are estimated from the regression). The following Cobb-Douglas production function is estimated:

$$Y = T \times L^{\alpha} \times (\tau K_1)^{\beta} \times (K_0)^{1-\alpha-\beta}$$

where Y= real GDP, L = labor input, K_1 = non-IT capital stock, K_0= IT stock, and τ=capacity utilization ratio.

Dividing both sides by L and taking the logarithm of each side, the following equation is obtained:

$$Ln\left(\frac{Y}{L}\right) = (\text{constant}) + (1-\alpha) * Ln\left(\frac{K_1}{L}\right) + (1-\alpha-\beta) * Ln\left(\frac{K_0}{K_1}\right) + \beta * Ln(\tau)$$

According to this regression, labor productivity of the overall industry[17] from 1996 to 1998 posted average annual growth of 2.5%. About 80% of such growth stems from the increase in the IT stock ratio.

The contribution of growth in the IT stock ratio to the increase in productivity is conspicuous especially in manufacturing industry. For manufacturing industry, regression results show that, the contribution of the IT stock ratio has grown remarkably since 1995 (Chart 14).

The above regression suggests that the improvement in the quality of capital stock and labor is generated by an increase in the IT stock ratio. As previously mentioned, there still remains the possibility that the contribution of business cycle factor is counted as the contribution of the IT stock ratio. Nevertheless, these regression results illustrate the fact that the recent increase in IT stock has made a considerable contribution to the acceleration of labor productivity, while bringing improvements in the quality of capital stock and labor.

4. Synergy Effect of IT Stock

The process of IT stock contributing to an increase in productivity can be understood as follows. Increasing IT stock itself has a labor saving effect.[18] Furthermore, it also contributes to productivity growth through synergies with capital for other purposes and labor.[19] For example, IT stock has the effect of reducing indirect costs such as administrative costs related to labor and inventories. Also, it will bring about greater organizational efficiency and swift decision making.

Based on a null hypothesis that the constant term equals zero is not rejected, regression without a constant is used. The sample period is from 1980 to 1998.

[17] Labor productivity statistics for all industries are not available. The figure is obtained by dividing real GDP by the labor input of all industries.

[18] A rapid increase in IT investment is the result of profit maximizing behavior on the part of companies in response to a drop in the prices of IT goods compared to labor costs. The ratio between the prices of IT goods and labor costs shows an inverse relationship with the ratio between IT capital stock and the number of employees (Chart 15).

[19] In July 1999, FRB Chairman Alan Greenspan commented that the synergistic effect of new technology is an important factor underlying improvements in productivity.

In the process of facilitating organizational efficiency, IT stock is expected to substitute for low skilled workers. Also, the use of IT will shorten the necessary time for replacing expensive capital stock and will enable efficient use of existing production capacity as it will minimize volatility fluctuations in capacity utilization; it will reduce need for surplus production capacity introduced to meet peak demand. Furthermore, through the development and introduction of new technologies by more and more companies, existing goods and services will be provided at lower prices and of higher quality. This improvement in efficiency is likely to spread to other companies which purchase goods and services provided by the above mentioned companies, resulting in the spread of synergistic effects.[20]

Among those mentioned, effects on the organization of business processes are a unique characteristic of IT stock. The US Department of Labor [1996] emphasizes that introduction of IT has the effect of improving the expertise of the workforce by making the work of each worker less segmented and more integrated as a result of a less hierarchical organization. Also, Doms, Dunne, and Troske [1997] reports that there is a positive correlation between IT investment and the skill of workers.

As for effects of IT innovation on the demand side, it is considered that increased demand for IT goods and services will push up total demand in the economy, thereby increasing the market size of the IT industry[21] (Chart 16). It is often pointed out that the characteristics of IT innovation in the 1990s were: (1) downsizing, (2) the greater diffusion of computers among the general public, (3) more networks, and (4) open systems or prevalence of systems that are inter-connectable with others. Along with the widespread use of the Internet, these factors have contributed considerably to the expansion of IT demand. Hence, IT stock is thought to have contributed to the growth of productivity through demonstrating "network externality" where an increase in the number of people in demand leads to further enhancement of user utility.

---

[20] See Inoue [1998] on this point. For a comprehensive study on the impact of information technology innovation, see Institute for Monetary and Economic Studies, Bank of Japan [1997].

[21] For details on the impact of IT innovation on the macroeconomy, see Inoue [1997].

5. Labor Productivity and IT Investment by Industry

(1) Labor productivity by industry

To find out how IT investment brings about an increase in productivity, we analyzed labor productivity by industry.[22] First, the private sector was broadly categorized into ten sectors[23]and the labor productivity of each was examined. It was found that some industries such as the construction industry have seen negative growth in labor productivity since 1995. However, quite a few posted accelerated productivity growth, i.e. the durable goods manufacturing industry, electric and gas utilities, and the retail industry (Chart17). Furthermore, detailed analysis of the durable goods manufacturing industry shows outstanding productivity growth in the electronic machinery and industrial machinery areas with more than 15% annual growth[24] (average annual growth 1995-97: Electronic machinery 22.3%; industrial machinery, 16.8%; Chart 18).

Next, it was found that labor productivity and the IT stock ratio (=IT stock/total capital stock)[25] show a positive correlation by industry. Comparing (1) the gap in productivity growth between the average of 1995-97 and 1980-94 with (2) differences in the IT stock ratio from 1990 to 1997 (Charts 19, 20), we found accelerating labor productivity growth in the durable goods manufacturing industry, especially industrial

---

[22] The labor productivity of each industry is calculated by dividing the real GDP of each industry by the number of employed in the industry. However, real GDP used here does not include software investment (GDP statistics by each industry under the new framework have not been released yet).

[23] These industries are construction, durable goods manufacturing, transportation, telecommunication, electric power and gas, finance and insurance and real estate, wholesaling, retailing, and services.

[24] High growth in the productivity of, electronic machinery and industrial machinery is achieved by rapid growth of GDP and a small increase in the number employed. This suggests that there is a high possibility that productivity growth is especially accelerating in the computer-related goods sector (computer and peripheral equipment, electronics parts and others) that has achieved extraordinary high growth during this period. (It should be noted that computer and peripheral equipment are categorized under the industrial machinery sector, while electronics parts including semiconductors are categorized under the electronic machinery sector). Productivity of computer-related goods and electronic parts showed extraordinary high annual growth of 48.5% and 47.2 % respectively during 1995-98.

[25] In this chapter, instead of using IT capital stock/non-IT capital stock, the share of IT stock within total capital stock is defined as the IT stock ratio.

machinery and electronic machinery, retailing, and finance, all of which saw increased IT stock ratios. On the other hand, construction and mining which experienced a slow-down in labor productivity, saw little increase in the IT stock ratios.[26]

The result of this analysis can be interpreted as the process of diffusion of IT stock over the whole economy. In the retail industry, the widespread use of "electronic data interchange" is thought to have led to a reduction in management costs and also the cost of receiving and placing orders. Also, expansion of sales through the Internet has contributed considerably towards a reduction in sales costs. In the financial industry, IT is easily applied to system and product development. As for electronic machinery and industrial machinery, with their nature of being on both the user side and maker side of IT, increases in productivity[27] are brought about not only through cost reductions but also through IT innovation and high demand growth.[28]

(2) Labor productivity of the service industry

As shown in Chart 19, since around 1995, labor productivity in the service industry has improved as the IT stock ratio has risen. In order to make a more detailed analysis, we decomposed the service industry into nine sectors(Chart 23).[29] In the business service, motion picture, and legal service sectors, increases in IT stock occurred simultaneously as increases in productivity. On the other hand, in sectors with decelerating productivity growth such as hotels and educational services, IT stock ratios hardly changed.[30]

---

[26] Also, in industries with higher labor productivity growth such as electronic machinery and industrial machinery, the IT stock ratio shows outstanding growth. The retail and financial sectors also exhibit relatively higher ratios (Charts 21, 22).

[27] In these industries, active R&D investments have been made along with the IT investment, contributing to the qualitative improvements in the IT stock they provide.

[28] In our analysis, the telecommunications sector saw neither an increase in the IT stock ratio nor improvements in the productivity. This is likely to be due to the fact that it has already achieved high productivity growth and was the recipient of IT stock investments in the 1980s (This also applies to the wholesale industry).

[29] Business services, motion pictures, legal services, auto repair, amusement facilities, health services, personal services, educational services, and hotel services.

[30] The business services sector has an extremely high IT stock ratio because it includes high technology industries such as software development.

As illustrated above, the improvement in productivity brought by IT investment also seems to have been realized in the service industry. However, negative labor productivity growth was the case for some service sectors. For examples, motion pictures and health services experienced negative productivity growth from 1995 to 1997, even though they had relatively high IT stock ratios (Chart 24).

Concerning this point, it should be noted that the low productivity of the service industry is said to be attributable to the difficulty in measuring its output. For example, in referring to the slowing down of labor productivity in such sectors as legal services, motion pictures, and healthcare services, the US Department of Commerce [1999b] argues that how to measure output of the service industry and how to incorporate qualitative improvements are the main problems.[31]

Considering the possibility of underestimation, the above result where many service industries have posted improved labor productivity growth since the late 1990s should be considered as evidence that the impact of IT investment has permeated the service industry.

(3) Impact of IT on labor and capital

IT investment contributes to a reduction in labor and non-IT capital stock, hence increasing their productivity. Therefore, in industries enjoying increased productivity

[31] Griliches [1994] has divided the economic sector into the “measurable output sector” like manufacturing industry and the “unmeasurable output sector” like finance and service industries. He then pointed out that the issue of mismeasurement is becoming more serious as the share of the “unmeasurable output sector” increases. Slifman and Corrado [1996] have also pointed out that there is a possibility that productivity in the service industry (legal services and health services) is underestimated. This is supported by the following facts: (1) it is difficult to continue operation for a long period with low productivity, yet the number of actual bankruptcies in these sectors is not increasing, and (2) the profits of these sectors are not so low.

Underestimation can be verified from another point, namely that the trend of labor productivity should be reflected in the trend of real wages over the long run. Thus by comparing relative real wages and labor productivity of manufacturing and non-manufacturing industries, we can examine the extent of mismeasurement in non-manufacturing industries (Chart 25). The result shows that the relative real wages of manufacturing industry are considerably lower than relative labor productivity. And the gap widened through the 1990s. Since relative real wages are less likely to be distorted, this could be evidence of underestimation of labor productivity in non-manufacturing industry.

growth such as durable goods manufacturing, finance, and retailing, a lowering proportion of unskilled workers in such areas as administrative support and services due to substitution by computers is observed. At the same time, the proportion of skilled workers such as technical jobs is increasing. On the other hand, in the construction and mining industries where labor productivity growth is declining, the share of skilled workers is not increasing (Chart 26).

It is notable that in the US the number employed has increased considerably since the mid-1990s when the increase in productivity growth became conspicuous. The underlying causes are likely to be the creation of new business opportunities and increased flexibility of the labor market. Changes in the number employed from early 1995 to end-1998 by industry show (Chart 27) that even in the retail and service industries, which have been active in making IT investments, the number employed has increased making a significant contribution to the overall employment increase in the US.

As seen above, achieving both the expansion of IT investment and an increase in employment in the overall economy simultaneously is an important factor in ensuring a productivity increase without having to experience a contraction of the economy through corporate restructuring.

Also, from the viewpoint of optimization of capital stock, industries with increased productivity growth have a more stable capacity utilization ratio than those with decreased productivity growth (Chart 28). This finding reflects stable production and a reduction in the time necessary for an increase/decrease in capital stock.

6. The "IT Paradox" Controversy

The above results support the hypothesis that IT investment contributes to an increase in productivity growth. However, there has been a lot of controversy among economists regarding the relation between IT investment and productivity, which has been termed the "productivity paradox" or the "IT Paradox".

Following high labor productivity growth in the 1960s, the US experienced sluggish labor productivity growth after the first oil crisis, and there has been little improvement since. This phenomenon where productivity of the overall macroeconomy does not increase despite an increase in IT investment, has been referred to as the "IT paradox", and was first discussed in a paper by Baily and Gordon [1988] (although some papers like that of Nordhaus[1972] pointed out sluggish productivity growth in the 1970s).

