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The Contribution of Information Technology to Productivity Growth

--International Comparison--

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Summary

(1) In the US, the acceleration of labor productivity growth that started from 1996 had entered a fifth year by mid-2000, leading to a growing consensus that the progress of IT innovation has contributed to a structural improvement in labor productivity. According to some analyses, the contribution of IT is estimated to have accounted for more than half of the acceleration in US productivity growth during the late 1990s. Furthermore, in a number of other countries such as Australia, Canada, and Norway, robust economic growth in the late 1990s led by IT was also observed. This paper examines the following: (1) the contribution of IT to labor productivity growth in the US; (2) international comparison of the size of the IT industry and IT capital deepening in developed countries and the contribution to labor productivity; and (3) reasons for the international difference in labor productivity growth in the late 1990s, and the extent to which IT contributed to the formation of this gap.

(2) The progress of IT has pushed up labor productivity in the following ways: (1) through an increase in Total Factor Productivity (TFP) in IT industries. (2) IT capital deepening; and (3) positive synergistic effects between the IT capital stock and other capital stock or labor. As for the US in the late 1990s, the growth rate of labor productivity increased by one percentage point compared to the long-term trend. Previous studies show that factor (1), improved efficiency in IT industries and factor (2), IT capital deepening accounted for 50-70% of the increase in the

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growth rate of labor productivity. Furthermore, as there is a strong correlation between TFP and IT stock ratio i.e. IT stock/total capital stock by industries, the contribution of factor (3), positive synergitic effect is also considered to be significant. Thus, the contribution of IT to the increase in labor productivity is quite substantial.

(3) In order to examine the extent to which IT pushed up labor productivity growth in countries other than the US, I compared the economic performance of the developed countries in the 1990s. In OECD countries as a whole, average GDP growth was slowing down in the 1990s compared to the 1980s. The labor productivity growth rate did not show any remarkable increase, either. Yet, in Scandinavian countries such as Sweden, Norway, and Finland as well as English speaking-countries such as the US, Canada, and Australia, GDP growth and the growth rate of labor productivity accelerated.

(4) I examined the effect of IT on the labor productivity growth by decomposing labor productivity growth into the previous mentioned three factors. As for factor (1), improved efficiency in IT industries, in Scandinavian countries such as Sweden and Finland, where IT industries are growing rapidly, the contribution of IT is large. In these countries it is probable that the expansion of IT industries has contributed to labor productivity growth to a substantial extent, even more so than in the US. As for factor, (2) capital deepening, as a result of the active IT investment in English-speaking countries such as the UK and Australia, IT stock has contributed considerably to labor productivity growth. With respect to factor (3), substantial synergistic effects are observed in English-speaking countries, where goods and labor markets are less regulated and the progress of capital deepening is rapid. There is a possibility that the accumulation of IT stock has achieved synergistic effects simultaneously in these countries.

(5) Because not enough data regarding IT innovation has been accumulated, we should be careful how we treat the above findings. However, in many countries that achieved strong growth in the 1990s, rapid progress in IT innovation in the form of growth in IT industries or IT capital deepening is observed. On the other hand, IT innovation tended to be slow in countries with poor economic performance. This shows that IT has a considerable effect on economic growth through the supply side. Also, the difference in the progress of IT actually exerted an influence upon the differences in economic performance during the 1990s in industrial economies.

(6) By looking at the background to the gaps in IT capital deepening and TFP growth by country, we can observe that there is a high correlation between IT innovation and the strictness of regulations in goods and labor markets. In countries with high TFP growth, regulations are generally lenient. On the other hand, in highly regulated countries, there is less competition between companies since corporate governance structures are not functioning effectively. Such an environment can curb the incentive to invest in IT, thus, in such an uncompetitive environment, it is hard to encourage TFP growth.

(7) When we turn to Japan, the size of IT industries is relatively large. However, IT capital deepening is much lower compared to English-speaking countries such as the US, Australia, and the UK. It means that there is a need to activate IT investment on the user side and, in order to realize this, it is important to provide a competitive environment for corporate activity.

1. Introduction

In the US, the growth rate of labor productivity had been sluggish for a long period. But, after 1996, and especially in 2000, it exhibited remarkable growth, promoting the belief that the progress of IT innovation has contributed to the structural increase in labor productivity[2]. According to some analyses, the contribution of IT is estimated to account for more than half of the increase in labor productivity growth in the late 1990s.

On the other hand, since demand for IT goods and services expanded worldwide in 1999 and 2000, it is expected that such productivity growth stemming from IT could also be the experience of other countries, including Japan. However, there is still not enough quantitative data regarding the relationship between productivity growth and IT. The relation between IT innovation and productivity growth has only just started to become clear in the US. And, as for other countries, not enough data has been accumulated regarding IT, and thus, it is not easy to grasp the development of IT innovation. But recently, some organizations such as OECD have started to accumulate IT-related data, making international comparison possible to some extent.

In this paper, I examine the route through which labor productivity is improved by IT, and then, based on the previous studies, examine to what extent IT has contributed to productivity growth in the US[3]. Next, I compare the progress of IT innovation in each developed country, and the contribution of IT to productivity in the countries.

2. Contribution of IT to productivity growth in the US

(1) Labor productivity in the US

First, let us look at labor productivity in the US. Labor productivity of the non-farm business sector had been sluggish from the 1980s to the mid-1990s. Since around 1996, however, it has started to show remarkable growth: average annual growth between 1980 to 1995 was +1.4%, but after 1996 accelerated to +2.7%, and after entering 2000 jumped to +4.5% for the first half (Chart1-1).

Such high growth leads to a saving in the input of labor to attain a certain level of

[2] FRB Chairman Alan Greenspan has frequently commented on the possibility of structural changes in productivity. For example, his remarks at the Monetary Report to the Congress in July 2000 are as follows: “So far there is little evidence to undermine the notion that most of the productivity increase of recent years has been structural and that structural productivity may still be accelerating.”
[3] Saito[2000] made an extensive analysis of the contribution of IT to labor productivity in the US.

output. Thus, the US economy has been able to continue to expand for a long period and, especially after 1999, economic growth accelerated simultaneously with a rise in labor productivity, leading to the stable growth of labor input (Chart1-2).

(2) Routes via which IT contributes to labor productivity growth

Next, the contribution of IT to labor productivity is examined. Progress in IT innovation can bring labor productivity growth in many ways. But the best known routes are as follows. (a) Improved efficiency in IT industries, i.e. the increase in Total Factor Productivity (TFP). (b) The deepening of IT capital. These two are considered to comprise the minimum impact on productivity. As mentioned later, in recent analyses these two have been quantified to measure the impact on labor productivity. As for the impact on productivity in a broad sense, (c) positive synergistic effects between IT capital stock and other capital stock or labor, should be considered. This last route[4] has a unique effect on IT stock in the following two ways. First, IT, or the Internet, has made inventory control much more efficient. Second, it allows more efficient transactions by lowering search costs. The following section will examine these three points in detail.

(a)Efficiency improvement in the IT industries: contribution from the production side

The first route is the efficiency improvement in IT industries such as the computer and semiconductor industries. This is considered to be the contribution of IT on the production side. Under rapid technological innovation, IT industries have succeeded in reducing output prices and expanding their profits. This is nothing but the achievement of rapid productivity growth. The increase in the share of IT industries contributes to an increase in the labor productivity of the whole economy.

(b) IT capital deepening

The second route of the contribution of IT to productivity growth is through IT capital deepening, which is a contribution on the user side of IT. According to standard growth accounting analysis, output growth can be decomposed into labor input, capital input, and technological progress. Labor productivity can be decomposed into

[4] The accumulation of IT stock not only increases capital stock per worker (capital deepening), but also brings about a synergistic effect. When we consider the effect of labor productivity growth brought about by IT, we may regard these two effects as a single effect. But, in this paper, we consider these two factors separately according to the growth accounting framework.

technological progress and the capital equipment ratio (capital stock per worker). As companies actively invest in IT and IT capital stock accumulates, labor productivity should increase.

(c) Synergistic effects of IT capital stock

The third route is the synergistic effect of IT capital deepening on other capital stock and labor. Generally, this is measured as an increase in the TFP of IT users. When companies use IT equipment such as computers to control capacity utilization or the input of raw materials, the efficiency of current capital stock could increase. And, when companies introduce IT equipment, it helps to improve organizational flexibility and quite often increases the efficiency of labor resources. Also, through the development of Internet transactions such as business-to-business transactions, corporate efficiency can also increase through network externalities.

(3) IT's contribution to productivity growth in the US

Through these three routes, I have quantitatively examined the contribution of IT to productivity growth in the US, based on the previous analysis.

(A) Contribution of IT in a narrow sense

(a) Efficiency improvement in IT industries

Labor productivity in IT industries as represented by computers and electronic components[5] accelerated in the 1990s, and, especially after 1998, the productivity of the computer industry posted annual growth of +60% (Chart 2-1).

The increase in productivity can also be confirmed from the fact that IT-related industries are maintaining high profits, while their output prices are falling. If we look at the profit and output prices of general machinery industries, which included the computer industry from 1987 to 1998, output prices dropped about 40% while profit expanded four times the original level (Chart 2-2).

It is characteristic that such an increase in productivity was brought about by an increase in TFP. According to the analysis by Oliner and Sichel [2000][6], the TFP growth of IT industries accelerated in the late 1990s with semiconductor industries

[5] Calculated as follows: Production index of IT industries/Number employed.
[6] Oliner and Sichel [2000] calculate the TFP using the standard growth account framework. The contribution of IT industries to TFP is calculated using income weight by industry. The same method is also used for in Jorgenson and Stiroh[2000] and CEA[2000].

showing a remarkable increase: annual average growth for 1996-99 in the computer industry was +16.3%, and in the semiconductor industry, +45.0% (Chart 3-1). The contribution of IT industries to the TFP growth of all industries for the same years was +0.47, which accounts for about 40% of the TFP growth of all industries (+1.25%). Compared to the average of 1991-95, the TFP growth rate of all industries for 1996-99 was +0.7 percentage points higher, of which the contribution from IT industries was +0.3 percentage points (Chart 3-2). Looking at the estimation results of other analyses, Jorgenson and Stiroh [2000] show that during 1996-98 compared to 1990-95, the IT sector contributed to the acceleration of the TFP growth of all industries by +0.2 percentage points. Also, CEA[2000], having compared 1973–95 and 1996-99, estimated that in the latter half of the 1990s the IT industry contributed to the acceleration of TFP growth by +0.2 percentage points.

(b) IT capital deepening

IT investment in the US has posted rapid growth. The annual growth rate for the first half of 2000 was over +25% (Chart 4). As a result, the share of IT investment to total investment reached 47% in the first half of 2000, translating into a rapid IT capital accumulation. By the end of 1999, the share of IT stock in total capital stock reached about 14% (Chart 5).

Next, the contribution of IT to productivity growth, estimated by growth account analysis[7] was an average +0.45 percentage points annually during 1974-90, +0.48 percentage points during 1991-95, and +0.94 percentage [8] points during 1996-99 (Chart 6).

(c) Total of (a) and (b)

We have so far examined the contribution of IT to productivity growth through two routes. Route (a) is the TFP increase in IT industries and route (b) the accumulation of IT stock i.e. increase in capital equipment ratio of the IT users. In many of the recent studies, these two routes are combined and considered to be the contribution of IT to productivity in a narrow sense. For example, Oliner and Sichel[2000] estimated the

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[7] $\dot{Y}-\dot{L}=\left[\alpha_C\left(\dot{K}_C-\dot{L}\right)+\alpha_{SW}\left(\dot{K}_{SW}-\dot{L}\right)+\alpha_M\left(\dot{K}_M-\dot{L}\right)+\alpha_o\left(\dot{K}_o-\dot{L}\right)\right]+\alpha_L\dot{q}+T\dot{F}P$

Where: Y= real GDP, L= labor input, K_c= computer stock, K_{sw}= software stock, K_M= communication equipment stock, K_o= non-IT stock, q= quality of labor, α= income weight.

[8] Whelan[2000] and CEA[2000] estimate that IT capital deepening has pushed up the productivity growth by about +0.5 percentage points in the latter half of the 1990s.

labor productivity growth rate to increase by around 1 percentage point between 1996-99 and 1991-95 (+1.6% to +2.7%), of which the contribution of IT, the total of (a) and (b), is about the two-thirds, 0.8 percentage points (Chart 7). CEA[2000] also shows that the contribution of IT to the acceleration of productivity growth during 1996-99 compared to 1973-95 accounts for almost half.

Jorgenson and Stiroh[2000], having compared 1990-95 and 1996-98, estimated that the contribution of IT to productivity growth acceleration was around 50%. Also, Whelan[2000] estimated the contribution of IT to be around 70% by comparing 1974-95 and 1996-98. Recent results are summarized in Table1.

On the whole, the contribution of IT (in a narrow sense) accounted for around 50-70% of the acceleration in labor productivity observed in the late 1990s, though there is a slight difference in the results depending on the estimation method and period. Thus, even in a narrow sense, IT is considered to have made a substantial contribution to the productivity increase.

(B) The contribution of IT in a broad sense (including the synergistic effects of IT users)

As mentioned earlier, the synergistic effects of IT are a positive IT stock accumulation's influence over other capital stock and labor. Statistically, this appears in an increase in TFP on the part of IT users. So, if we find that the TFP of IT users has increased as IT capital deepening is taking place, and also that the deeper IT capital is, the higher TFP growth by industry, then we can conclude that IT stock is not just contributing to the expansion of production capacity, but also exerting a positive influence over other production factors.

In order to confirm this, we look at the TFP growth of non-IT industries estimated by Oliner and Sichel[2000] (Chart8). It is quite clear that TFP growth improved significantly during the late 1990s. As for the contribution to labor productivity growth, the analyses by Oliner and Sichel[2000] and Jorgenson and Stiroh[2000] give +0.6% and +0.8% respectively, which is more than twice the contribution in the first half of the 1990s. Moreover, if we compare the changes in TFP with those in the IT stock/total stock ratio for 1990-94 and 1995-98 by industry, we find a clear positive correlation between the two. Namely, industries with a higher share of IT capital stock such as durable manufacturing, retail sales, and finance show an increase in the TFP growth rate (Chart9).

From these points, it can be concluded that IT capital deepening also brings TFP growth. The contribution of IT to labor productivity including this synergistic effect can be quite substantial[9].