A few hypotheses have been put forward to explain this seeming paradox, including: (1) measurement of output in the service industry is incomplete, (2) IT stock represents only a small fraction of total capital stock and does not have a large impact on aggregate production, and (3) it takes time for new technology to be acquired and absorbed by an economy. Regarding measurement, hypothesis(1), the major problems include difficulties in correctly measuring output in the service and financial industries and software expenses not being included in GDP statistics.[32] However, official statistics are showing some improvement. For example, when GDP statistics were comprehensively revised in October 1999, software expenditure was transformed to be included into output (as fixed investment). Also, in the banking sector, the output of unpriced services is now obtained using a wide variety of statistics such as ATM transactions. The small share of IT stock, hypothesis(2), focuses on the argument that even if computers bring about high marginal productivity, because the proposition of IT stock in the overall macroeconomy is too small, the impact is limited. Oliner and Sichel [1994] reported that the annual contribution of computers to real GDP growth from 1970 to 1992 was merely 0.16%. As the underlying causes for this, they argue that the share of computers to total capital stock is significantly small (in 1993, the share of computers to total capital stock was merely 2%) and also that due to rapid depreciation, growth in computer stock is not so large on a net basis. The time lag hypothesis(3), applies to such cases where the introduction of IT by corporations cannot take full effect until such companies have adopted to new business processes suitable for IT. Furthermore, these changes are often costly,[33] thereby delaying the diffusion of computer technology itself and taking a long time before they have any significant effect on productivity. On this

[32] Papers on measurement error include: Nordhaus [1982], Baily and Gordon [1988], Griliches [1994] and Slifman and Corrado [1996], as well as the Advisory Commission to Study the Consumer Price Index [1996], Kozicki [1997], Nardhaus [1997].

[33] For details on adoption cost for the introduction of new technology and its popularization, see Inoue [1998].

point, David [1990] took up electric power technology, which was a major technological innovation at the time of the second industrial revolution, as an example. He points out that it took about 30 years for electric power technology to gain more than 50% of the market share and bring a significant improvement in productivity.

There are still a number of economist who are skeptical about the relation between productivity and IT investment even after the actual confirmation of growth in labor productivity. For example, Gordon [1999] categorizes manufacturing industry into the computer sector and non-computer sector and points out that during the fourth quarter of 1995 to the first quarter of 1999, the computer sector achieved outstandingly high productivity growth while the non-computer sector did not show any great improvement. Also the US Department of Commerce [1999b] categorizes all industries into either the service sector or goods sector. Each sectors are then classified into those with a relatively higher share of IT stock per capita (IT users) and those with a relatively lower share (non-IT users). The Department reports that in the goods sector, high productivity growth is observed in the IT user group while in the service sector the non-IT user group shows higher productivity growth.

However, the following facts are found in this paper:

(1) The accelerating growth of labor productivity is confirmed statistically. This trend has become especially conspicuous since the revision of GDP statistics.

(2) Accelerating productivity growth occurs simultaneously as the share of IT capital stock rapidly increases.

(3) Analysis by industry also shows that the industries with a higher IT stock ratio attain higher productivity growth.

(4) Increased productivity is also confirmed in the service industry. Improved productivity is more conspicuous in industries with a higher IT stock ratio. Although the growth rate of productivity is still low, many industries have experienced an improvement since the late 1990s.

These points suggest that the conventional “IT paradox” is not valid anymore[34].

---

[34] However, the possibility that it will take some time before the contribution of IT

7. The Future of IT Investment in the US and Lessons for Japan and Europe

So far, we have examined the recent trend of labor productivity and its relation with IT investment. Finally, we discuss prospects for IT investment in the US and lessons of the US experience for Japan and Europe.

(1)Prospects for IT investment in the US

The fact that active IT investment brought about a notable increase in productivity will give US companies an incentive to make further IT investments. Looking back at the 1990s, the following features can be observed: (1) continuous cost reduction efforts made by US companies to survive within an internationally competitive environment, and (2) a continuous drop in prices of IT goods. Consequently, demand for IT investments that substitute for labor is increasing. Furthermore, incentives for more IT investments are swelling as unemployment decreases and labor costs rise. Actually, while corporate unit profit has been squeezed due to the increasing cost of labor,[35] IT investment increased (Chart 29). Especially since late 1997, the trend has become prominent: IT investment has been increasing at a rapid pace, while the unit profit of US companies dropped caused by the inflow of cheap imported goods from Asian countries. Also, as seen in Chart 15, there is a relatively stable relation between the ratio of IT stock/number employed and the ratio of prices for IT stock and labor costs. Therefore, even if the economy slows down in the future, IT investments are likely to continue to increase so long as there is cost reduction pressure.[36]

There may be limits, to some extent, regarding the expansion of IT investment in certain industries. For example, the construction industry which has a small proportion of skilled workers and low capital equipment ratio, will have a low incentive for IT

---

investment to productivity growth becomes apparent is not denied in this paper.

[35] Unit profit has been calculated by decomposing the GDP deflator of the non-financial business sector.

[36] If the US economy slows down in the future, upward pressure on employment costs will likely to ease. But, even under such a situation, IT goods prices are expected to continue dropping due to technological innovation. Therefore, the ratio of labor costs/prices of IT goods is not likely to change dramatically. Of course, the important point in discussing the outlook for IT investment is whether it will generate new

investment. However, many manufacturing industries such as automobiles and processed metals are little different from the industrial machinery and electronic machinery sectors in terms of the composition of employees. Therefore, IT investment seems to have further room to permeate to various industries in the future thus promoting labor productivity growth.

On the other hand, attention should be paid to the possibility that if stock prices plunge, fund raising may become difficult, especially for high-tech industries (such as computers and software development). As most high-tech companies rely heavily on equity financing and have also introduced pay schemes such as stock options that are directly connected to equity market conditions, a drop in share prices may cause serious problems for expanding operations. Contraction of investment in leading industries can dampen IT investment demand in the overall economy.[37] Attention also needs to be paid to the possibility that the supply of IT-related workers may be exhausted as the US labor market tightens.

(2) Lesson for Japan and Europe

IT investment in Japan and Europe is on the rise (Chart 30). There is also a rapid increase in M&A among corporations with leading information technology. For example, in the telecommunications area, there is an ongoing trend to form business alliances to use information networks more efficiently.

However, despite such a trend, accelerated labor productivity growth is not confirmed in Japan or Europe (Chart 31). Labor productivity growth in Japan and Europe was higher during 1986 to 1995 than in the US. However, since 1996, while the US has experienced rapid productivity growth, Japan and Europe have experienced a deceleration in productivity growth.[38] IT innovation has progressed worldwide and the

industries and eventually lead to the expansion of final demand.

[37] Also, in such an instance, R&D investments may also shrink, which could result in a deterioration of the marginal productivity of IT stock.

[38] Current Japanese GDP statistics do not count software expenditures as fixed investment. This may be one of the causes for the gap in the growth of labor productivity in Japan and the US.

US economy has actually been enjoying the benefits, but not so the Japanese and European economies. Why not?

It is often said that the United States pioneered the introduction of IT innovation. However, by its nature, technological knowledge is quickly transferred at marginally small cost. Therefore, even if US companies hold many basic licenses, it is not the main factor for the long standing US advantage.

It is not possible either to take an optimistic view that productivity growth will increase through expansion of IT investments as European economies expand and the Japanese economy recovers. However, it should be pointed out that some structural problems prevent IT investment from improving the productivity of the overall economy in Japan and European countries.

Bearing all this in mind, we can learn much from the US experience in its early stage of IT innovation. Experiencing recession from 1990 to 1991, the following economic recovery was rather sluggish. With the end of the Cold War, military expenses were expected to be cut and redirected towards technological development in the private sector, but which did not happen. The Council of Economic Advisers to the President [1993] pointed out that shrinking entrepreneurship as the result of an inflexible tax system and excessive regulations were the main factors for the sluggish economy. To solve these structural problems, President Clinton [1993] stated the intention of his administration to focus on the reactivation of corporate activity as the most important thrust of economic reform measures. President Clinton proposed changing the tax system to stimulate the investments of small firms and reducing the huge budget deficit.

Putting these proposals into action, entrepreneurship was again stimulated, leading to subsequent expansion of the US economy for a long period. This episode shows that technological innovation alone does not guarantee economic growth, but removing structural problems which prevent active corporate activity is important.

The above US experience clearly indicates some solutions to the problems in Japan and Europe where IT innovation does not lead to productivity gains. For IT businesses to be successful, the following are considered to be important: (1) building corporate governance system that focuses on business areas with comparative advantage, (2) encouraging competitiveness in financial and capital market so as to distribute risk capital efficiently to IT businesses; and (3) restructuring and reengineering to make full use of limited capital and human resources in a competitive environment.

As for corporate governance, US companies have made continuous efforts to maximize shareholder value by adopting strategies that contributed to reducing costs. Through the 1990s, US companies continued to pursue reductions in labor costs through the introduction of computers that were becoming increasingly cheaper. Recently, in Japan, many companies are starting to adopt clear-cut strategies to maximize shareholder value.[39] But it is often pointed out that priority is still given to on others such as creditors, customers, and employees.[40] As a result, restructuring is sluggish and not many companies succeed in increasing their productivity through the introduction of IT stock. The existence of regulations and an uncompetitive environment are the main obstacles for introducing US-type corporate governance in Japan.[41] More efficient company management is required to survive amid global competition. In adopting strategies for maximizing shareholder value, accountability, such as explaining investment decisions to shareholders, is very important.

Regarding competitiveness in financial and capital markets, even the US faced some difficulties on some occasions despite the existence of a fully developed capital market. Traditionally, debt financing schemes with fixed interest payments were considered to be difficult for R&D or IT investment.[42] Therefore, a deep and liquid capital market is indispensable for the growth of IT businesses. In the US, competition in the capital market became fierce reflecting tax system improvements and stock market growth in an environment that promoted the starting up of businesses.

---

[39] On this point see Maeda and Yoshida [1999].

[40] Gibson [1998] gives characteristics of Japanese corporate governance as follows:
(1) Corporate management often values internal stakeholders more than general shareholders.
(2) Low presence of institutional investors.
(3) Lack of a TOB market.

[41] As for the development and the impact of deregulation in the US, see Takeuchi and Takeda [1998]. For the current situation and problems regarding deregulation in Japan, see OECD [1999b].

[42] Myers [1977] explained theoretical issues and Sakuraba [1987] made an empirical study using Japanese corporate data.

Consequently, a virtuous cycle has been realized: the capital market has become more efficient, the supply of risk capital has increased, and investors are increasingly sophisticated as they search for companies with lower risk and higher return.

Europe, with the introduction of the euro, has seen the rapid transformation of financial markets such as the opening and expansion of the OTC market. And the same is true of Japan. However, we should remind ourselves that a new stock market alone does not promise the efficient supply of risk capital.[43] Moreover, in Japan, impairment of the intermediary function of banks seems to have led to a decline in funds to high-risk projects like IT investments. Hence, improved management and competitiveness on the part of financial institutions, tax reform, and introduction of an effective accounting system are indispensable.

Regarding business restructuring and business process reengineering, US companies have specialized in businesses in which they have a comparative advantage. Also, business processes have continuously changed so as to take full use of information technologies. On the other hand, companies in Japan and Europe are often said to be reluctant to undergo such drastic management changes against the background of strong emotional resistance to company acquisitions. According to OECD [1999a], European companies face much greater difficulty in reducing labor because of strict employment protection systems in place and complicated dismissal procedures (Chart 33). Such labor market rigidity is considered to be a reason hindering the flow of labor to the growing industries and hence an obstacle to economic dynamism.[44] With enlargement of information networks and the outsourcing of internal operations, greater specialty is required for workers. Therefore, employees are required to constantly upgrade their skills. Also, in order to survive in a new area where IT is extensively used, replacing managers with those having a deep knowledge of IT and company acquisitions may be options for improving competitiveness, even in Japan. As described above, managers as well as employees are required to take bold action to free themselves from traditions so

[43] Although venture capital in Japan has a long history, most such funds flow to companies with established creditability (Chart 32). Saga [2000] points out several issues regarding the recent IPO trend of venture firms.

[44] Comparing gross job gains and job losses, the US has a high ratio for both, evidencing considerable labor market mobility (Chart 34).

that optimized resource allocation of labor, capital and technical knowledge stock appropriate for the IT era can be realized.

The above structural changes cannot be avoided if business management is to be innovated. As mentioned, such efforts were taken in the early 1990s even in the US. Japan and Europe can learn much from the past ten years' experience of the US; namely the permeation of increasing productivity growth in the overall economy through the greater efficiency of corporate management employing IT.

ANNEX: Main Points of the Comprehensive Revision of US GDP Statistics (October 1999)

The US Department of Commerce [1999a] comprehensively revised GDP statistics in October 1999. The revision was different from the annual revision in that it included: (1) definition and classification changes, and (2) statistical changes (a typical case is the introduction of the Chain Weighted Method in 1996). The following two changes were effected to measure the effect of IT innovations on GDP statistics:

1. Changes in the Treatment of Software Expenses

The biggest change here is the inclusion of corporate expenditures on software in GDP statistics as fixed investments. Prior to the revision, only "embedded" software was counted as fixed investment. Any portion purchased separately from hardware and also that internally developed were treated as inputs to production and therefore not included in value added. As a result of revision, portions purchased or internally developed are included in value added as fixed investments. In the government sector, software expenditures were previously counted as government consumption, but now government investment. Furthermore, the depreciation of software stock has been added to government production and also government consumption. This is because any services that government assets produce are counted as government production. Since this is estimated based on input cost, the depreciation of software stock as a cost will lead to an increase in production. In the household sector, treatment of software expenditures has not been changed and they are still considered as household consumption.

2. Change in the method of Calculating Output in the Banking Sector

Revision was made to the calculation of unpriced bank services. Such services were previously captured based on total labor hours of the financial sector, but following the revision, they will be estimated based on ATM transactions and electronic fund transfers, which is expected to enhance the accuracy of productivity statistics in the banking sector.

Bibliography

Inoue, Tetsuya, "Johogijutsu niyoru Keizai eno Impact to Kinyuseisaku no arikata ni tsuite," *Kinyu Kenkyu*, Vol.17, No.4, Institute for Monetary and Economic Studies, Bank of Japan, 1998

————, "Johokakanrensangyo no Seicho to sono Hosokuni okeru Mondai ni tsuite," *Kinyu Kenkyu*, Vol.16, No.4, Institute for Monetary and Economic Studies, Bank of Japan, 1999

Saga, Takao, "Venture Ikusei no tameno Finance no arikata," *Monthly Kinyu Journal*, Vol.41, No.2, 2000

Sakuraba, Chihiro, "Kigyo no Toushi, Zaimukodo no Bunseki," in Y. Horie eds., *Nihon no Keikihendo to Kigyokodo*, Toyokeizaishinpousha,1987

Shinozaki, Akihiko, "Beikoku ni okeru jyohokanren no Youin, Keizaikoukabunseki to Nippon no Douko," *Chosa*, Vol. 208, Japan Development Bank, 1996

Takeuchi, Junichiro and Takeda Yoko, "Beikoku no Supplyside to Roudoushijou no Henbou ni tsuite," *Bank of Japan Monthly Bulletin*, October, 1998

Small and Medium Enterprise Agency, *Chushokigyou Hakusho*, 1997

Maeda, Eiji and Yoshida, "Shihonkouritsu wo meguru Mondai ni tsuite," *Bank of Japan Monthly Bulletin,* October, 1999

Institute for Monetary and Economic Studies, "Workshop, Conceptualization wo megutte," *Kinyu Kenkyu*, Vol.16, No.4, Institute for Monetary and Economic Studies, Bank of Japan, 1997

Yamada, Hisashi, "Akkasuru Roudoushijou to Koyosouzou eno Kadai –Nichibei Koyou Soushutsu Pattern Hikaku karano implication," *Japan Research Review*, Japan Center for Economic Research, 1998

Advisory Commission to Study the Consumer Price Index, *Toward a More Accurate Measure of the Cost of Living*: *Final Report to the Senate Finance Committee*, 1996

Baily, M. and R. Gordon, “The Productivity Slowdown, Measurement Issues, and the Explosion of Computer Power,” *Brookings Paper on Economic Activity (2)*, 1988

Board of Governors of the Federal Reserve System, *Monetary Report to the Congress Pursuant to the Full Employment and Balanced Growth Act of 1978*, 1999

Brynjolfsson, E. and L. M. Hitt, “Paradox Lost? Firm-Level Evidence on the Returns to Information Systems Spending,” *Management Science*, April 1996

Clinton, W., *A New Direction, Address to Joint Session of Congress*, February 1993

Council of Economic Advisers, *Economic Report of the President*, January 1993

David, P., “The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox,” *AEA Papers and Proceedings*, Vol 80 No. 2, 1990

Doms, M., T. Dunne, and K. Troske, “Workers, Wages, and Technology,” *Quarterly Journal of Economics*, February 1997

European Information Technology Observatory, *European Information Technology Observatory 99*, 1999

Fernald, J. G. and S. Basu, “Why is Productivity Procyclical? Why Do We Care?,” *International Finance Discussion Papers*, Board of Governors of the Federal Reserve System, June 1999

Gibson, M. S., “BIG BANG Deregulation and Japanese Corporate Governance,” *International Finance Discussion Papers*, Board of Governors of the Federal Reserve System, September 1998

Gordon, R., “Has the New Economy Rendered the Productivity Slowdown Obsolete,” mimeo, Northwestern University, June 1999

Griliches, Z., “Productivity, R&D, and the Data Constraint,” *The American Economic Review*, 84(1), 1994

Kozicki, S., “The Productivity Slowdown: Diverging Trends in the Manufacturing and Service Sectors,” *Economic Review*, Federal Reserve Bank of Kansas City, First Quarter 1997

Myers, S. C., "Determinants of Corporate Borrowing," *Journal of Financial Economics*, 5, 1977

Nordhaus, W., "Traditional Productivity Estimates are Asleep at the Technological Switch," *Economic Journal*, 107, 1997

_________ , "The Recent Productivity Slowdown," *Brookings Papers on Economic Activity (3)*, 1972

OECD, *Employment Outlook*, 1996

_________ , *Employment Outlook*, 1999a

_________ , *Regulatory Reform in Japan*, 1999b

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

Slifman, L., and C. Corrado, "Decomposition of Productivity and Unit Costs," Board of Governors of the Federal Reserve System, 1996

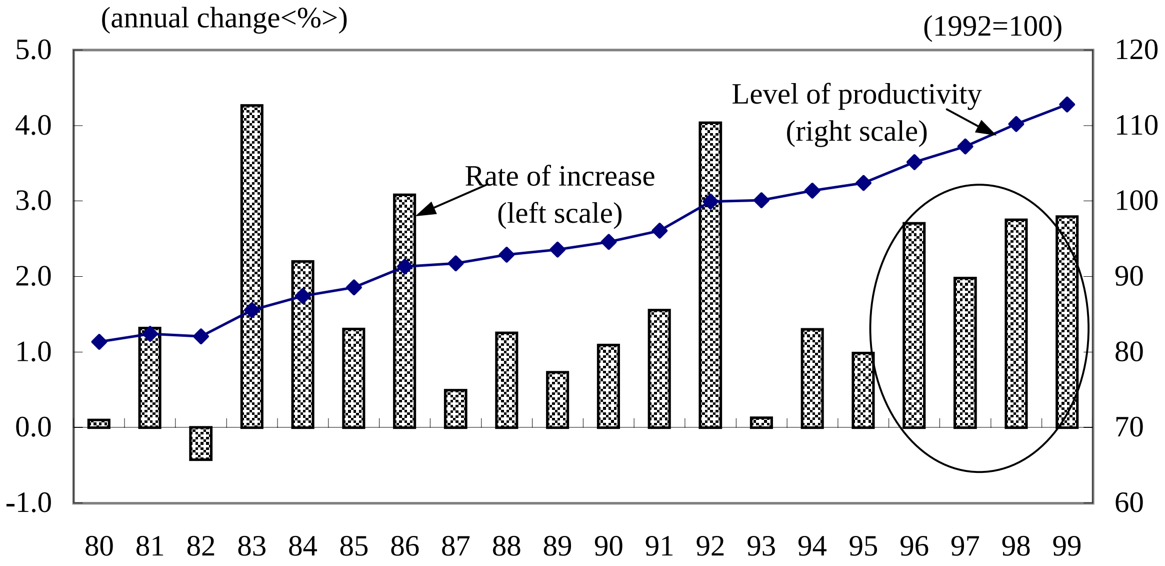
U. S. Department of Commerce, *A Preview of the 1999 Comprehensive Revision of the National Income and Product Account*, 1999a

_________ , *The Emerging Digital Economy II*, 1999b

_________ , *The Emerging Digital Economy*, 1998

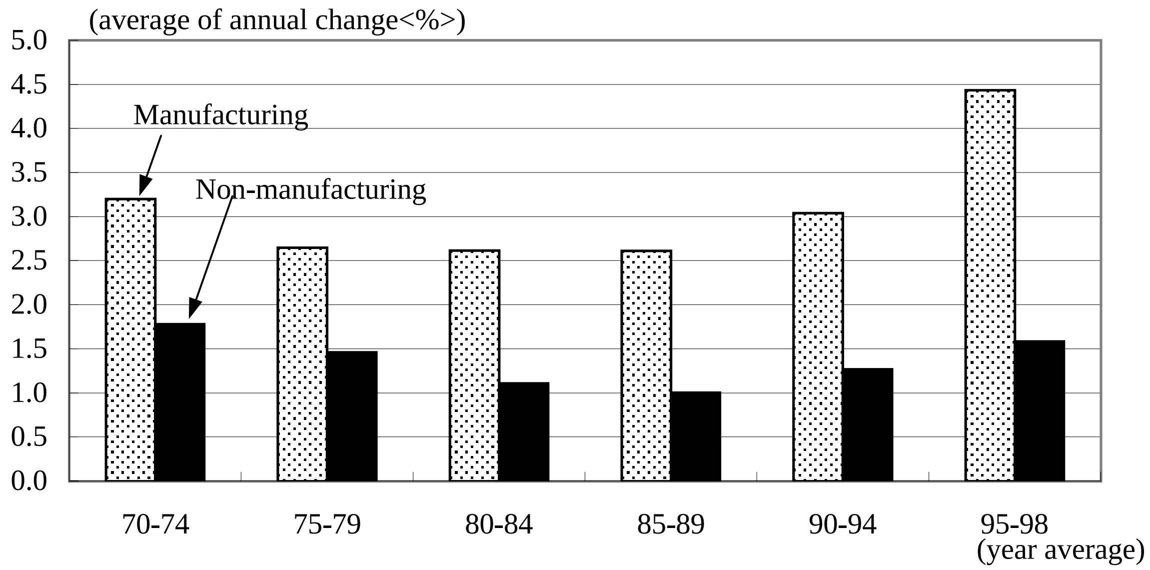
U.S. Department of Labor, "The Role of Computers in Reshaping the Work Force," *Monthly Labor Review*, August 1996

(Chart1) Labor Productivity (non-farm business sector)



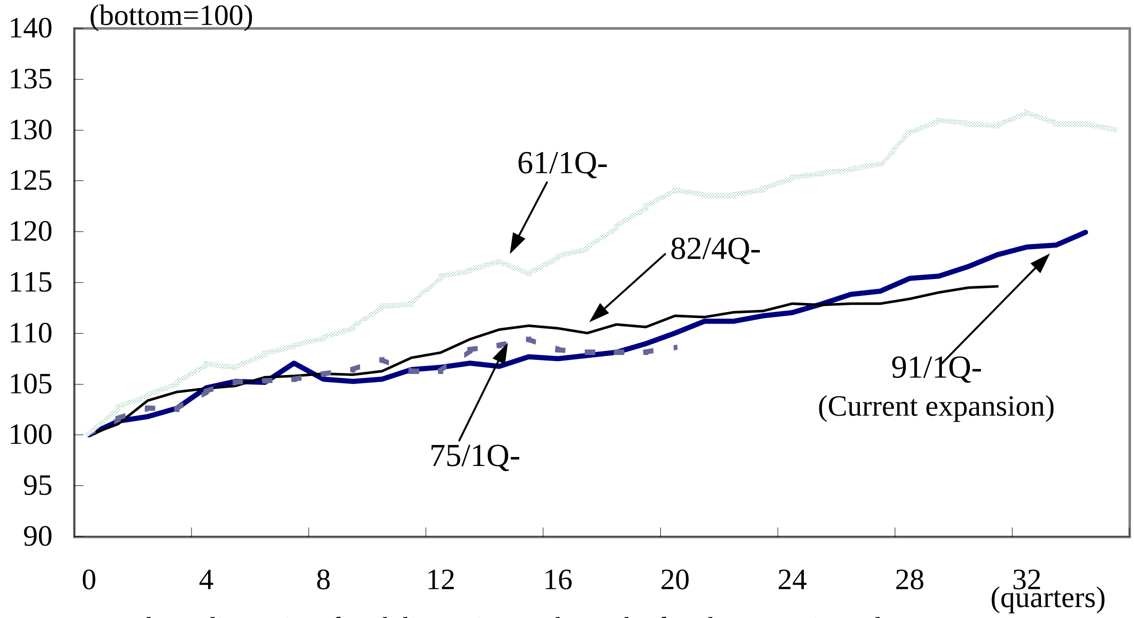
Note: For 1999, the average for 1Q-3Q is used.