(C) The effect of the comprehensive revision of US GDP statistics

The comprehensive revision of GDP statistics in October 1999 had a large impact on productivity growth[10]. As a result of this revision, corporate expenditures on software and internally-developed software are counted as fixed investment. Prior to this revision they were treated as inputs to production and therefore not included in GDP. And thus, growth in GDP and labor productivity was pushed up as a result of the revision. The average increase in labor productivity growth due to this comprehensive revision during the 1990s was +0.6 percentage points (Chart10-1). By industry, industries such as retail sales and finance, which are considered to have increased their investment in software, were revised substantially upwards[11](Chart10-2). Up until then, it was considered that labor productivity growth in non-manufacturing industries such as finance and service was not completely reflected in the statistics[12]. Yet, by this comprehensive revision, the problem of incompleteness of statistics was more or less solved.

3. International comparison of the contribution of IT to productivity growth

In this sector, I conduct an international comparison of the relationship between IT and productivity growth. First, I examine whether the contribution of IT to productivity growth is observed in countries other than the US. Then, the contribution of IT with respect to the difference in output and labor productivity growth in the major

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[9] Saito[2000] makes a regression of labor productivity growth on the capital equipment ratio of non-IT capital stock and the IT stock ratio (IT stock/Non-IT capital stock), and shows that the contribution of the IT stock ratio to labor productivity growth after 1996 was about 80%. This result can be considered as an attempt to quantify the contribution of total IT (including synergistic effects) to productivity growth.

[10] See US Department of Commerce (1999) for details on the comprehensive revision of GDP statistics.

[11] GDP by industry is calculated by subtracting gross output from inputs to production. Prior to this revision, expenditures on software and internally-developed software were treated as inputs to production. Therefore, the inclusion of corporate expenditures on software as assets in output pushed GDP up by the decrease in inputs to production. Also, gross output for companies that internally develop software is pushed up by the revision. Thus, industries with large expenditures on software and those with substantial internally-developed software tend to have larger upward revisions.

[12] See Baily and Gordon[1988], Nardhaus[1997].

developed countries during the late 1990s is examined[13].

(1) GDP growth rate and labor productivity growth rate in the major developed countries

Before we compare the contribution of IT, first let us compare economic performance in major developed countries. The OECD average of real GDP growth slowed down during the 1990s compared to the 1980s (Chart 11-1). In countries such as Germany, France, Italy and Japan, the slowdown was significant. Yet, with respect to the average for 1995-99, though the OECD averages for GDP growth rate is still sluggish, in countries such as the US, Canada, Australia, Norway, Sweden, and Finland, growth accelerated (Chart 11-2). This shows that increased number of countries had regained growth compared to the 1980s[14].

In order to exclude the effects of increases in population and short-term economic fluctuations on economic growth, I also compared the trend of GDP growth per capita[15] (Chart11-3). After entering the 1990s, in many countries such as Japan and major European countries, the trend of GDP growth per capita slowed down. But, in the US, Australia, Norway, and the Netherlands it accelerated.

Next, an international comparison in the trend of labor productivity shows that, like the trend of GDP per capita, Japan and major European countries saw a slowdown (Chart12-1). On the other hand, US and Australia saw an acceleration. However, unlike GDP, while labor productivity growth dropped in the Netherlands, it increased after entering the 1990s in Scandinavian countries such as Sweden and Finland. [16]

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[13] Strict international comparison of the contribution of IT is quite difficult due to the unavailability of data. And, though I have reached a preliminary conclusion in this paper, we should bear in mind that it is not easy to draw a definite conclusion on the issue. The main problems with regard to data can be summed up as follows. (a) Lack of comprehensive and timely data on the IT industry. (b)the different deflating methods for IT investments and IT stock; and (c) difficulties in measuring the output for the service industry, which is the major IT user.

[14] It is characteristic that the gap in the growth rate of developed countries' increased in the 1990s; in OECD countries it widened from 0.9% (1980s) to 1.3% (1990s).

[15] An HP filter is used for the trend growth rate.

[16] In Scandinavian countries labor productivity is rising, while GDP growth per capita is slowing down. This is due to a decrease in the ratio of "Number employed/Total population" due to the aging population. Based on Scarpetta *et.al* [2000], decomposition of GDP growth per capita into labor productivity and demographic factor shows that the demographic factor held back the growth rate considerably (Change in the number of employed/Total population <Chart12-2>), in Sweden and Finland. Yet, in the Netherlands, the opposite trend is observed. Labor productivity growth is not as high but the growth rate is high due to the significant positive contribution of a demographic factor.

The above findings can be summarized as follows. Labor productivity slowed down in Japan and major European countries in the 1990s compared to the 1980s. However, in English-speaking ones; (the US, Canada, Australia) and Scandinavian ones (Finland, Norway, Sweden), the growth rate accelerated[17][18].

(2) Contribution of IT to labor productivity

To confirm whether IT has contributed significantly to the difference in labor productivity in these countries, the contribution of IT to productivity growth is decomposed into three routes: (a) an increase in the efficiency of IT industries, (b) IT capital deepening, and (c) the synergistic effects of IT as discussed in Chapter 2.

(a) Efficiency improvement in IT industries

To estimate the qualitative impact of efficiency improvement in IT industries, the TFP of IT industries needs to be estimated and then weighted according to the share of the IT industry in the whole economy. Because not enough data has been accumulated to compare productivity and TFP in IT industries internationally, in this paper, I focus on the share of IT industries in the economy in order to conduct an international comparison.[19]

First, the ratio of IT industries' value added to nominal GDP by country shows that IT industries account for a relatively large share in the US, Japan, Scandinavian countries (Sweden, Finland), and Ireland (Chart 13-1). As estimated by Credit Suisse First Boston Securities[2000], slightly over 7% in Ireland, 6% in the US and Japan, and over 5% in Sweden and Finland. On the other hand, figures are relatively low in major European countries such as Germany, France, and Italy at around 4%. This inclination is also seen in an estimation by OECD[2000b] (excluding software, 1997).

Next, looking at the changes in the ratio of IT industries' value added to GDP from 1995 to 1998, we find that Sweden, Finland, and Ireland show a large increase which is even bigger than that of the US, while the increase in the ratio in Japan and the major

[17] Ireland shows a continuously high growth rate in the trend of labor productivity since the 1980s (average for the 1980s of +3.5% -> +3.2% for the 1990s).
[18] Based on the above findings, I examine the contribution of IT to productivity growth in the major developed countries.
[19] The IT industry is assumed to have higher productivity than others. Thus, it can be concluded that the larger the share of IT industry in the overall economy, the higher the contribution of IT to productivity growth through efficiency improvements in the IT industry.

European countries is limited (Chart 13-2).

From these findings it is concluded that, in terms of efficiency improvement in IT industries, the contribution to productivity growth in the overall economy is significant in countries such as the US, Sweden, Finland, and Ireland[20].

(b) IT Capital deepening

Next, the ratio of IT investments to GDP estimated by Daveri[2000], is compared[21](Chart 15). As well as in the US and Scandinavian countries, the share of IT investment is high in the UK, Canada, and Australia. In the UK and Australia, IT investments reached close to 4% of nominal GDP in 1997. In the US, Canada, and New Zealand, the ratio was about 3.5%. As for changes in the IT investments/GDP ratio from 1992 to 1997, English-speaking countries such as the UK, Canada, and Australia saw remarkable growth. Japan is situated in the middle of the high English-speaking countries and the low major European countries such as Germany, France and Italy, in terms of both the level of the ratio and changes in it. According to Schreyer's [2000] estimation for the G7 countries, the US, UK, and Canada are also leading in terms of both the growth of real IT investments and ratio of IT investments /Equipment investments[22](Chart16).

Reflecting this gap in IT investments, the US is leading in terms of the deepening of IT stock (IT stock/Capital stock) followed by the UK and Canada (Chart17).

Next, based on IT stock data, the contribution of IT stock to the real GDP growth rate is estimated using standard growth accounting analysis. According to Schreyer[2000], the US scores the highest within G7 countries (excluding software stock), with a contribution of +0.4% annually. In Canada and the UK, the contribution is +0.3% (Chart18). According to Daveri[2000], which includes software stock in IT stock and

[20] As mentioned earlier, it is necessary to assume that the IT industry has higher efficiency than other industries if the increase in the share of IT industry contributes to the productivity growth of the whole economy. To confirm this point, I looked at the price movements of IT-related goods. Chart14 shows that prices of computer-related equipment have dropped significantly not only in the US but also in other developed countries (annual average of –20% to –25%).

[21] To make an international comparison of IT stock, investments have to be estimated based on nominal IT-related expenditure data released by private research institutes. Then it should be deflated and discarding rate should be estimated. Schreyer[2000] and Daveri[2000] use this method for IT stock estimation. As for nominal IT-related expenditures, they are based on data from WITSA (World Information Technology and Services Alliance) and IDC (International Data Corporation).

[22] Schreyer[2000] does not give a specific IT investment/Nominal GDP ratio.

covers more sample countries, in the US, UK, and Australia (average of 1991-1997), where the IT investment/GDP ratio is growing, the contribution of IT stock is quite high (+0.7% annually)[23](Chart 19). On the other hand, in Germany, France, Spain and Italy, the contribution is +0.3%-0.4% annually. From this evidence we conclude that the IT capital deepening factor can account for the economic growth gap of +0.3-+0.4% between the front-runners like the US and the laggards like major European countries. As for Japan, the contribution of IT stock is around 0.5%, which is slightly higher than for Germany and France.

To summarize these findings, from the viewpoint of IT capital deepening, the contribution of IT to labor productivity and real GDP is high in English-speaking countries such as the US, the UK, Australia, and Canada.

(c) Synergistic effect: TFP increase for IT users

The synergistic effect of IT capital refers to the effect of IT capital deepening on non-IT capital stock and labor. Ideally, this should be measured as the increase in TFP for IT users. However, due to limitations in internationally comparable data for IT users' TFP, I compare the TFP of the whole economy and examine the relationship between IT capital deepening and TFP.

Based on the analysis of Bassanini, Scarpetta and Visco[2000], the TFP growth rates of the major developed countries during the 1990s are compared. Chart 20 shows that TFP is slowing down in Japan and major European countries, while accelerating significantly in English-speaking and Scandinavian countries. This trend did not change during the late 1990s (average for 1995-98).

It should be noted that the TFP growth in the whole economy can be influenced by the size of the IT industry. The IT industry has a high TFP growth rate, so countries with a high share of IT industry may have high TFP growth. In fact, Chart21-1 shows that countries with a high increase in the IT share such as the US, Sweden, and Finland also have a high TFP growth rate, while countries with a low growth rate experienced a slowing down in the TFP growth rate. In this regard, TFP growth in IT industries contributes to total TFP growth to some extent, which is in line with the results in (2) (a). However, if we look more closely at these countries, the correlation between the

[23] If we single out 1996-97 (Chart19-2), the contribution to growth on the whole is rising. In addition, the gap between English-speaking and Scandinavian countries widened to +0.5 percentage point.

presence of IT industries and TFP growth rate is not necessarily apparent. For example, in the group where the TFP growth rate is slowing down, there are some countries, such as Spain, which have a relatively high IT industry growth rate. Therefore, the size of the IT industry alone is not the only reason for the gap in TFP growth.

Next, a positive correlation can be observed between TFP growth rate changes and the IT investment/GDP ratio (Chart21-2). In Australia and Canada, where the IT investment/GDP ratio is very high, TFP growth is accelerating. On the other hand, in Spain, the Netherlands, and France, where the IT investment ratio remained stable, TFP growth slowed down. Japan is in the middle of these two groups.

The above results suggest that the difference in IT capital deepening influences TFP development of IT users and also that of the total economy. The fact that countries with more IT capital tend to have higher TFP growth indicates that IT capital deepening contributes to productivity growth through network externalities and a reduction in search costs. In other words, IT stock seems to have synergistic effects. IT stock accumulation has improved supply capacity through capital deepening, as well as contributed to productivity growth by the increase in TFP, especially in English-speaking countries such as Australia and Canada.

As background to the expansion of IT capital deepening and the contribution of IT to productivity[24], regulations on goods and market services and the flexibility of labor markets are frequently pointed out. Chart22 shows a negative correlation between changes in TFP growth and the strictness of each country's regulations[25], which indicates that the more lenient the regulations, the higher the TFP growth rate[26] .

The result that countries with a high TFP growth rate tend to have a high IT investment/GDP ratio and the fact that in these countries regulations in goods and labor markets are lenient (on the contrary, countries with a low IT investment/GDP ratio and low TFP growth have strict regulations) suggest that in highly regulated countries

[24] See Saito[2000]. FRB Chairman, Alan Greenspan also pointed out in a speech that the difference in labor market flexibility is an important factor behind the labor productivity difference in Japan, Europe, and the US.
[25] International comparison of regulations is based on Nicoletti, Scarpetta and Boylaud[1999].
[26] For Scandinavian countries, such as Norway, Sweden, and Finland, the growth of IT industry has contributed to TFP growth. And, the correlation with market strictness is not considered to be strong in these countries. If we exclude these Scandinavian countries, the correlation between the strictness of regulations and TFP becomes clearer (Chart23).

markets are uncompetitive and there is less incentive for IT investments, which leads to sluggish TFP growth[27].

(3) Tentative conclusion

It should be noted that the conclusion in this paper about the contribution of IT to productivity is only tentative. First of all, the accuracy of data on IT stock and IT industry size varies. Secondly, the demand-side situation should be considered.[28] Moreover, to make a conclusion on the effect of IT on economic performance, we need to make observations over a longer period of time.

Having said that, the conclusions of the paper can be summed up as follows:

(1) In many countries, the GDP growth rate is slowing down and labor productivity remained the same in the 1990s compared to the 1980s. However, in some countries such as Scandinavian ones, Sweden, Norway, and Finland, and English-speaking ones such as Australia and Canada, acceleration in GDP growth and productivity during the late 1990s was observed.

(2) In Scandinavian countries, rapid growth in highly efficient IT industries contributed to the increase in labor productivity growth of the whole economy. As for English-speaking countries, the accumulation of IT stock (IT capital deepening) contributed substantially to labor productivity growth. IT investment has had a positive effect on TFP growth in these countries. On the other hand, major European countries such as Germany, France, and Italy, have been outperformed by the Scandinavian and English-speaking countries in terms of both the size of IT industry and IT capital deepening. In Japan, the size of the IT industry is relatively large but IT stock accumulation is far lower than in English-speaking countries.

(3) The above findings show that the contribution of IT either on the production side or user side is large in countries that achieved a high growth rate during the 1990s. In fact, the contribution of IT is one of the main factors that explain the gap in GDP growth during this period. Regarding the contribution of IT, IT stock accumulation has had significant effects on economic growth and labor productivity since it not only

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[27] Supporting evidence for this point is the negative correlation between Internet use and communication costs. For example, OECD[2000a] shows that there is a clear negative correlation between Internet costs and the number of Internet hosts, confirming that the strictness of regulations can influence the level of IT investment and expand TFP as a result.

[28] Considering the cyclicality of TFP, it is important to note the difference in demand during this period.

strengthened capital deepening but also raised TFP. IT stock accumulation not only brought about capital deepening but also led to an increase in TFP. Through this increase in TFP, capital deepening activated the supply side of the economy, which eventually led to growth rate and productivity differences.

(4) There is a correlation between IT stock deepening or TFP growth, and the strictness of regulations. In countries that saw an increase their TFP growth during the 1990s, the regulations are quite often lenient. In countries with strict regulations, competition is not severe, which curbs the incentive for IT investment, leading to low growth of IT stock accumulation.

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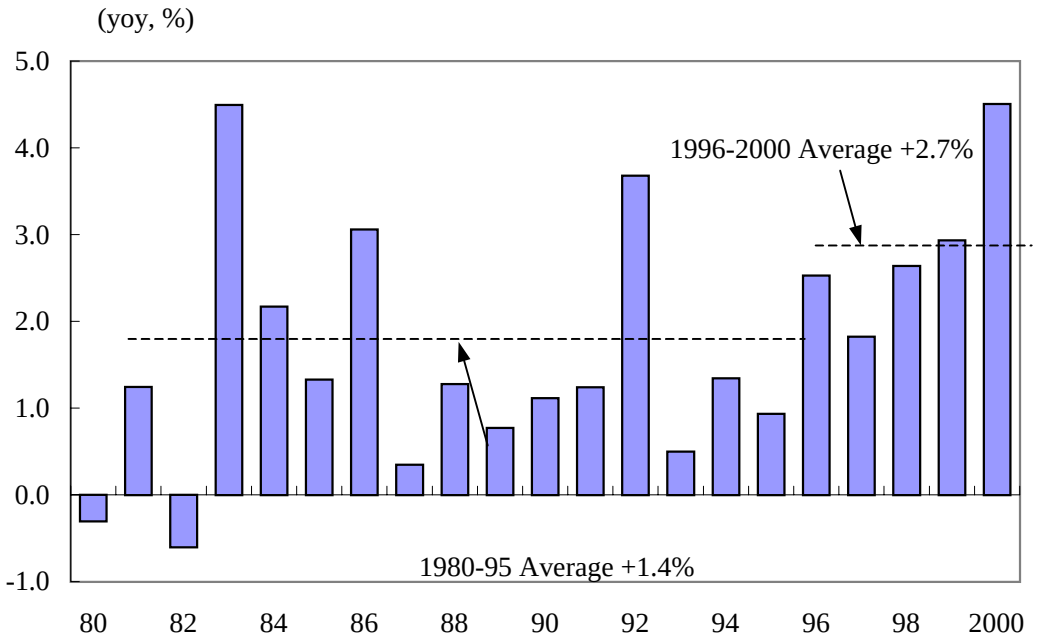
(Chart1)

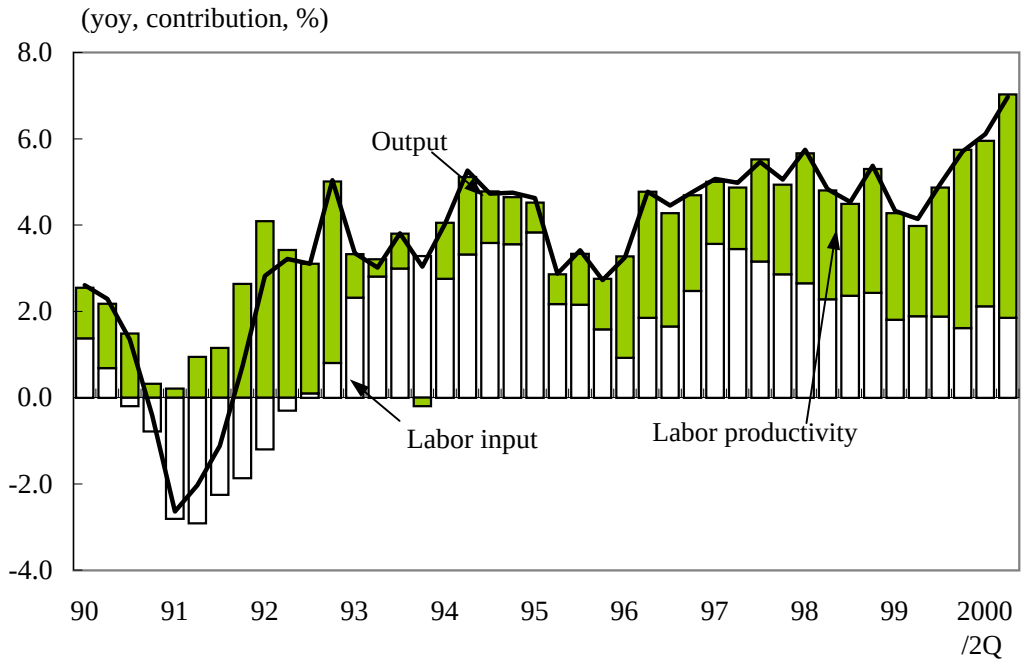
US Labor Productivity (Non-farm Business Industries)

(1) Labor Productivity (Non-farm Business Industries)



Note: As for 2000, the average of the first half of the year is used.

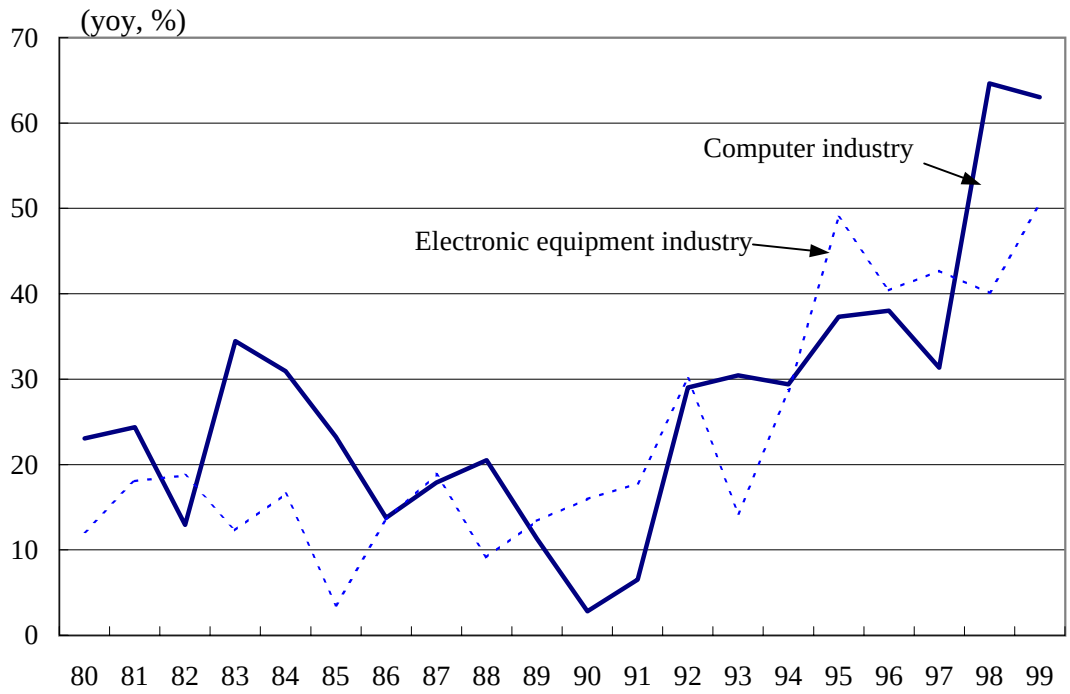
(2) Contributions to Output



(Chart2)

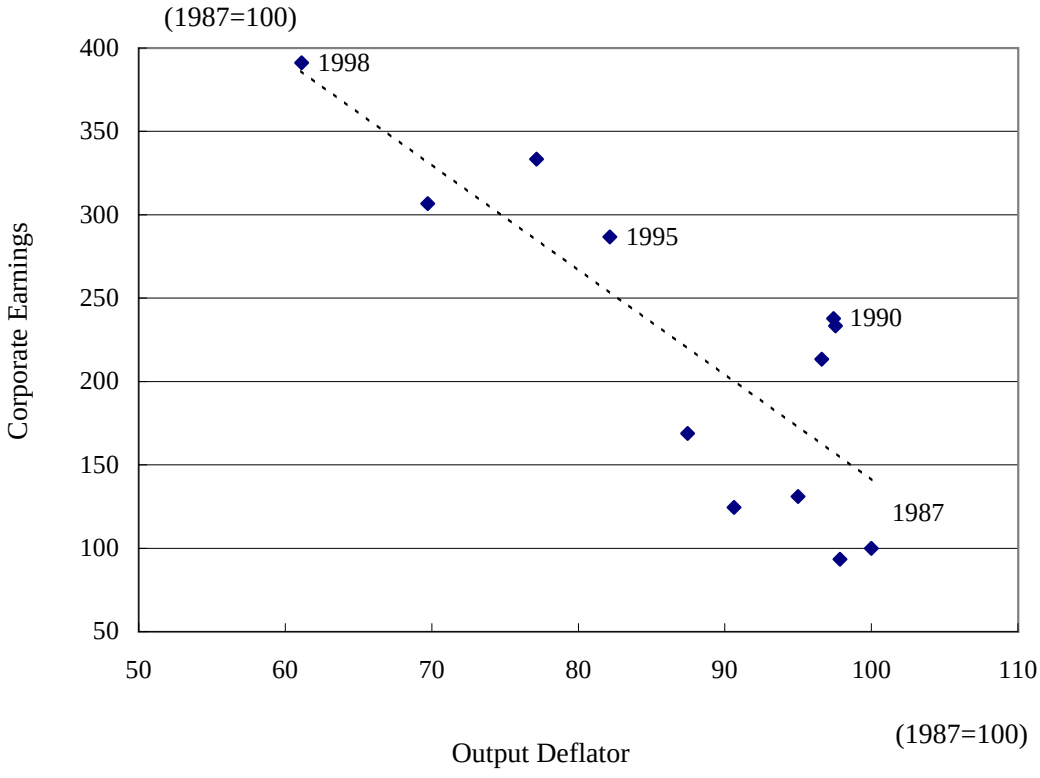
Labor Productivity of IT Industries

(1) Labor Productivity of Computer, Computer-related Equipment



Note: Labor productivity is calculated by dividing output by number of employees.

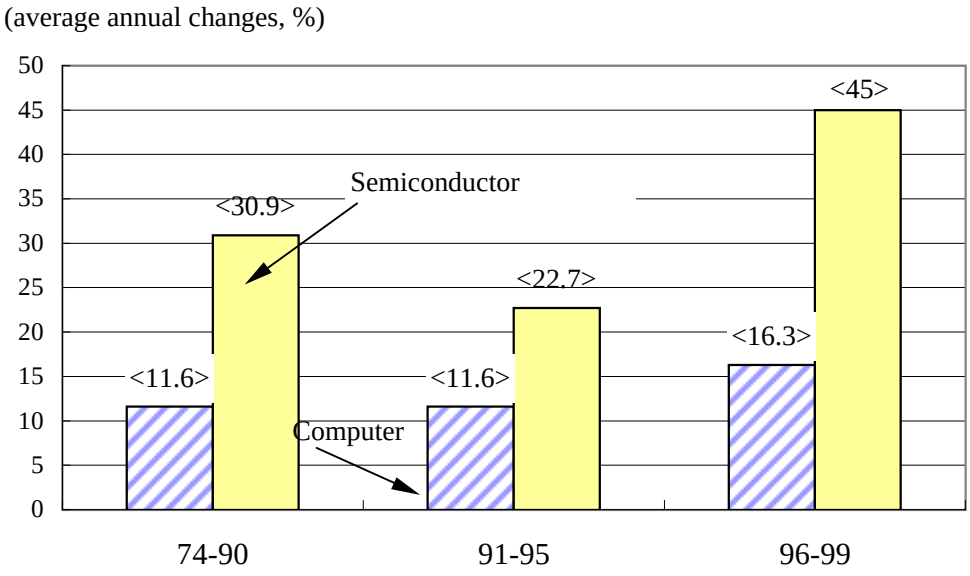
(2) Output Deflator and Corporate Earnings (Industrial machinery sector)



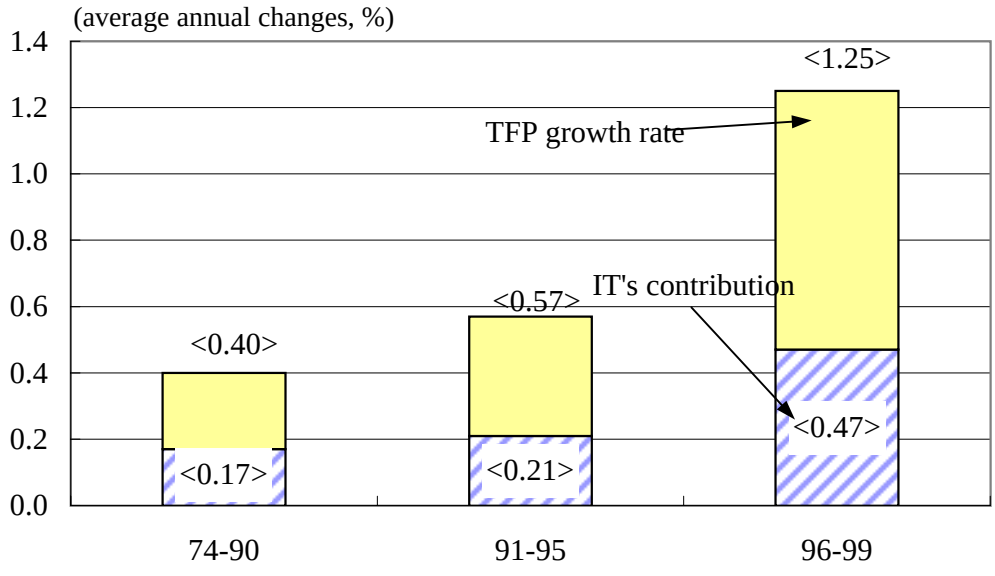
(Chart3)