(Chart2) Labor Productivity (manufacturing and non manufacturing sector)



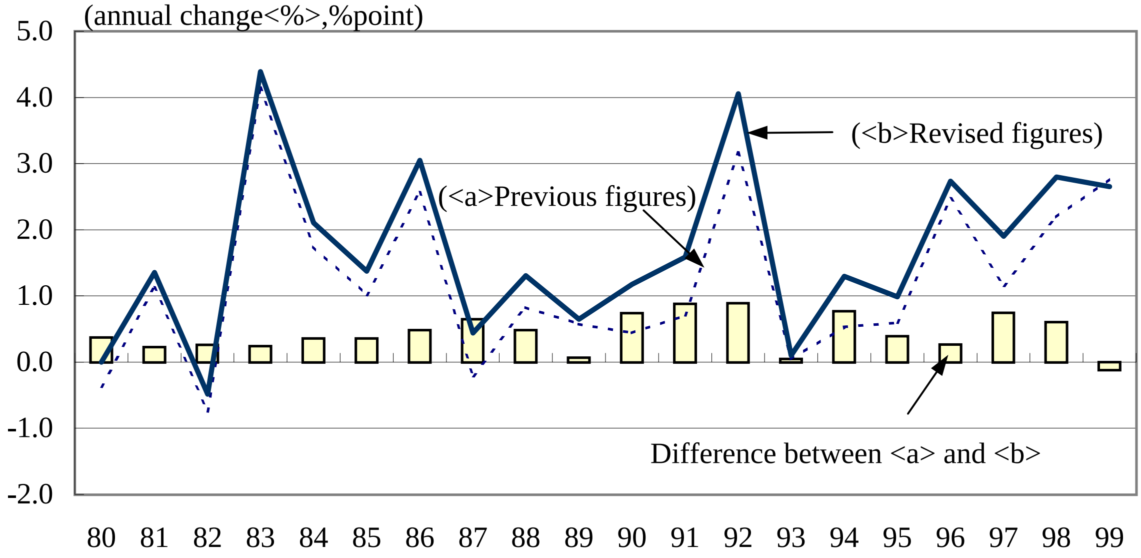
Note: Data for non-manufacturing are calculated from non-farm sector data and manufacturing data.

(Chart3) Labor Productivity and Economic Cycle



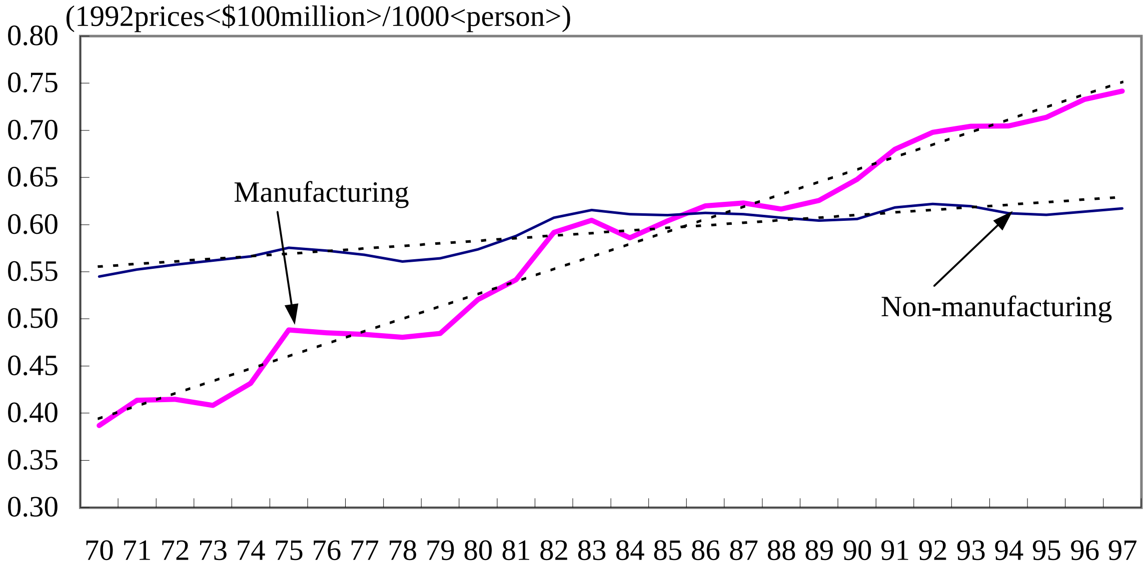
Note: The ending point of each line points to the peak of each economic cycle.
(As for the current expansion, the ending point points to the data for 99/3Q).

(Chart4) The Revision of Labor Productivity (Nov. 1999)



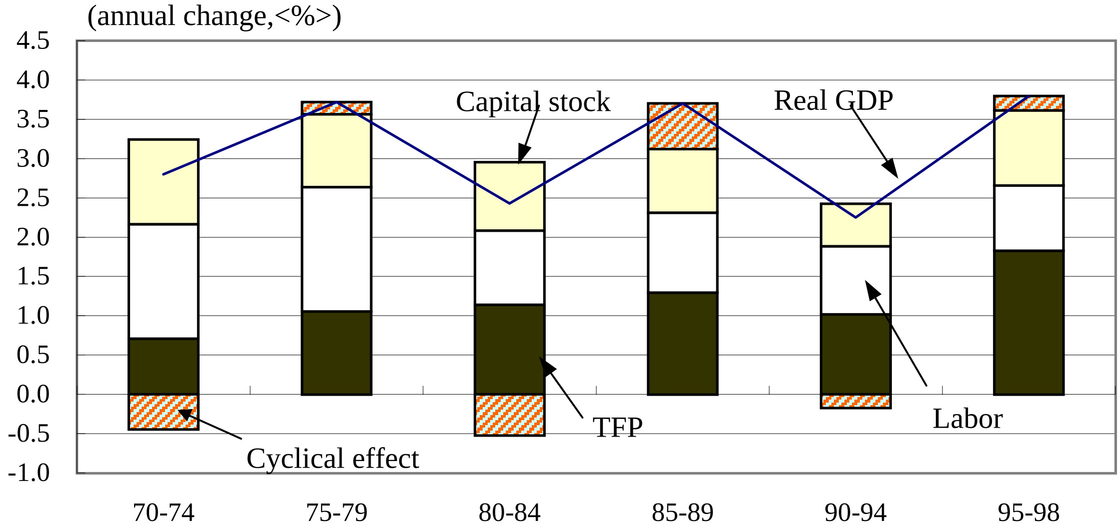
Note: For 1999 the average for 1Q-2Q is used.

(Chart5) Capital Equipment Ratio



Note: Capital equipment ratio=Capital stock/Number of employees

(Chart6) Decomposition of real GDP Growth



Note: Decomposition is based on the following Cobb-Douglas production function:

$$Y = T \times (\rho L)^{\alpha} \times (\tau K)^{1-\alpha}$$

where

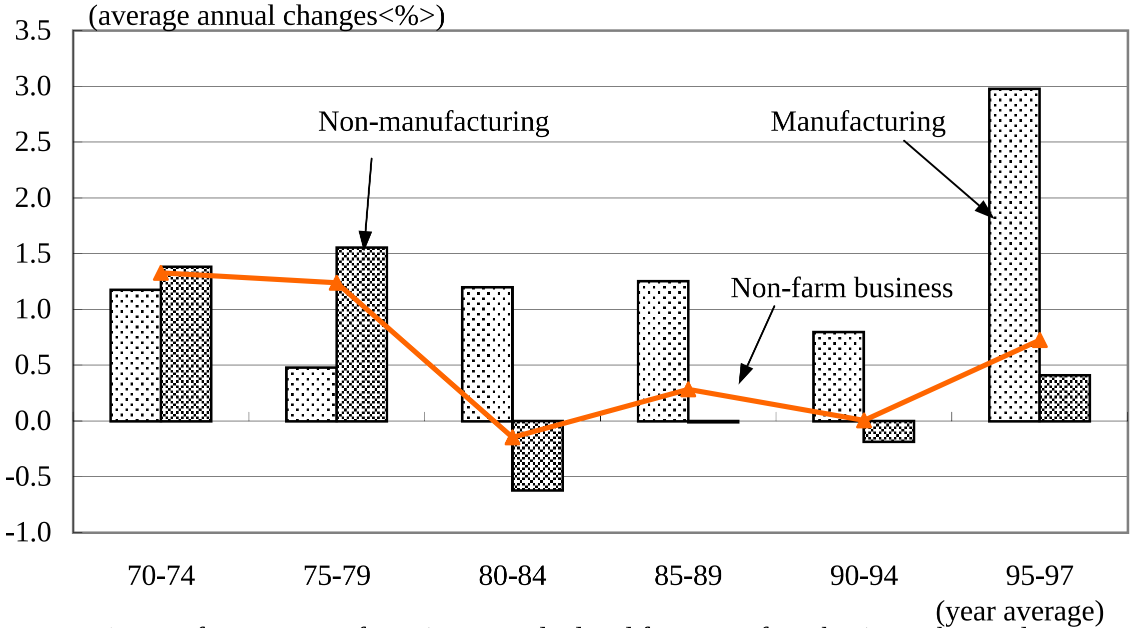
Y: real GDP, *L*: labor force ×working hours, *K*: real capital stock (including software),
T: total factor productivity, ρ : utilization of labor = (1- unemployment rate),
τ : capacity utilization, α : Income share of labor

Taking logarithms on both sides and differentiating by time, we obtain

$$\frac{\dot{Y}}{Y} = \frac{\dot{T}}{T} + \alpha * \frac{\dot{L}}{L} + (1-\alpha) * \frac{\dot{K}}{K} + \left(\alpha * \frac{\dot{\rho}}{\rho} + (1-\alpha) * \frac{\dot{\tau}}{\tau} \right)$$

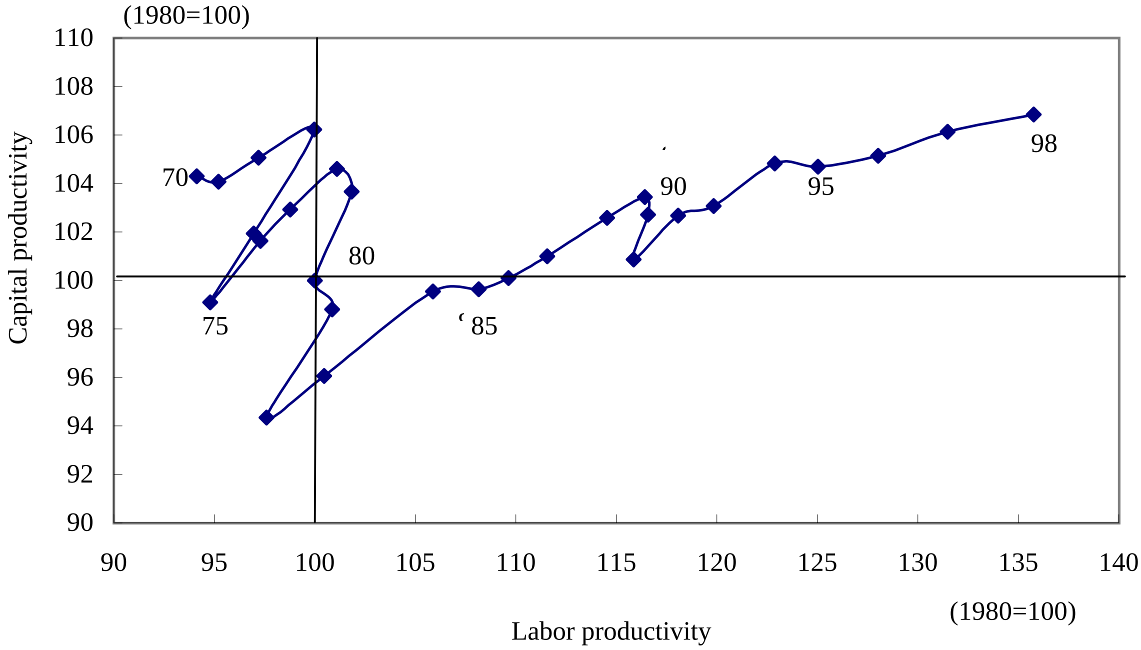
(Cyclical effects)

(Chart7) Total Factor Productivity (released by Department of Labor)



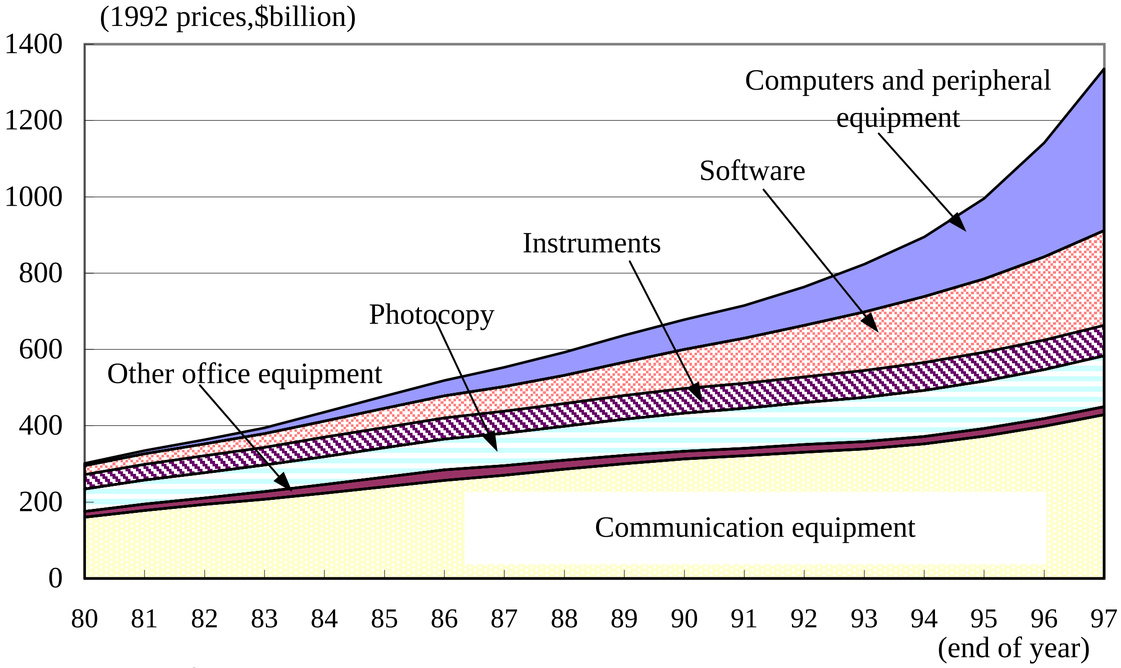
Notes: 1. Data for non-manufacturing are calculated from non-farm business data and manufacturing data.
2. For 95-97 TFP, the 95-96 average is used for manufacturing and non-manufacturing.

(Chart8) Labor Productivity and Capital Productivity



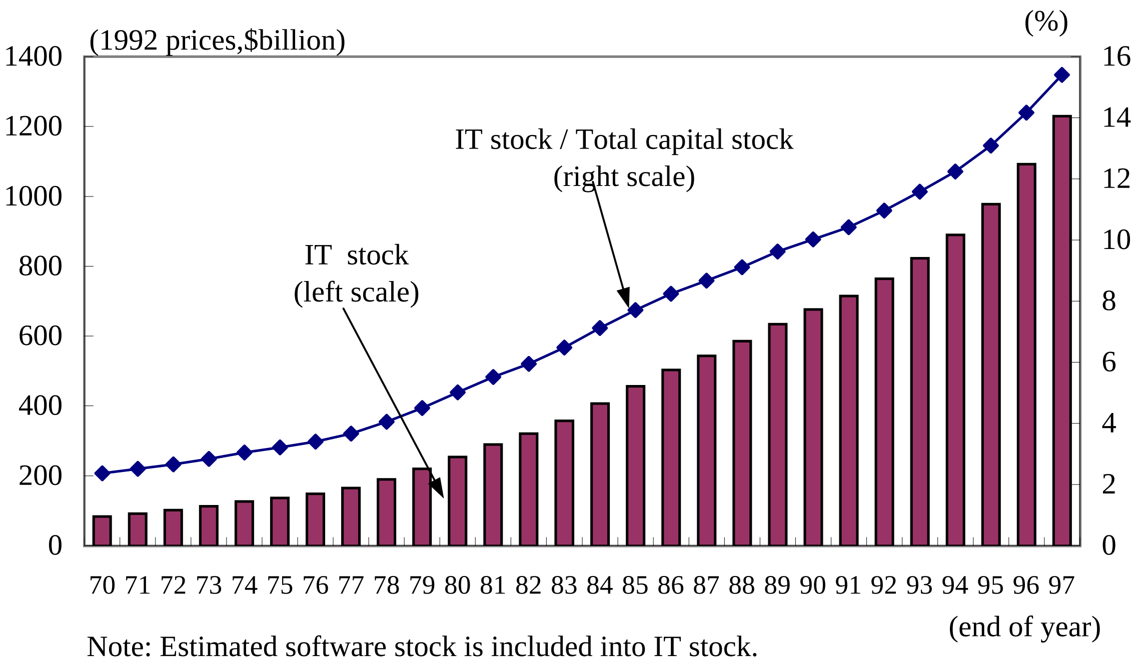
Notes: 1.Labor productivity=real GDP/number of employees,
2.Capital productivity=real GDP/real capital stock
3.Estimated software stock is included into real capital stock.

(Chart9) Components of ITstock



Note: Software stock is an author's estimation.

(Chart 10) The Share of IT Stock within Total Capital Stock



Note: Estimated software stock is included into IT stock.

(Chart 11) Gross Domestic Income of IT related Industries

(GDI, $bil, %)

	1994	1995	1996	1997	1998
Total	466.6	517.7	571.7	626.7	682.6
(Annual changes)	(n.a.)	(11.0)	(10.4)	(9.6)	(8.9)
(Share in total economy)	(6.7)	(7.1)	(7.5)	(7.8)	(8.1)
Hardware	155.9	183.6	209.6	232.1	254.1
Software/services	89.7	102.6	117.0	133.3	152.0
Communication equipments	36.3	39.9	45.0	48.1	51.3
Communications	184.6	191.6	200.2	213.2	225.2

Note: Figures after 1996 are prediction.
Source: US Department of Commerce[1998]

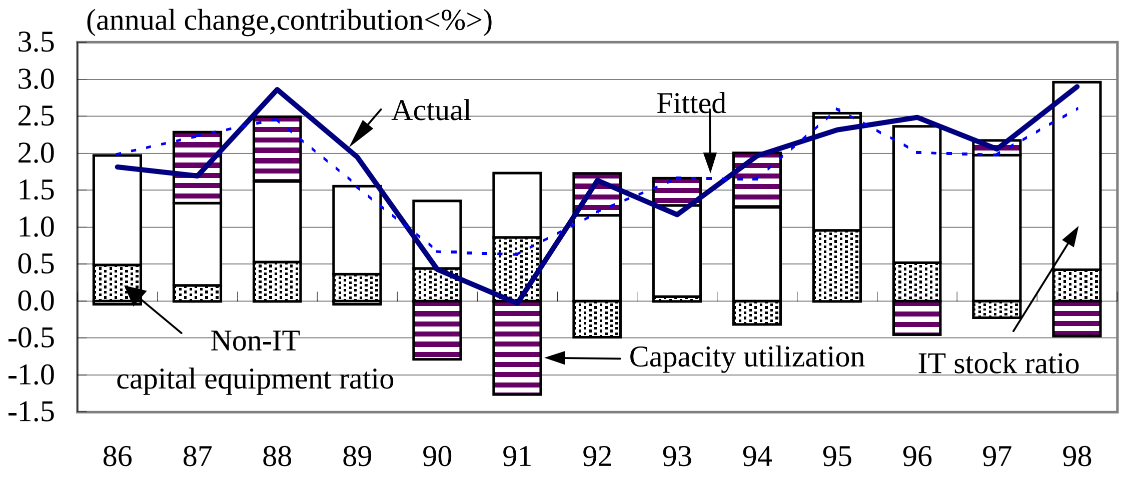
(Chart12) Marginal Rate of Return for IT stock

(annual%)

		Gross return on investment (A)	Depreciation rate (B)	Net rate of return (A)-(B)
Shinozaki				
	Non-computer capital	20.2	8.2	12.0
	Computer capital	63.9	15.8	48.1
Brynjolfsson&Hitt				
	Non-computer capital	6.3	n.a.	n.a.
	Computer capital	81.0	14.0	67.0

Note: Shinozaki's estimation is based on macro statistics. Brynjolfsson&Hitt used data of 380 companies, which made IT investments during 87-91.
Source: Shinozaki [1996], Brynjolfsson and Hitt [1996]

(Chart13) Regression of Labor Productivity (all industries)



Note:

(Estimation) $ln(LP)=0.665*ln(K_1/L)+0.206*ln(K_0/K_1)+0.266*ln(CU)$

(21.9) (61.9) (7.8)

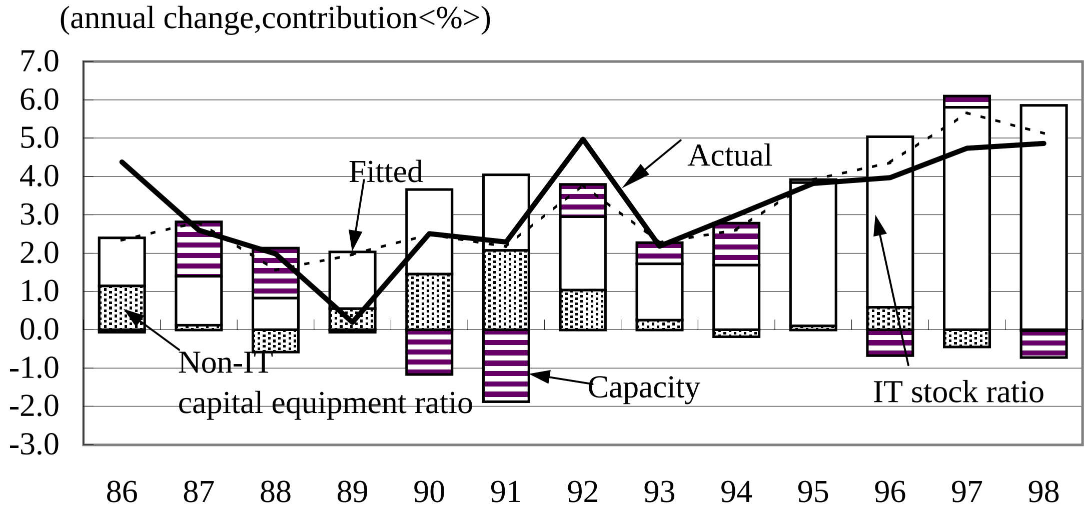
where

LP: labor productivity, CU: capacity utilization rate

K_1: non-IT stock, K_0: IT stock, L: labor input, $AdjR^2=0.998$, D.W.=1.34,

sample period: 80-98, figures in the parenthesis are t-statistics.

(Chart14) Regression of Labor Productivity (manufacturing)



Note:

(Estimation) $ln(LP)=0.478*ln(K_1/L)+0.329*ln(K_0/K_1)+0.433*ln(CU)$

(9.4) (32.9) (9.8)

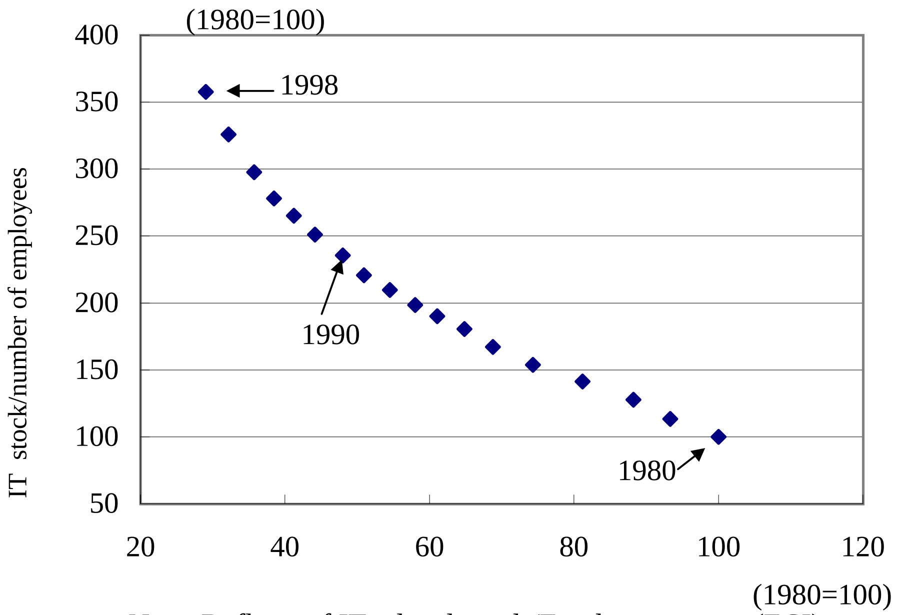
where

LP: labor productivity, CU: capacity utilization rate

K_1: non-IT stock, K_0: IT stock, L: labor input, $AdjR^2=0.996$, D.W.=1.72,

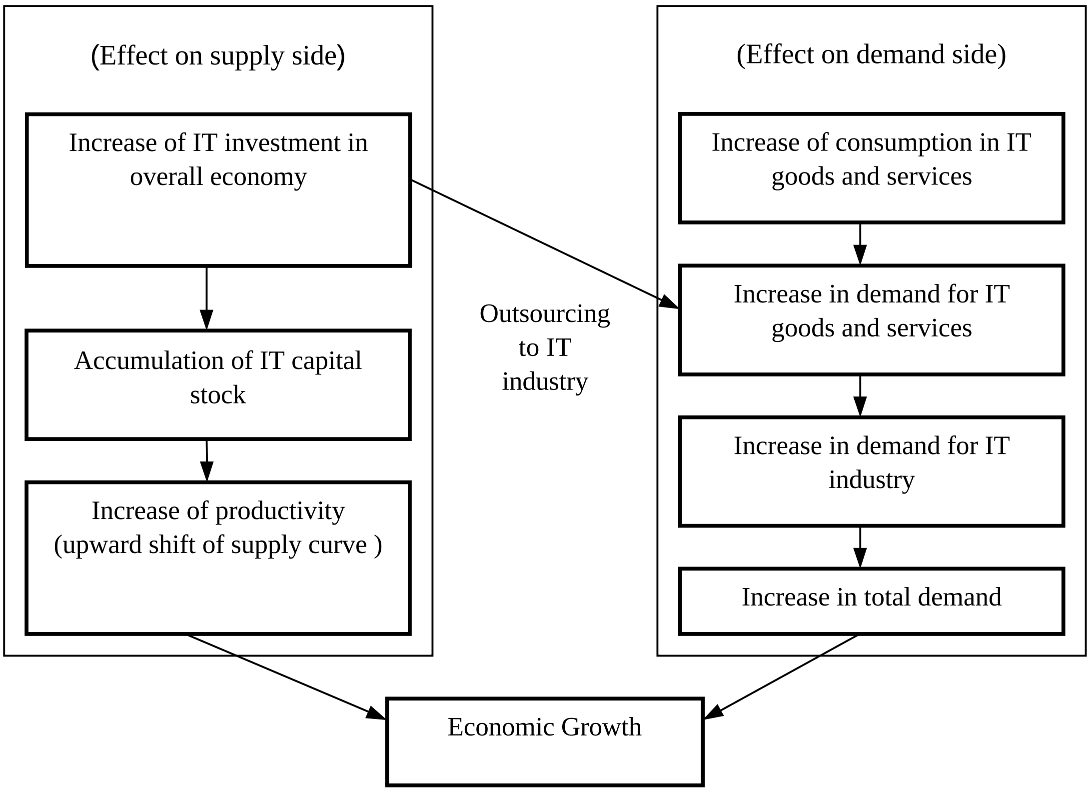
sample period: 80-98, figures in the parenthesis are t-statistics.