Total Factor Productivity (TFP) of IT Industry

(1) TFP Growth Rate of IT Industry



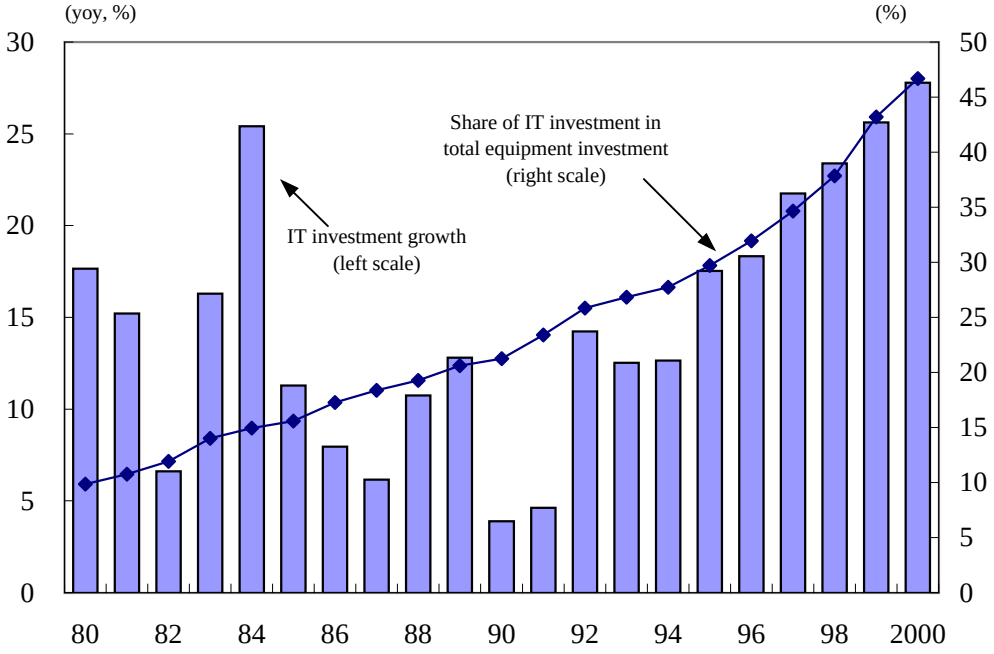
(2) Contribution of IT Industry to Total TFP Growth



Source: Oliner and Sichel (2000)

(Chart4)

IT Investment in the US

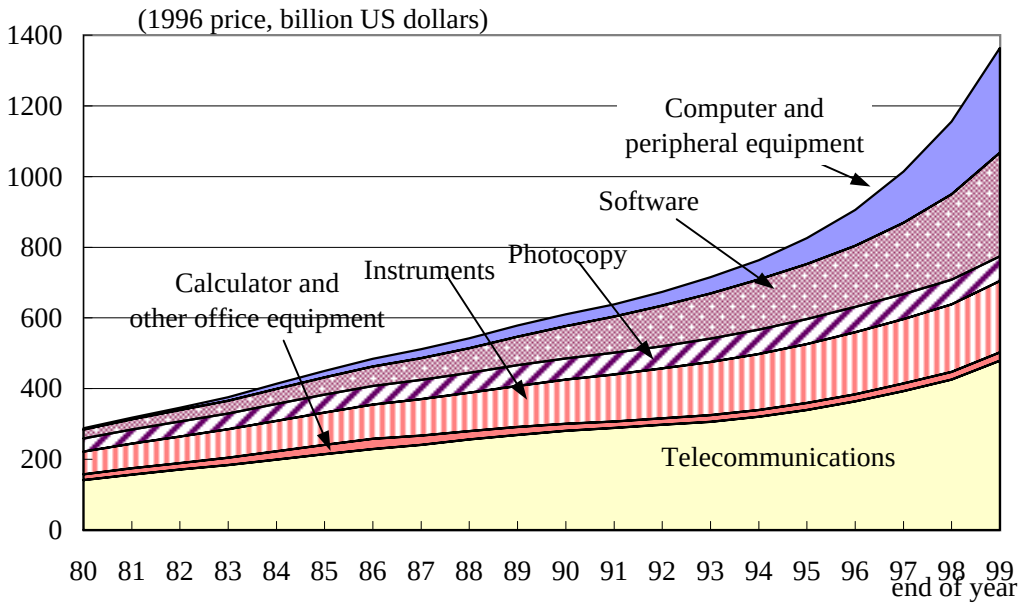


Note: As for 2000, the average of the first half of the year is used.

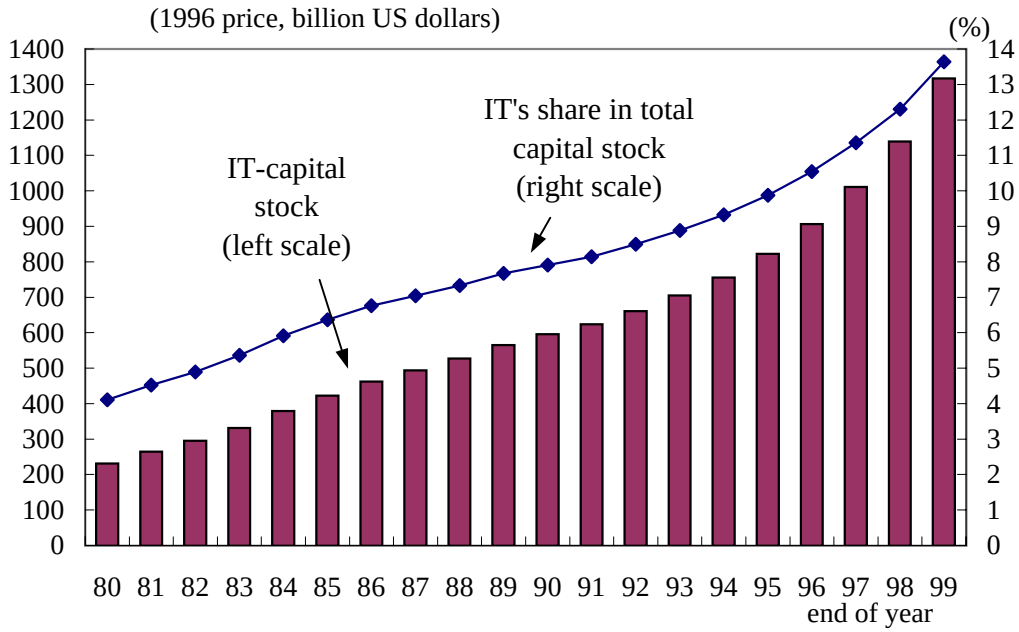
(Chart5)

IT Capital Stock

(1) Composition of IT Capital Stock

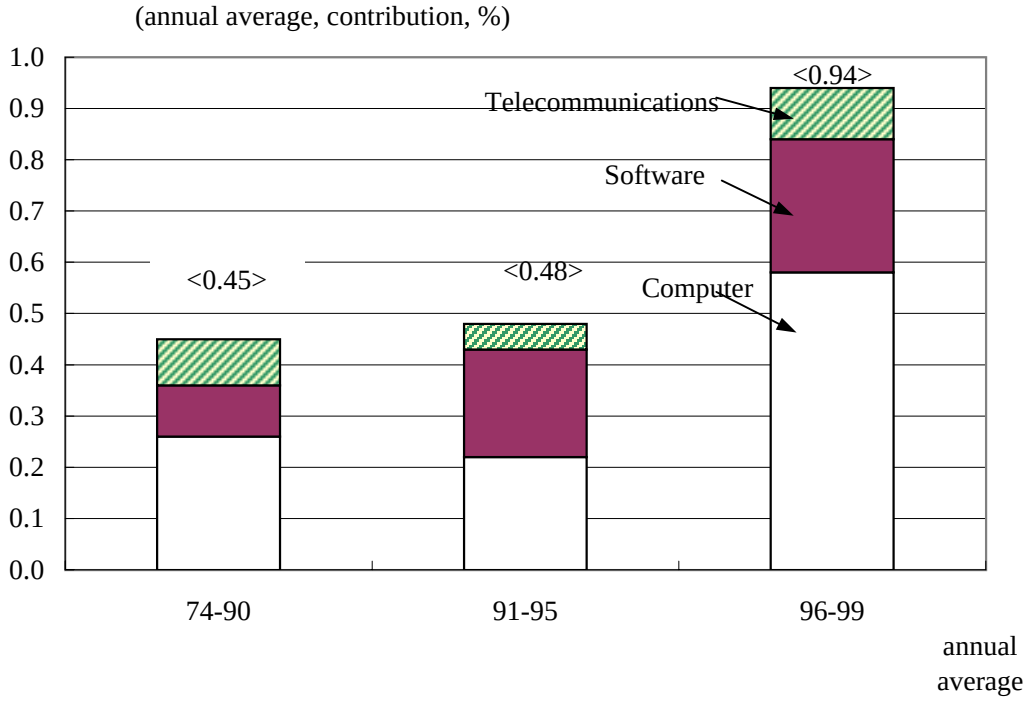


(2) Share in Capital Stock



(Chart6)

IT Capital Stock's Contribution to Productivity Growth

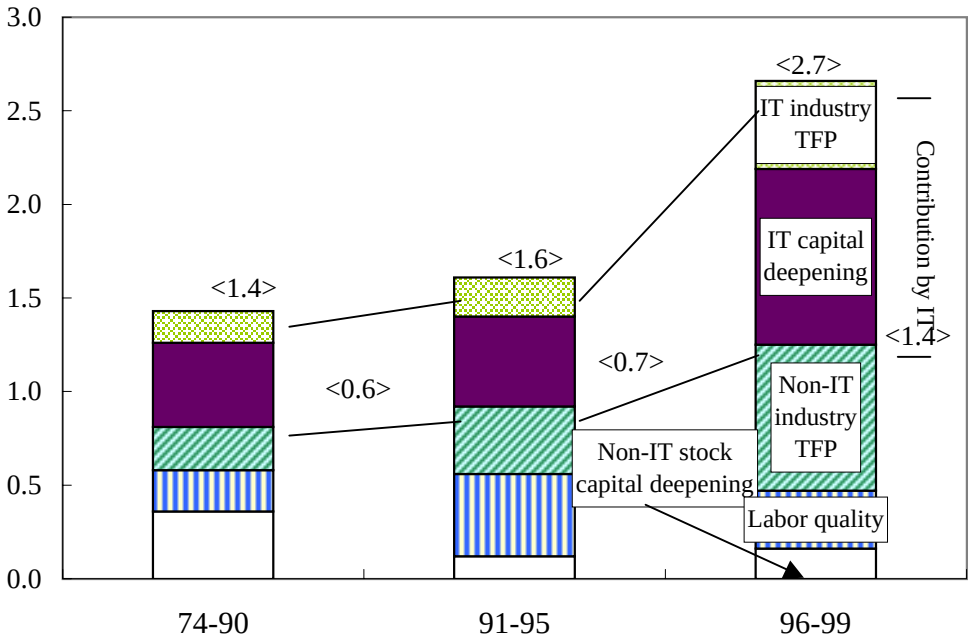


Source: Oliner and Sichel (2000)

(Chart7)

Decomposition of Labor Productivity

(average annual changes, % point)



Note: IT contribution is the sum of IT capital deepening and IT industries' TFP.

Source: Oliner and Sichel (2000)

(Table1)

Empirical Results of the US Labor Productivity

(% point)

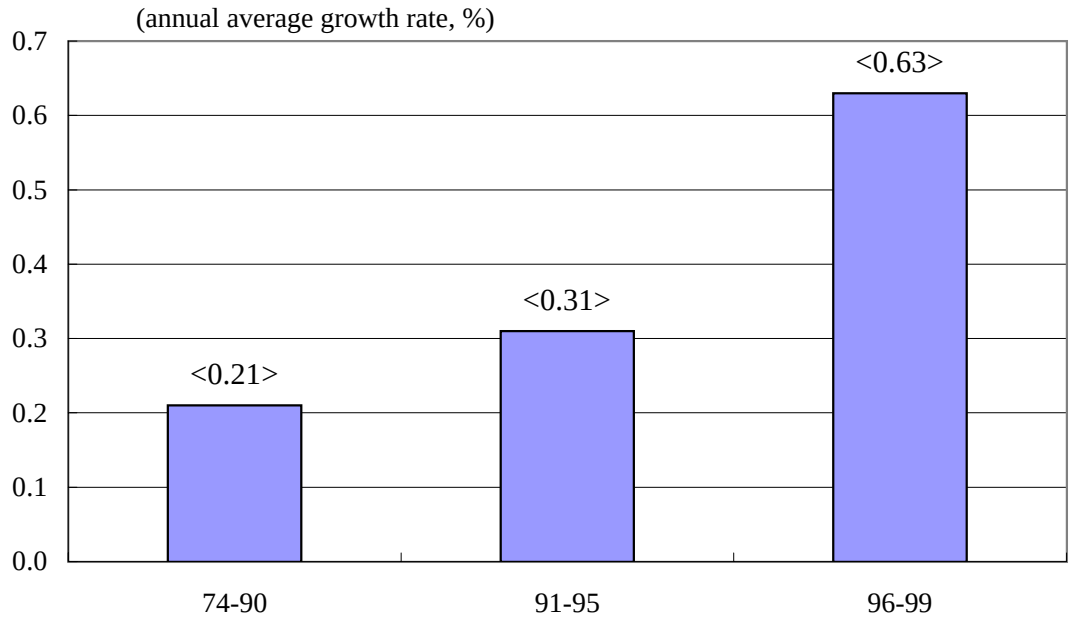
	Jorgenson and Stiroh (2000)	Oliner and Sichel (2000)	Whelan (2000)	CEA (2000)	Gordon (2000)
Comparison Period	90-95 to 96-98	90-95 to 96-99	74-95 to 96-98	73-95 to 96-99	72-95 to 96-99
Acceleration in Labor Productivity Growth	1.0	1.1	1.0	1.5	0.8
Capital Deepening	0.5	0.5	n.a.	0.5	0.3
IT sector	0.3	0.5	0.5	0.5	n.a.
Non-IT sector	0.2	0.0	n.a.	0.0	n.a.
Labor Quality	-0.1	-0.1	n.a.	0.1	0.1
TFP	0.6	0.7	n.a.	0.9	0.3
IT sector	0.2	0.3	0.3	0.2	0.3
Non-IT sector	0.4	0.4	n.a.	0.7	0.0
IT contribution to Productivity Growth Acceleration(*)	0.5	0.8	0.7	0.7	n.a.
Percent of Acceleration in Labor Productivity Related to Information Technology	About 50%	About 67%	About 70%	About 50%	n.a.