(Chart15) IT stock/Number of Employees



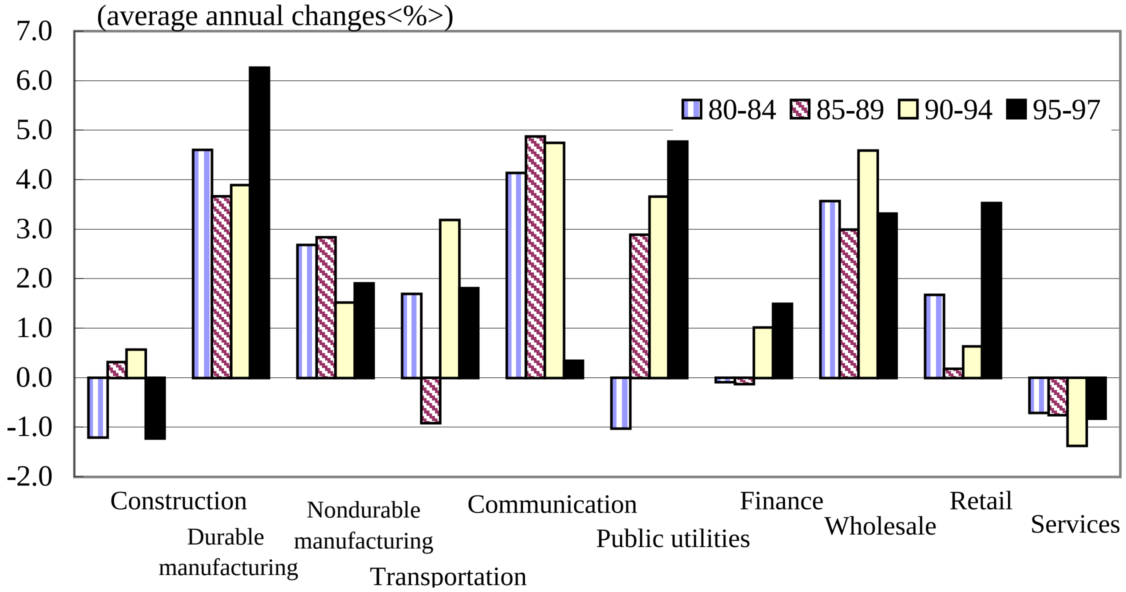
Note: Deflator of IT related goods/Employment cost (ECI)

(Chart16) Effect of the Expansion of IT related Industries on the Macro economy



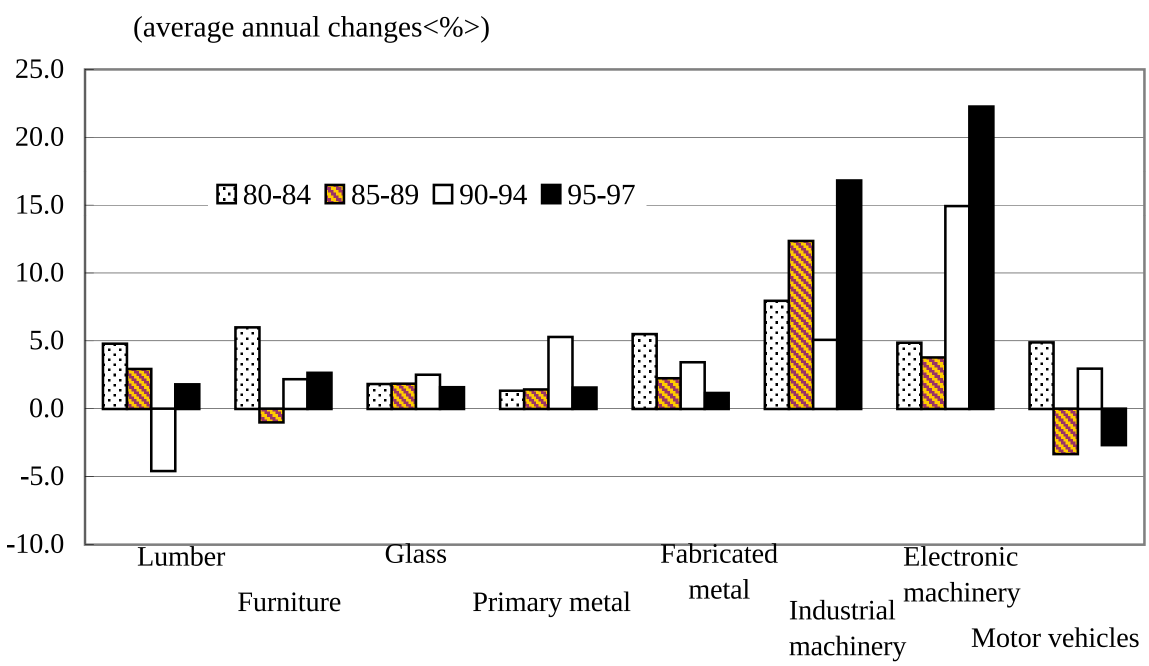
Source: Inoue (1997)

(Chart17) Labor Productivity by Industry

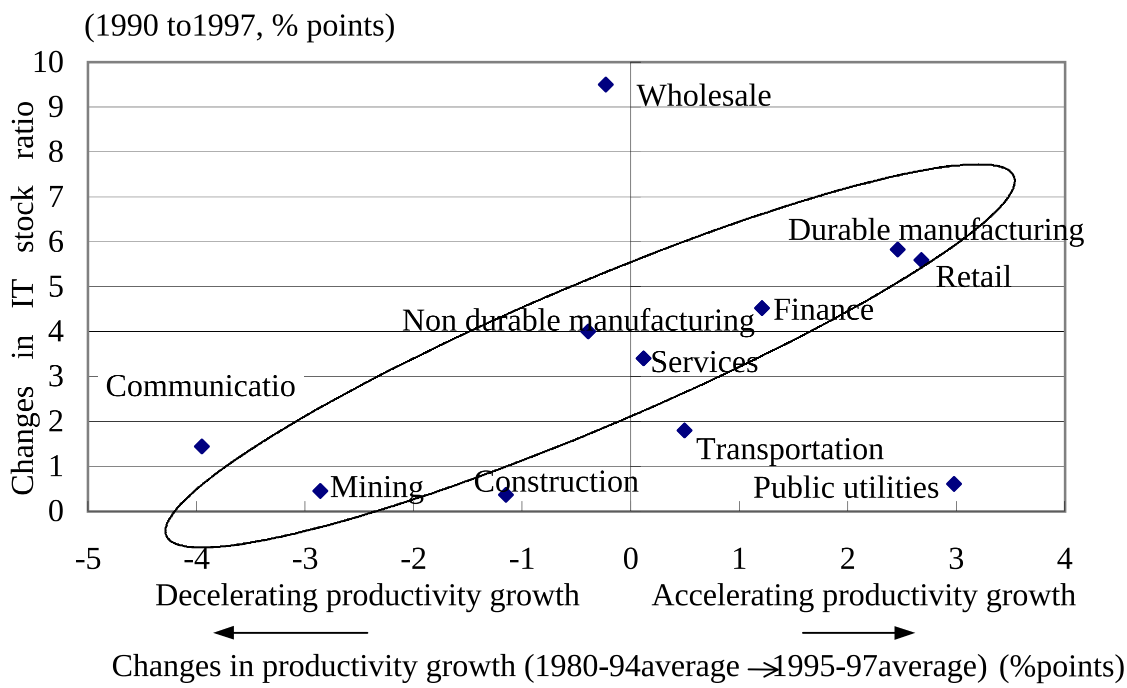


Note: The labour productivity was calculated by dividing real GDP of each industries by the number of employees(same below).

(Chart18) Labor Productivity by Industry (durable manufacturing)

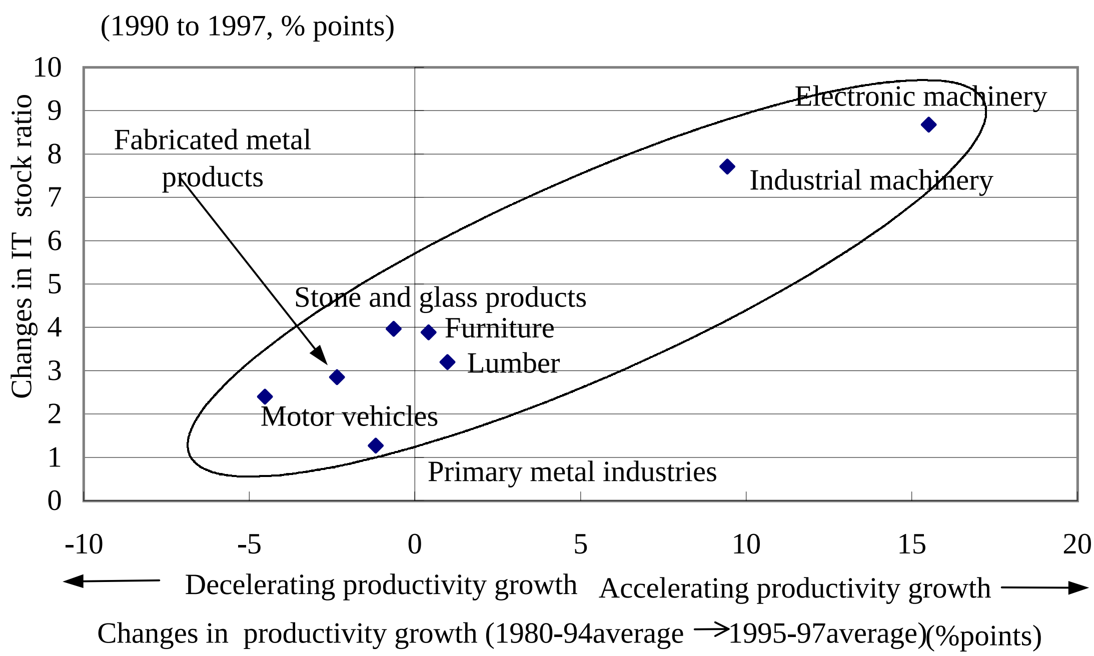


(Chart19) Correlation between ITstock and Labor Productivity (all industries)

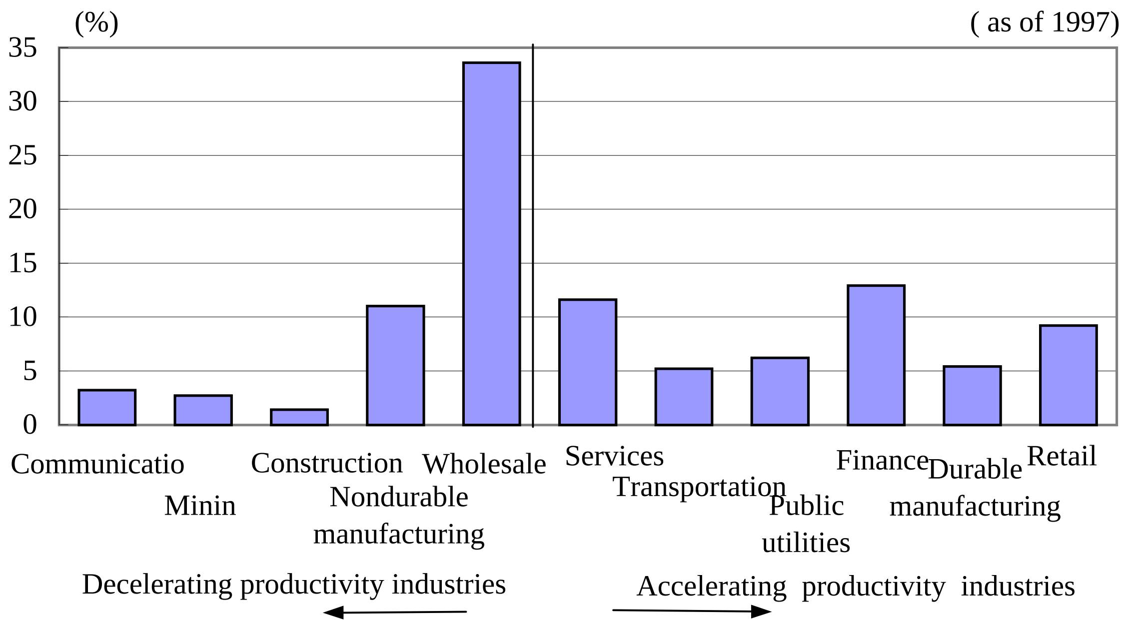


Notes: 1. Services exclude business services.
2. IT stock ratio= IT stock/ Total capital stock

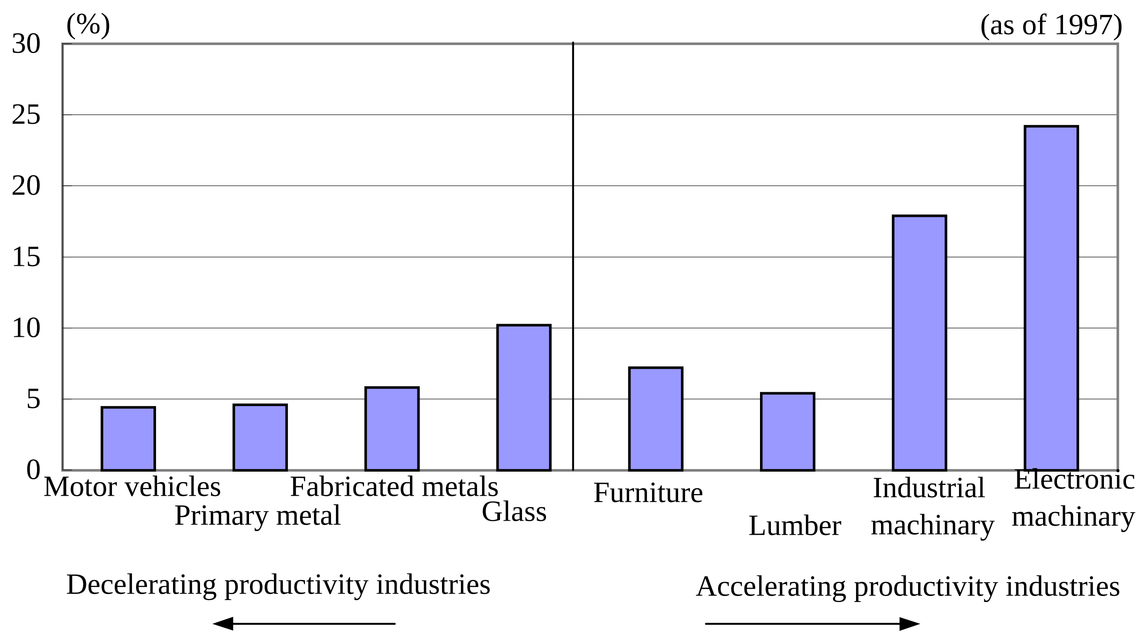
(Chart20) Correlations between IT stock and Labor Productivity (durable manufacturing)



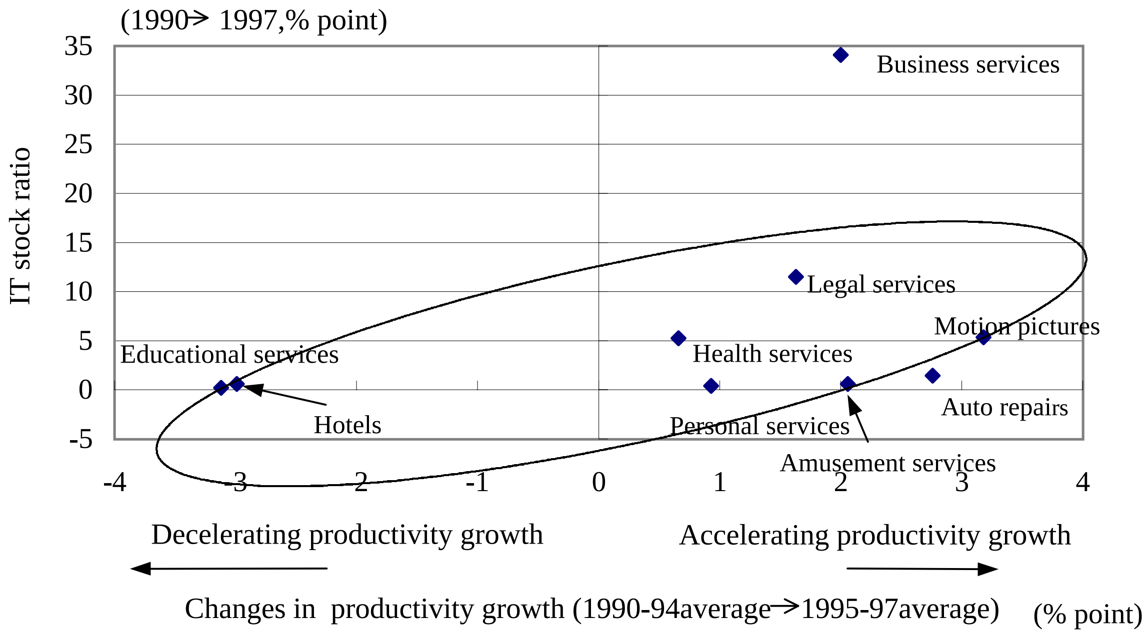
(Chart21) IT Stock Ratio by Industry (all industries)



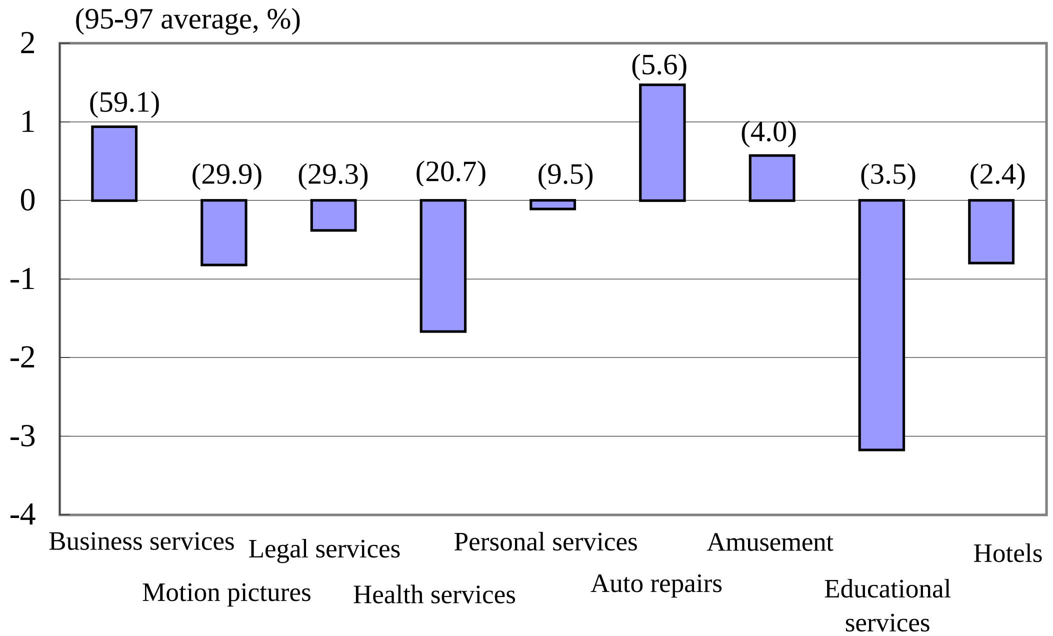
(Chart22) IT Stock Ratio (durable manufacturing)



(Chart23) Correlation between IT Stock and Labor Productivity (service industries)

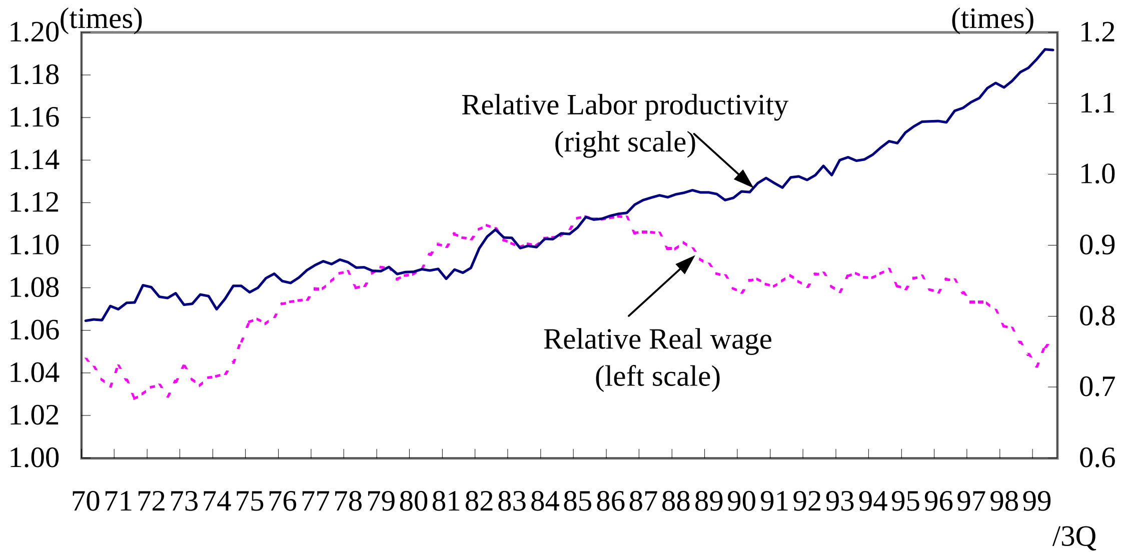


(Chart24) Labor Productivity of Service Sector



Note: IT stock ratio is shown in the parenthesis.

(Chart 25) Relative Real Wage and Relative Labor Productivity of Manufacturing



Note: Both wages and productivity are expressed as the ratio of manufacturing to the industry total.

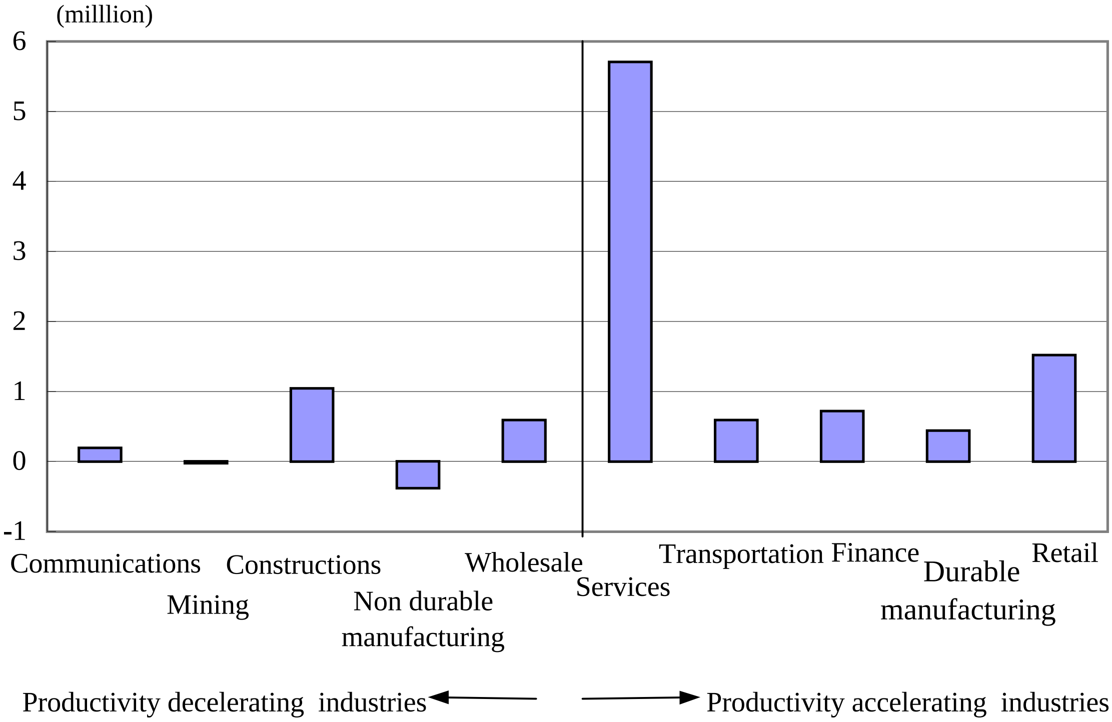
(Chart26) The Composition of Occupations

(%, %points)

		Executive	Professional	Technicians	Sales	Administrative support	Service	Blue collar
Productivity accelerating industries	Durable manufacturing	12.6--14.3 (+1.7)	9.6--10.8 (+1.2)	4.1--3.4 (-0.7)	2.5--2.5 (+0.0)	10.4--9.0 (-1.4)	1.4--1.2 (-0.2)	59.4--58.9 (-0.5)
	Finance	26.3--28.9 (+2.6)	3.1--4.1 (+1.0)	2.0--1.9 (-0.1)	24.3--24.9 (+0.6)	36.9--33.2 (-3.7)	3.6--3.8 (+0.2)	3.8--3.1 (-0.7)
	Retail	8.1--8.7 (+0.6)	1.7--2.1 (+0.4)	0.6--0.9 (+0.3)	41.8--42.1 (+0.3)	7.7--6.5 (-1.2)	23.4--23.2 (-0.2)	16.5--16.7 (+0.2)
Productivity decelerating industries	Construction	13.0--16.2 (+3.2)	1.9--1.7 (-0.2)	0.6--0.6 (+0.0)	1.0--0.7 (-0.3)	5.4--4.9 (-0.5)	0.5--0.3 (-0.2)	77.6--75.7 (-1.9)
	Mining	15.3--16.3 (+1.0)	11.2--10.2 (-1.0)	3.5--3.1 (-0.4)	0.7--1.8 (+1.1)	11.0--8.7 (-2.3)	1.2--1.4 (+0.2)	57.3--58.6 (+1.3)

Note: Figures are the occupation share for 1993 and 1998, respectively.
(Figures in the parenthesis are the changes in occupation share during this period)

(Chart 27) Changes in the Number of Employees by Industry



Note: The changes between January 1995 and December 1998.