Note (*): The IT contribution to the changes in the growth rate.

(Chart8)

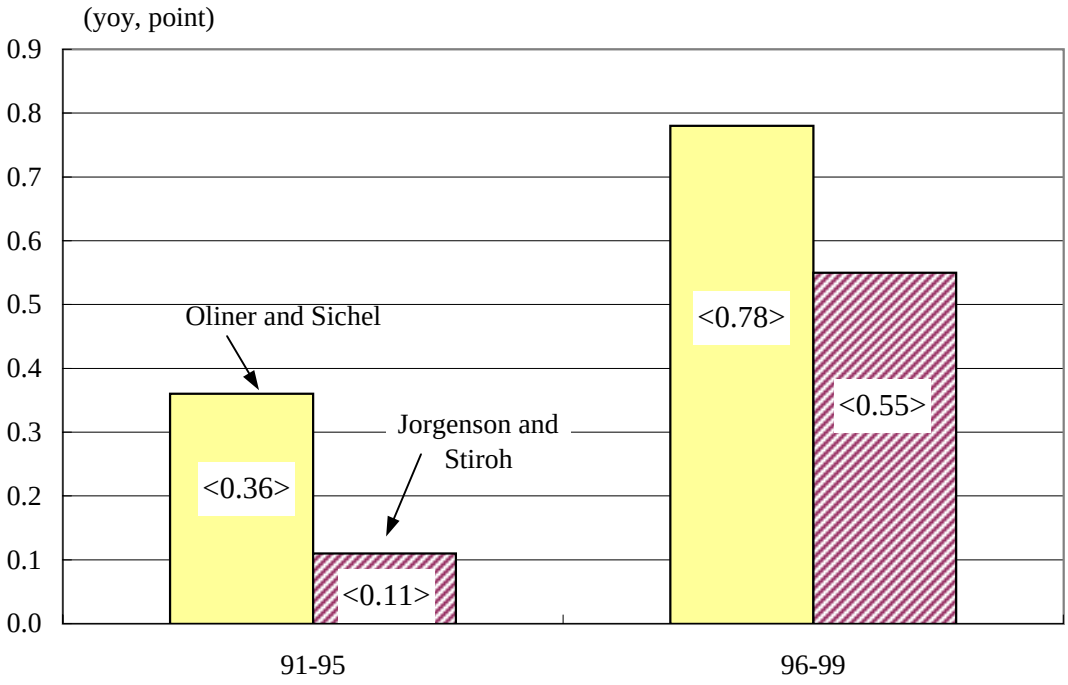
TFP of Non-IT Industries

(1) TFP Growth Rate



Source: Oliner and Sichel (2000)

(2) Contribution to Labor Productivity

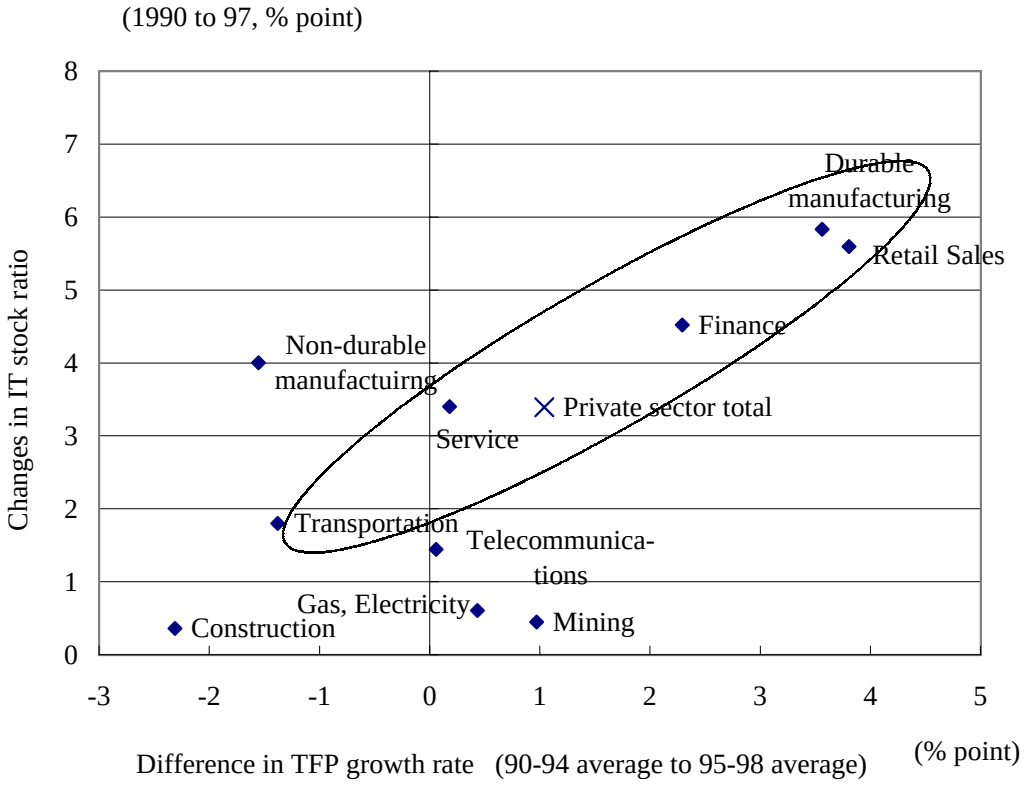


Note: For Jorgenson and Stiroh, the averages for 1990-95 and 1996-98 are used respectively.

Source: Oliner and Sichel (2000), Jorgenson and Stiroh (2000)

(Chart9)

The Correlation between TFP Growth Rate and IT Stock Ratio



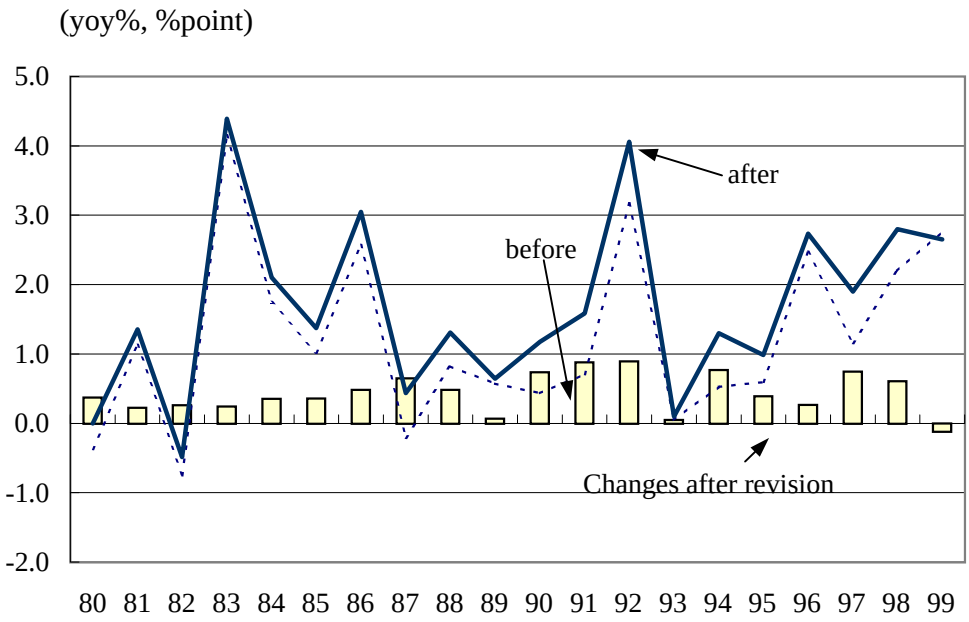
Notes:1. IT Stock Ratio = IT Stock / Total Capital Stock × 100

2. TFP is calculated using Cobb-Douglas production function.

(Chart10)

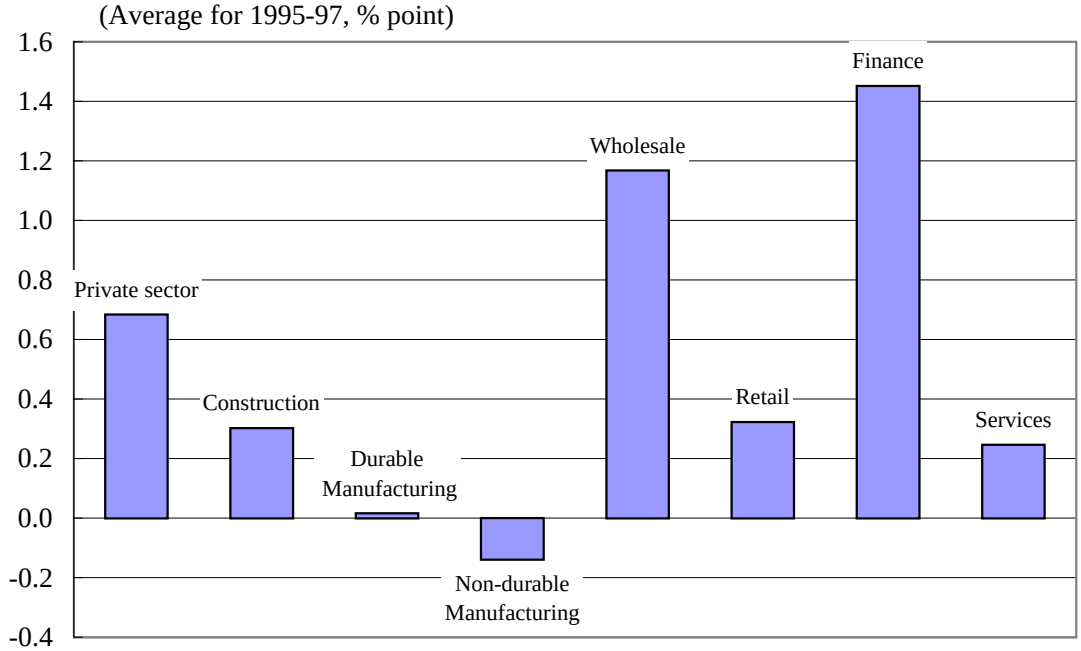
Results of the Comprehensive Revision of GDP Statistics

(1) Labor Productivity



Note: As for 1999, the average for the first quarter and the second quarter.

(2) Changes in Labor Productivity by Industry

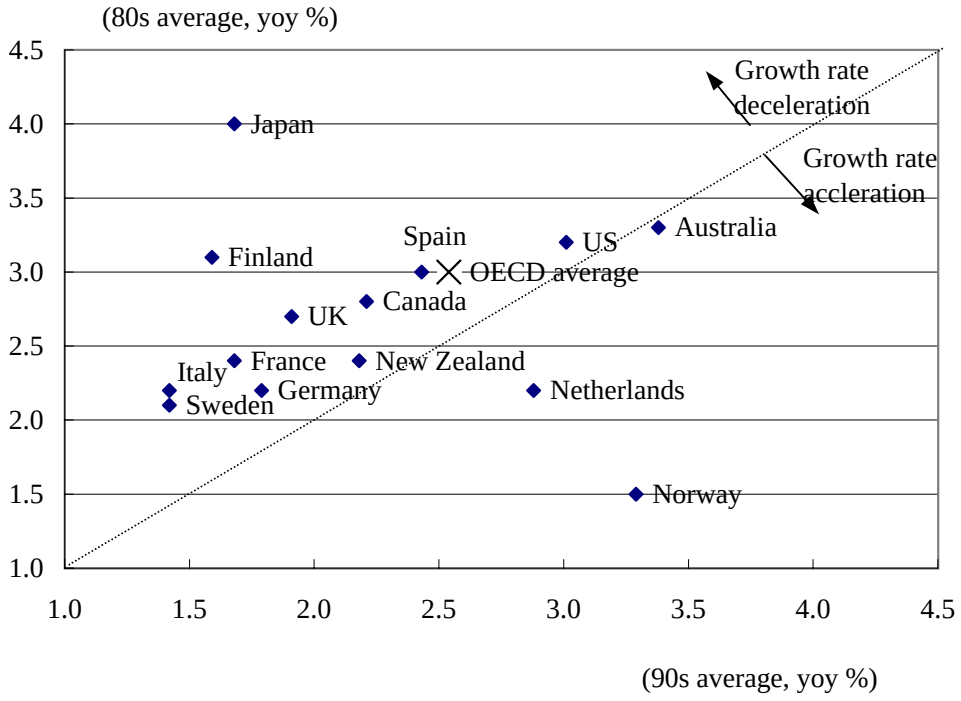


Note: The figures are calculated by subtracting the pre-revison average growth rate from the post-revision average growth rate for 1995-97.