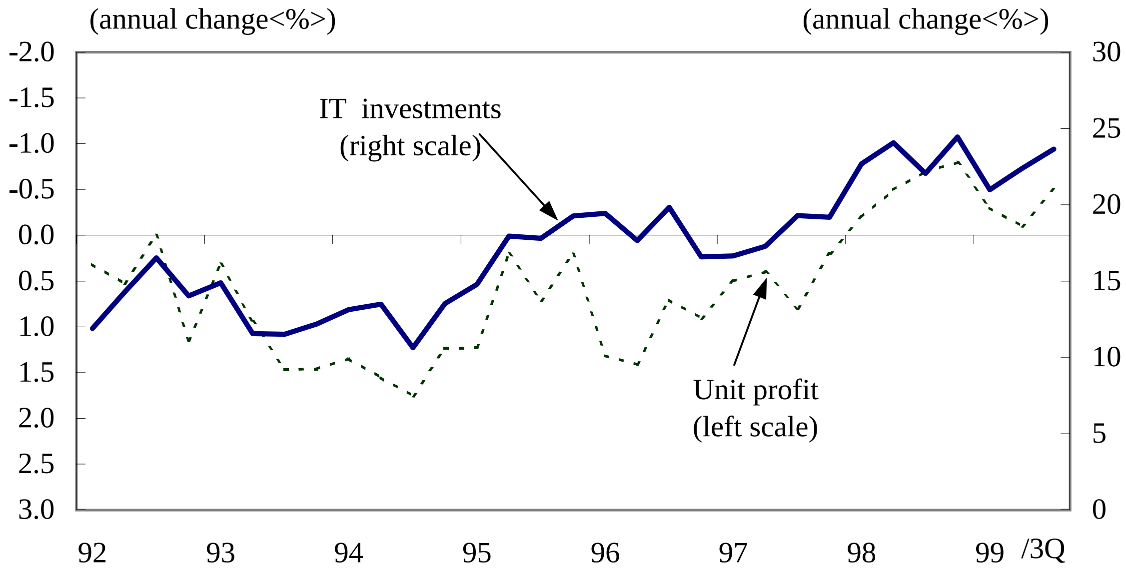
(Chart 28) Variance of Capacity Utilization Rate (manufacturing)

(%)

	Productivity accelerating industries	Productivity decreasing industries
Nov.1970-Nov.1973	27.0	25.6
Mar.1975-Jan.1980	32.4	30.0
Nov.1982-Jul.1990	19.2	22.7
Mar.1991-Oct.1999	8.1	13.5

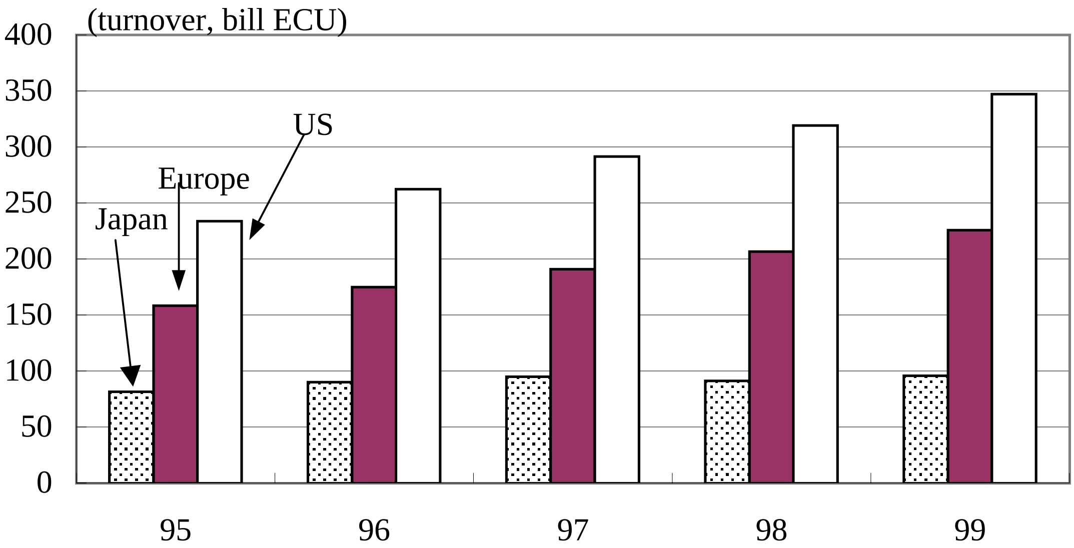
Note: Productivity accelerating industries are; industrial machinery, electronic machinery, lumber, furniture, tobacco, apparel, printing equipment, oil.

(Chart 29) IT investments and Unit Profits



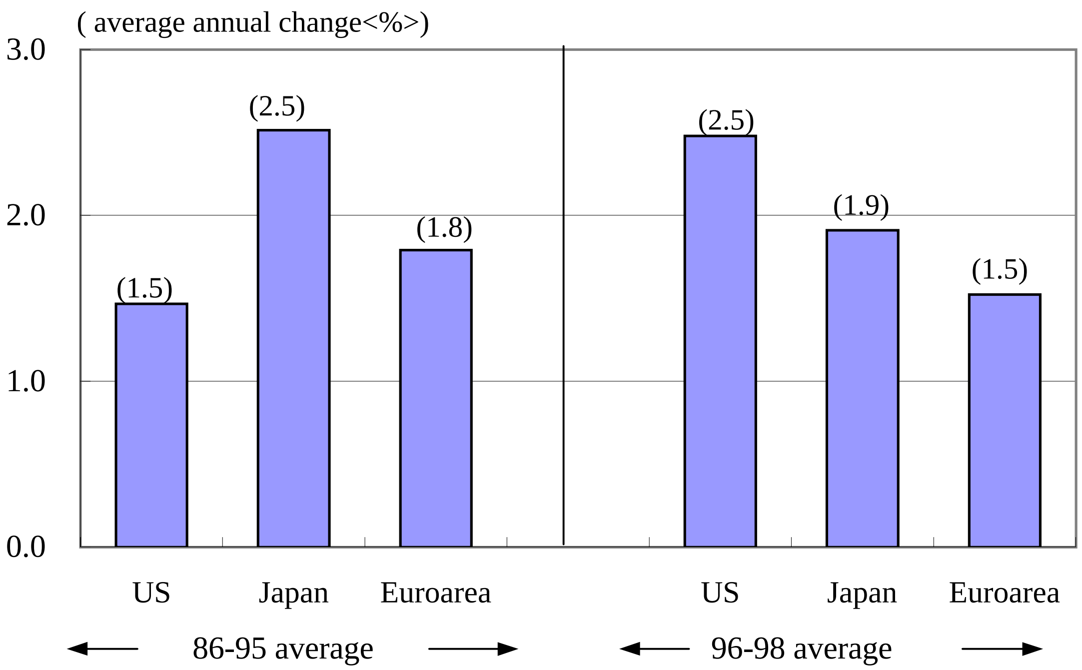
Note: Unit profit is calculated by decomposing GDP deflator.

(Chart 30) Turnover of IT Industries



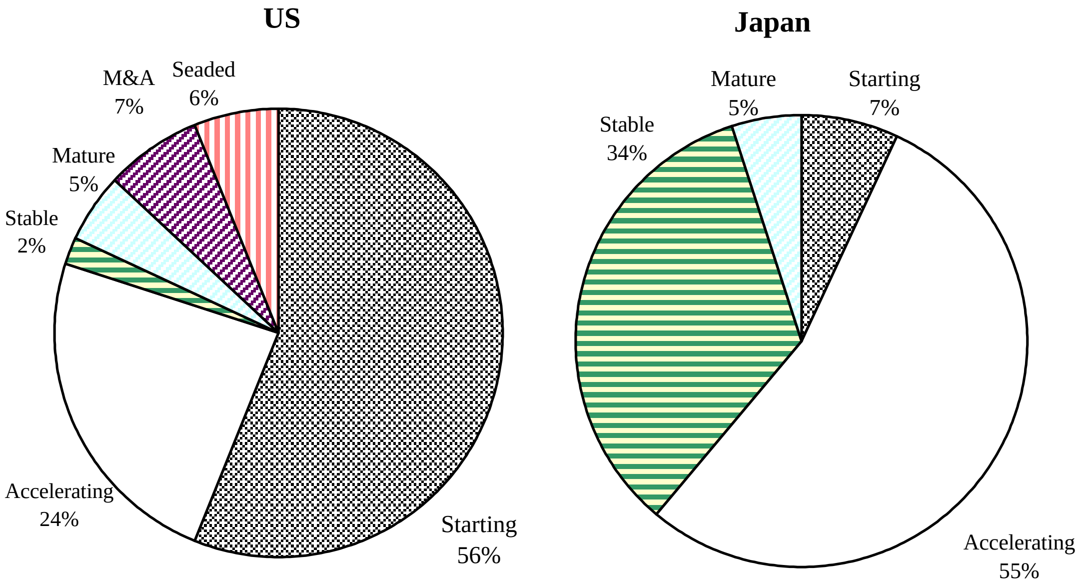
Notes:1. Figures after 98 are forecasts by European Information Technology Observatory.
2.Europe includes Eastern Europe.
Source: European Information Technology Observatory[1999]

(Chart31) International Comparison of Labor Productivity



Notes: 1. US: real GDP of nonfarm business / labour input (from US Department of Labor)
2. Japan: real GDP / total working hours* number of regularly employed
3. Euro area: real GDP / number of employed (excluding Austria and Luxembourg <from ECB>)

(Chart32) Companies Receiving Investment by Venture Capitals



Note: The growth stages of venture companies are categorized into the following stages; seaded-- starting--accelerating--stable--mature.

Source: Small and Medium Enterprise Agency [1997]

(Chart 33) Employment Protection System in G7 Countries

(point)

	Regular procedural inconveniences	Notice for no-fault dismissals	Difficulty of dismissal	Aggregate index
US	0.0	0.0	0.5	0.2
Japan	2.0	1.8	4.3	2.7
Germany	3.5	1.3	3.5	2.8
France	2.8	1.5	2.8	2.3
UK	1.0	1.1	0.3	0.8
Italy	1.5	2.9	4.0	2.8
Canada	0.0	0.8	2.0	0.9

Note: The figures show the degree of strictness of the regulations (the larger the more strict).
Source: OECD[1999a]

(Chart34) Job Gains and Job Losses

		US (84-91)	Japan (85-92)	Germany (83-90)	France (84-91)	UK (85-91)
Gross job gains		13.0	(12.7)	9.0	12.7	8.7
	Openings	8.4	(4.1)	2.5	6.1	2.7
	Expansions	4.6	8.6	6.5	6.6	6.0
Gross job losses		10.4	(8.6)	7.5	11.8	6.6
	closures	7.3	(3.3)	1.9	5.5	3.9
	contractions	3.1	5.3	5.6	6.3	2.7
Net employment change		2.6	(4.1)	1.5	0.9	2.1

Notes: 1. Annual rates as a percent of total employments
2. For Japan the sources of figures in parenthesis are Yamada(1998) (sampling period is 91-94).

Source: OECD [1996] , Yamada [1998]