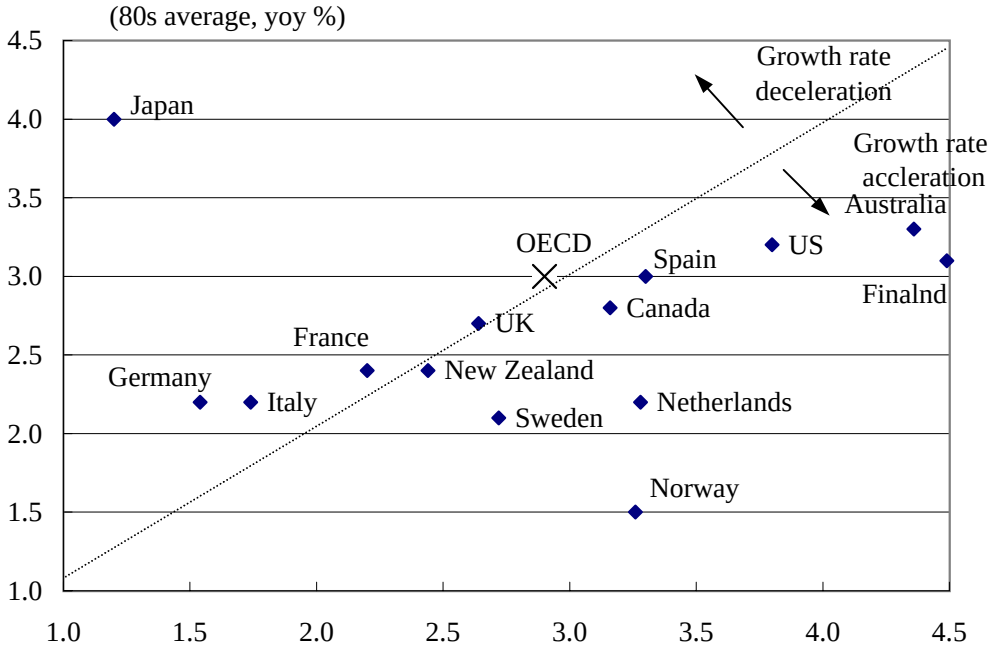
(Chart11)

Real GDP Growth Rate in the Major Developed Countries

(1) Comparison of the 1980s and the 1990s

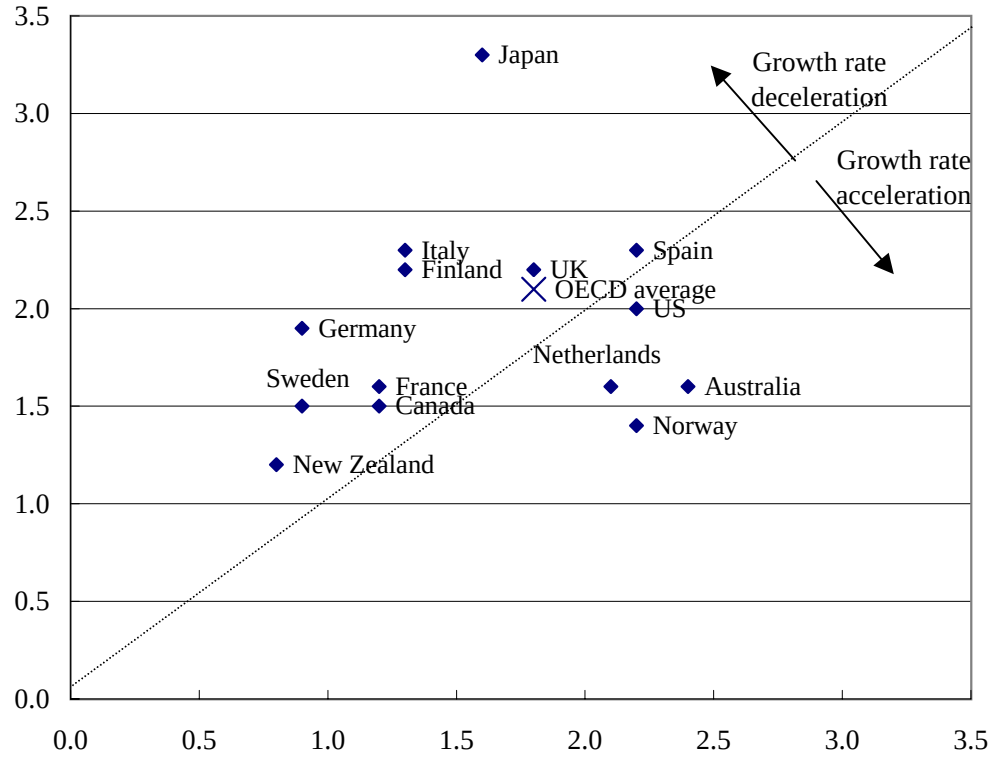


(2) Comparison of the late 1990s and the 1980s



Source: OECD (2000a), Scarpetta *et al.* (2000)

(3) Trend GDP Per Capita in Major Developed Countries



(90s average, yoy %)

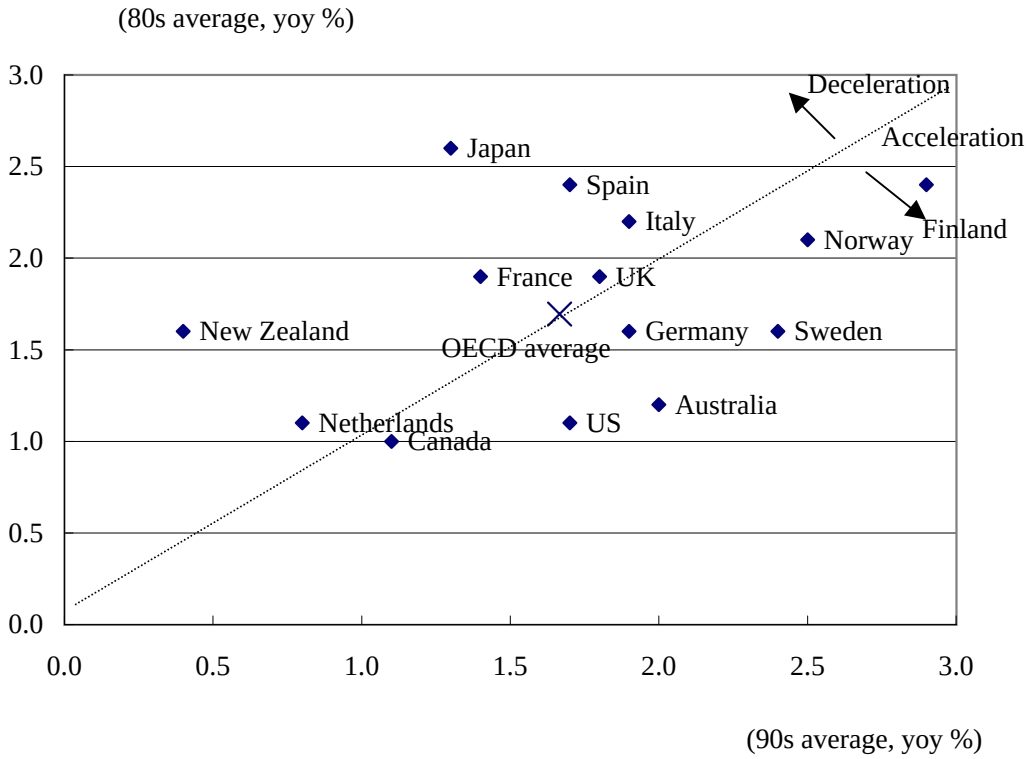
Note: As for 1990s, the average for 1990 to 98.

Source: Scarpetta *et al.* (2000)

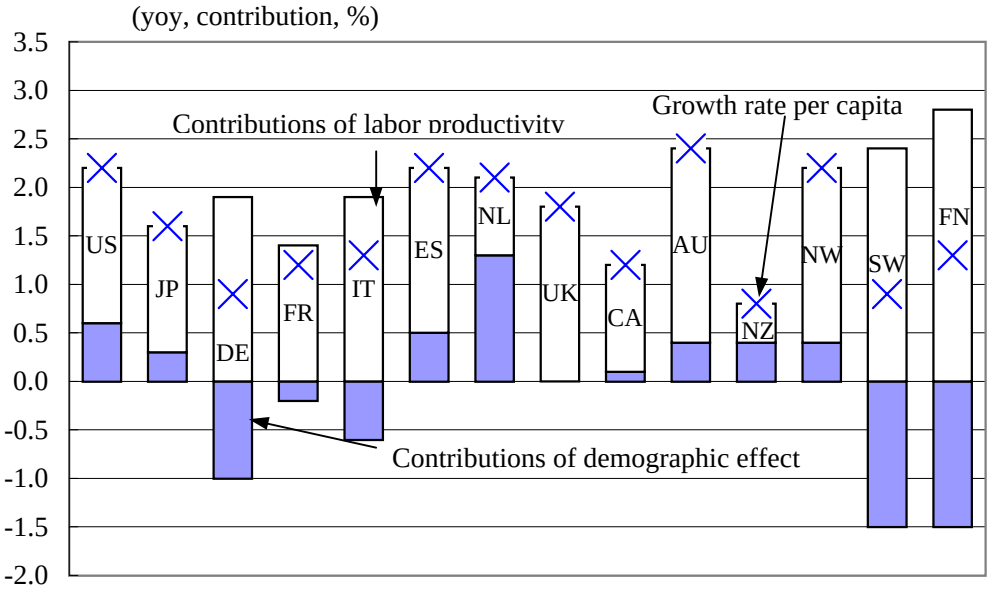
(Chart12)

Labor Productivity in the Major Developed Countries

(1) Trend Labor Productivity Growth in the Major Developed Countries



(2)Decomposition of GDP per Capita into Contributions of Labor Productivity and Demograpic effect

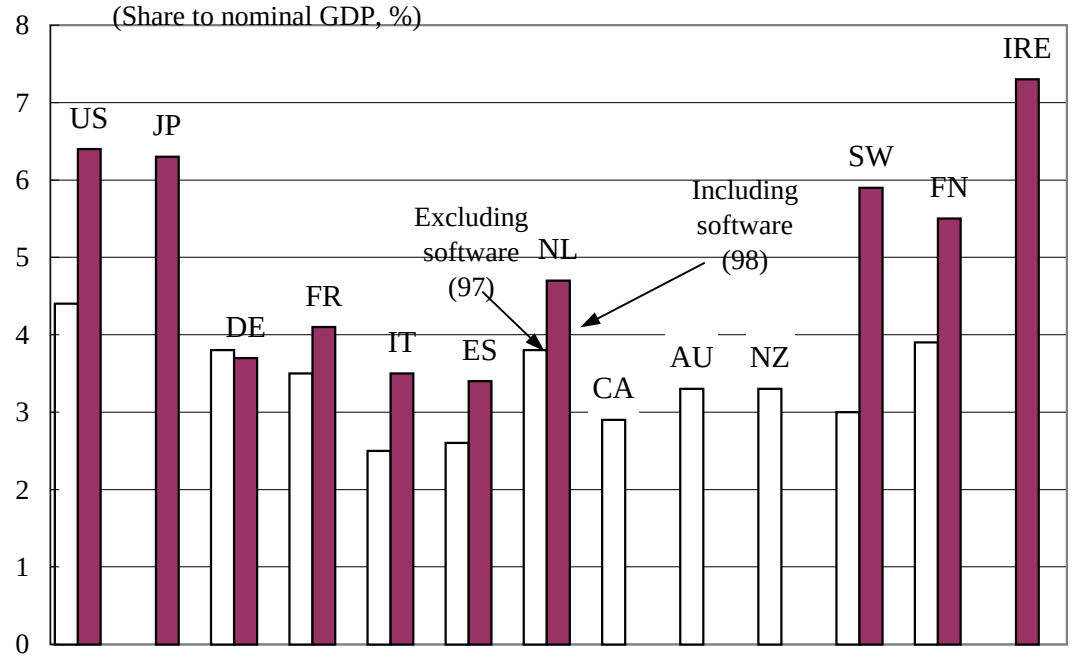


Notes:1. US: United States, JP: Japan, DE: Germany, FR: France, IT: Italy, ES: Spain,
NL:Netherlands, UK: United Kingdom, CA: Canada, AU: Australia,
NZ: New Zealand, NW: Norway,
SW: Sweden, FN: Finland.
2. As for 1990s, the average for 1990-98.

(Chart13)

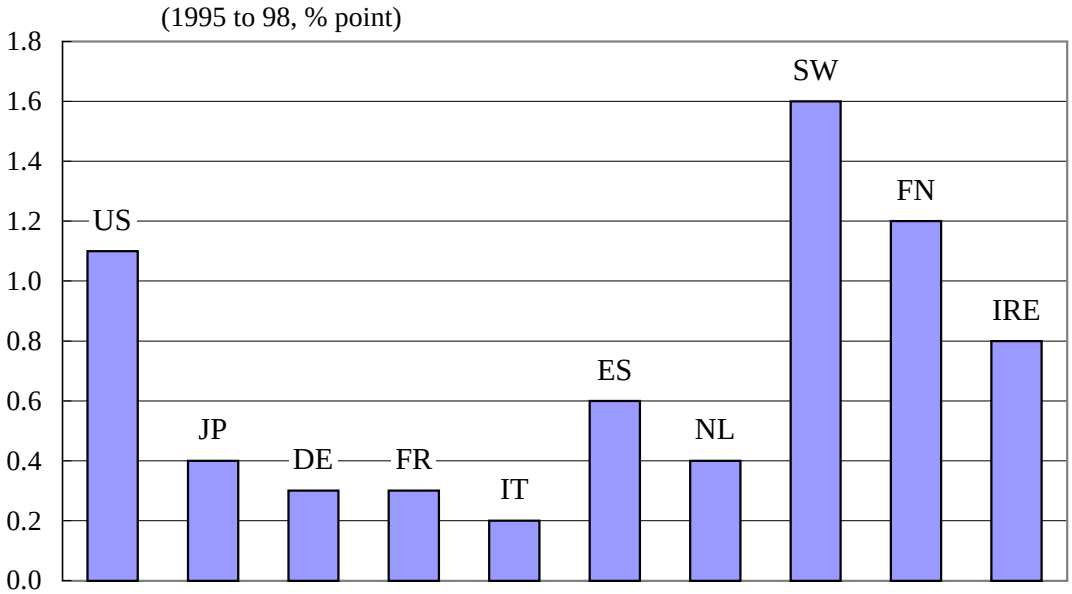
The Share or IT Industry

(1) The GDP Share of IT Industry



Notes: 1. Blank bars mean that data are not available.
2. The source for the data excluding software is OECD (2000b), for data including software, Credit Suisse First Boston Securities (2000).

(2) Changes in the GDP Share of IT industry



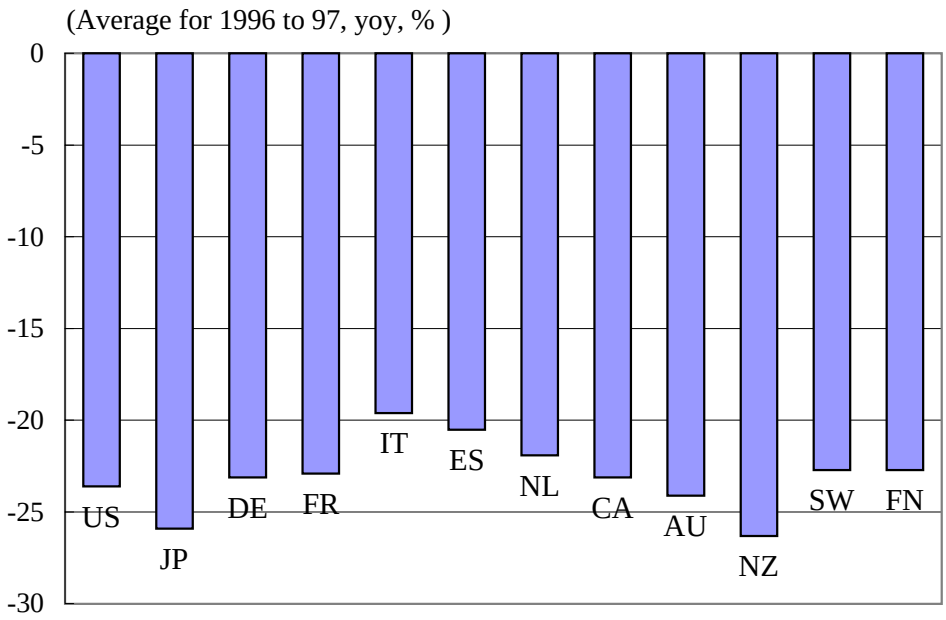
Note: Including Software

Source: OECD (2000b), Credit Suisse First Boston Securities (2000)

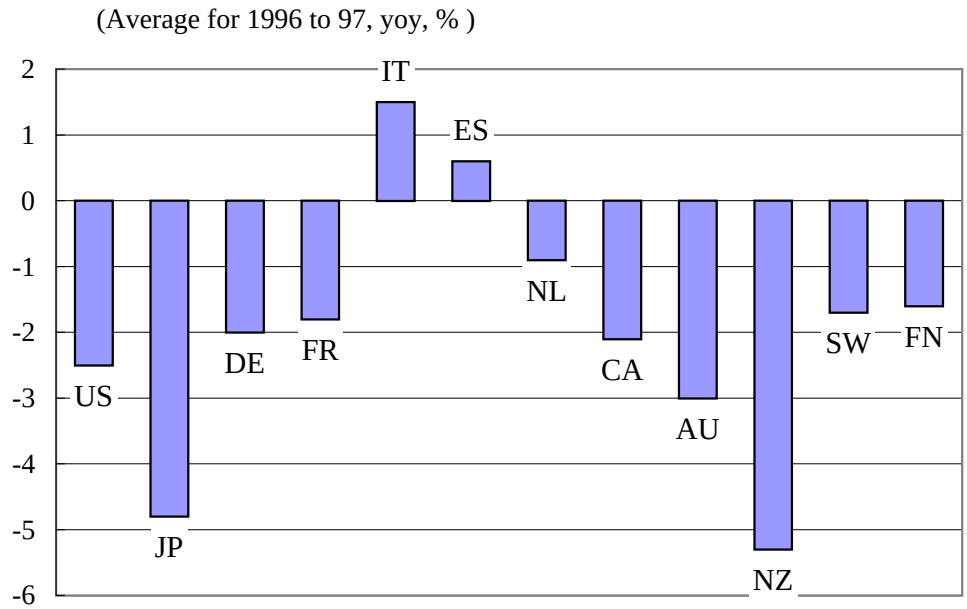
(Chart14)

Price Index of IT-related Products

(1) Computer



(2) Communication Equipment

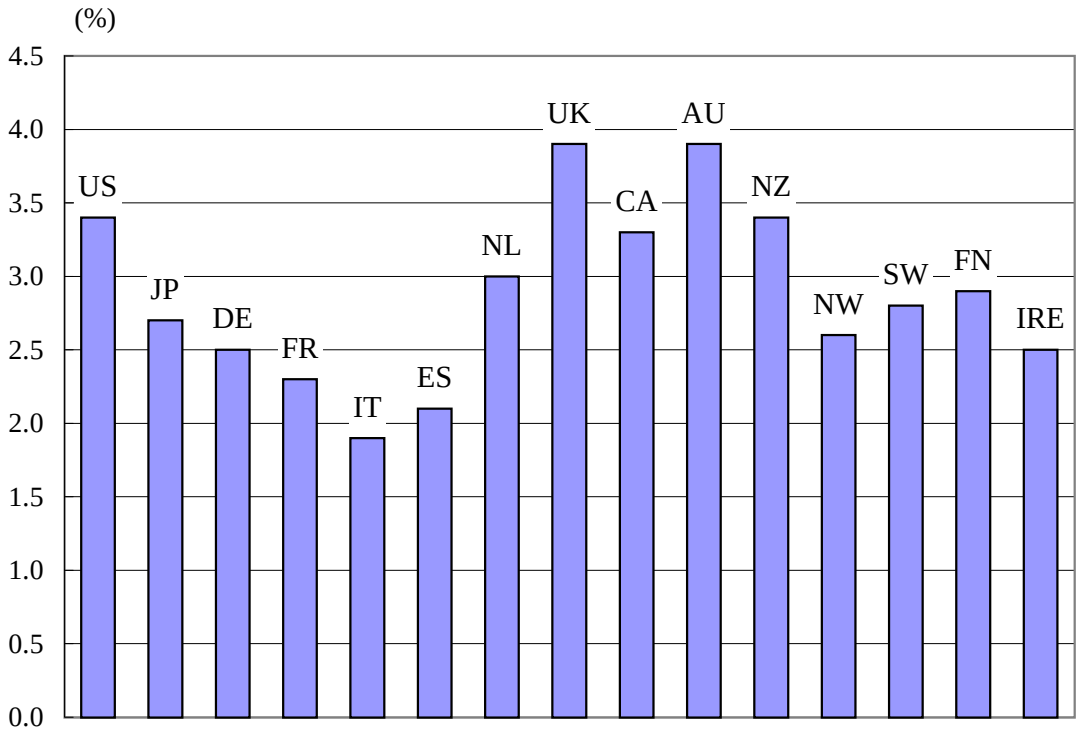


Note: National differences in the calculation for deflators are adjusted.
Source: Daveri (2000)

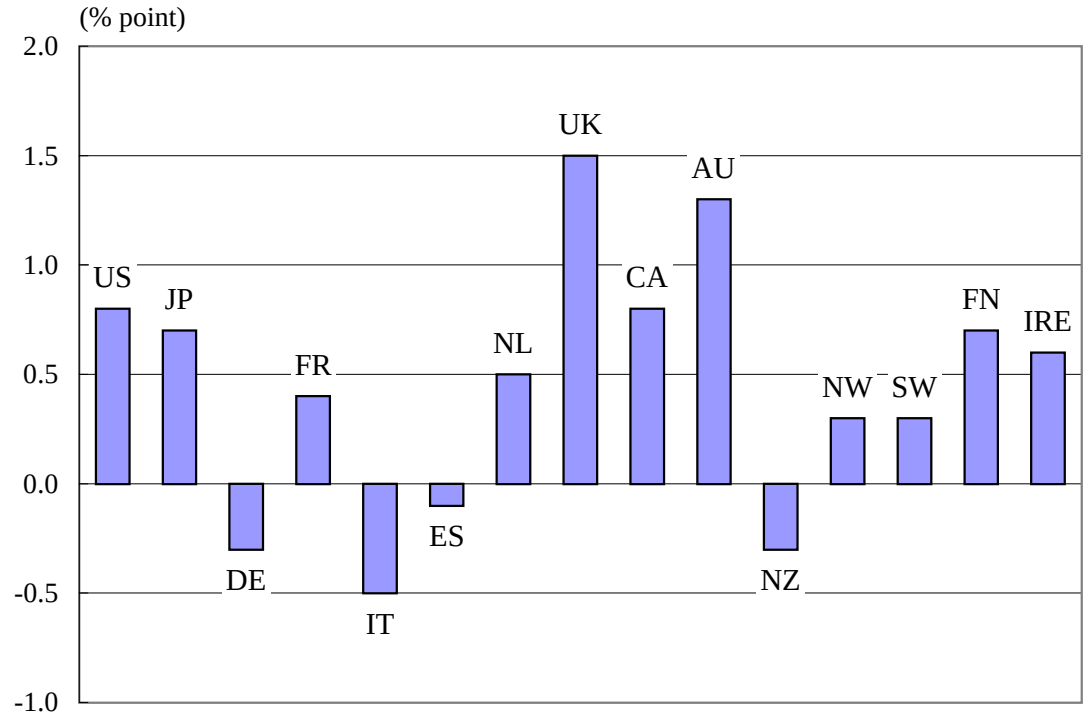
(Chart15)

International Comparison of IT Investment

(1)Share of IT Investment to Nominal GDP (1997)



(2) Changes in the Share of IT Investment to Nominal GDP (1992 to 97)

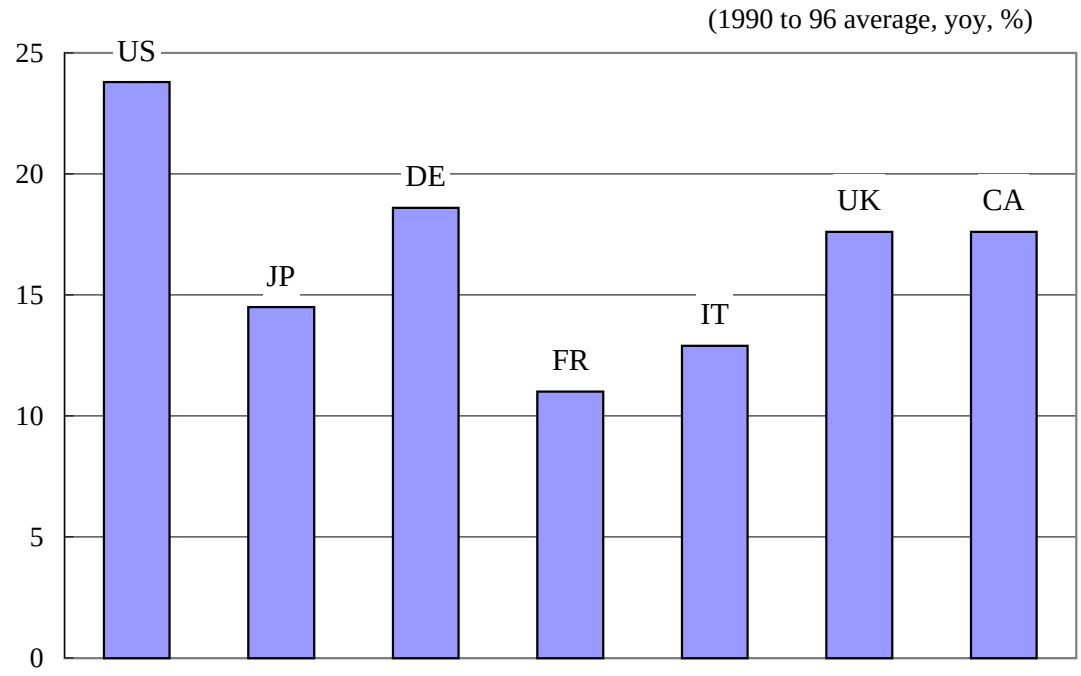


Source: Daveri (2000)

(Chart16)

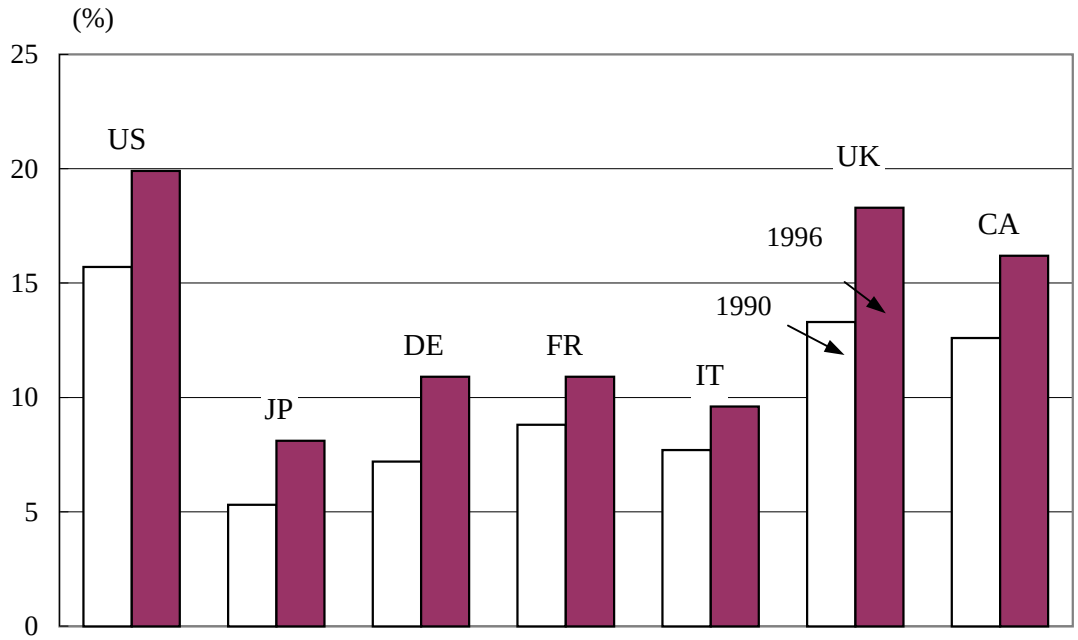
International Comparison of the IT Investment (2)

(1) Growth Rate of Real IT Investment



Note: Computer (hardware)

(2) The Share of IT Investment in Equipment Investment



Note: Excluding software.

Source: Schreyer (2000)

(Chart17)

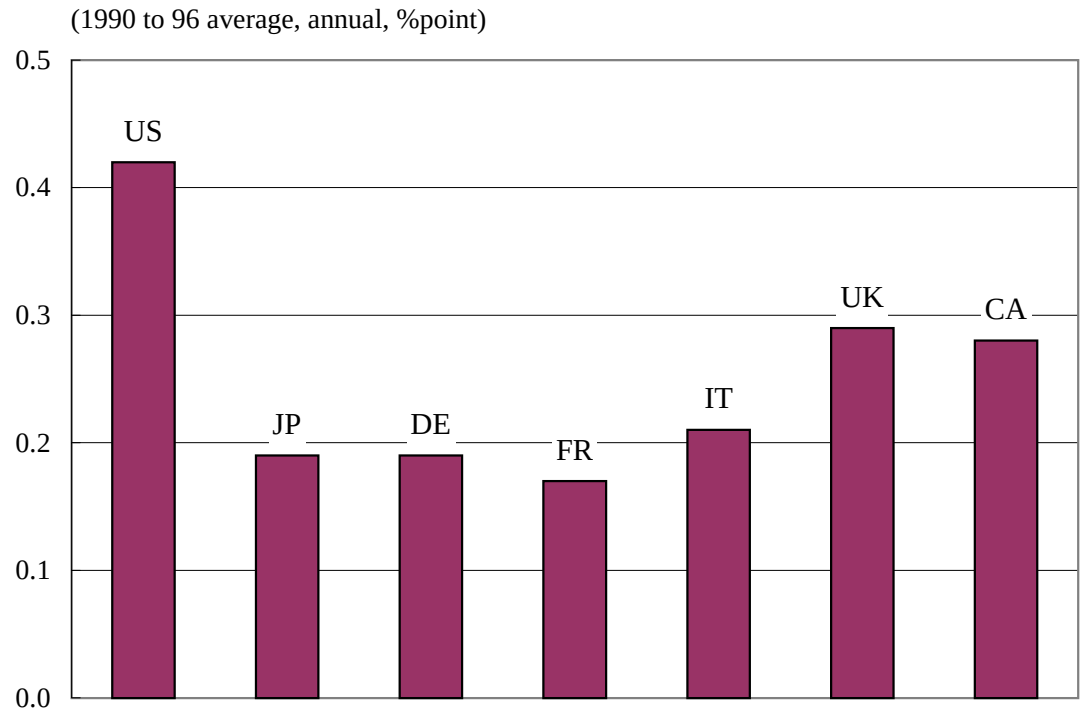
The Share of IT Stock in Capital Stock

Note: Softwares are not included in IT stock.

Source: Schreyer (2000)

(Chart18)

Contribution of IT Stock to Economic Growth (1)



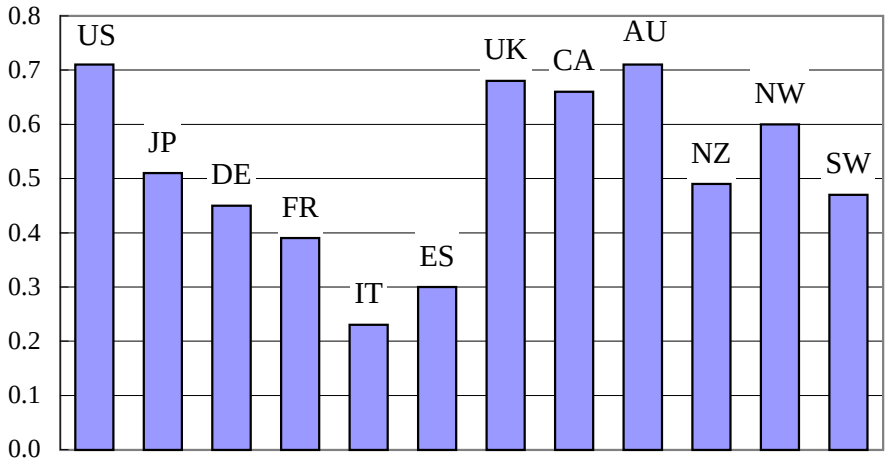
Note: IT stock excludes software.

Source: Schreyer (2000)

Contribution of IT Stock to Economic Growth (2)

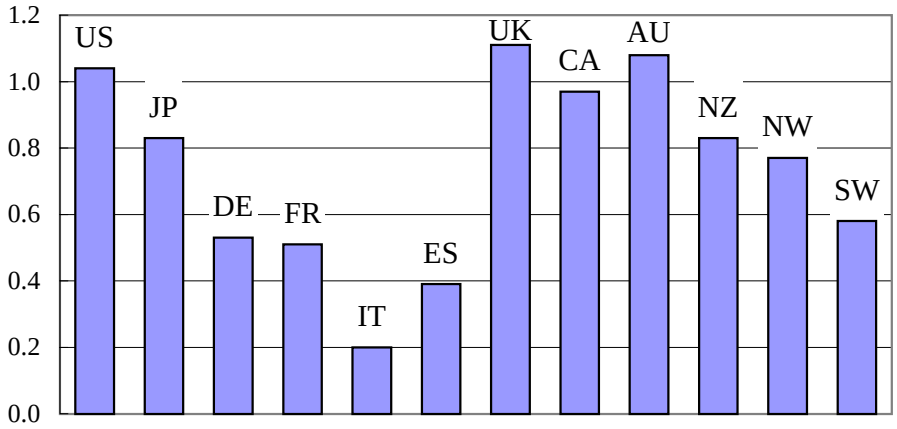
(1) 1999-97 Average

(annual, %point)



(2) 1996-97 Average

(annual, %point)



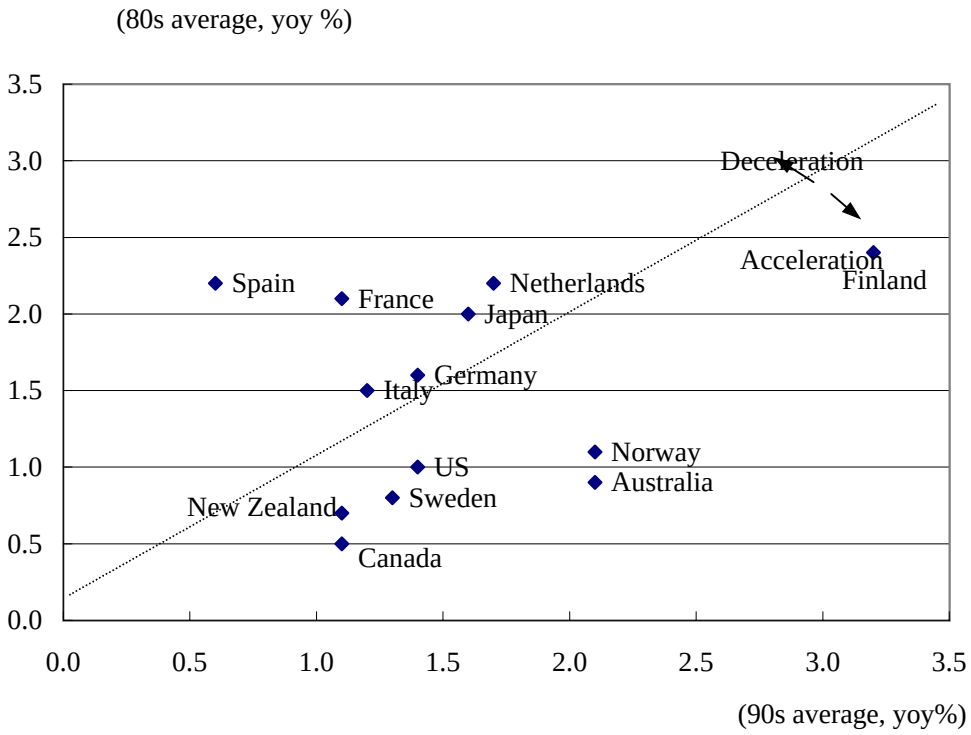
Note: Including software.

Source:Daveri (2000)

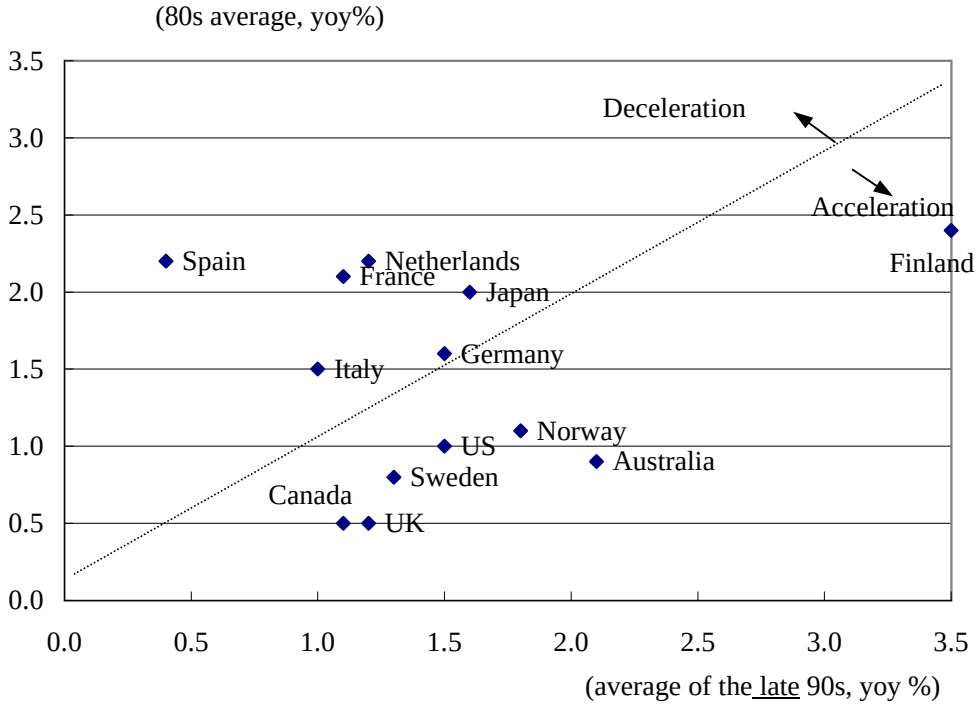
(Chart20)

TFP in the Major Developed Countries

(1) Comparison of the 1990s and the 1980s



(2) Comparison of the 1990s and the 1980s

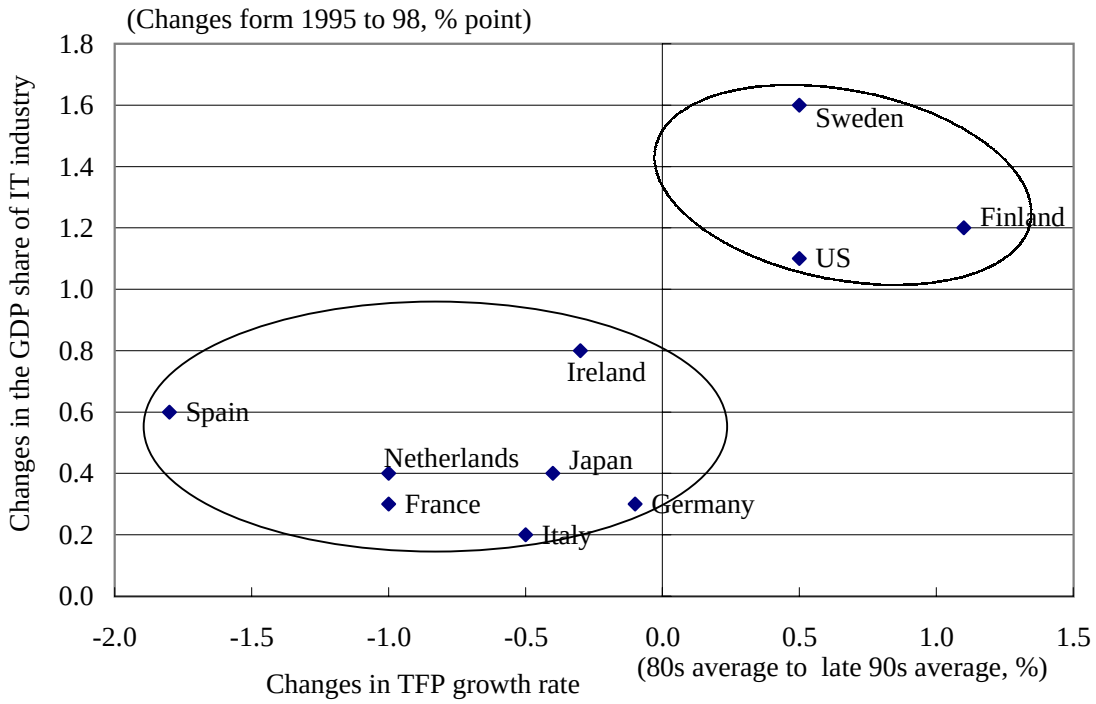


Note: As for the UK, the comparison between the 90s average and the late 1990s.
Source: Bassanini, Scarpetta and Visco (2000)

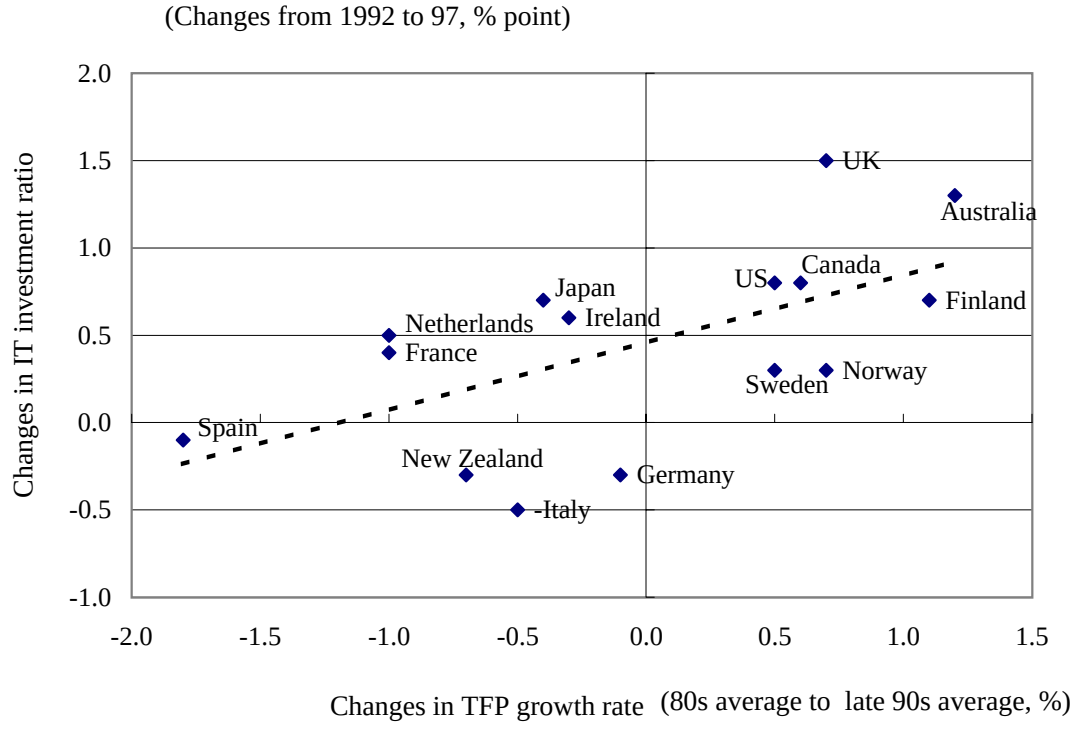
(Chart21)

The Correlation between TFP and IT

(1) The Correlation between TFP and the Share of IT Industry



(2) The Correlation between TFP and IT Investment Ratio

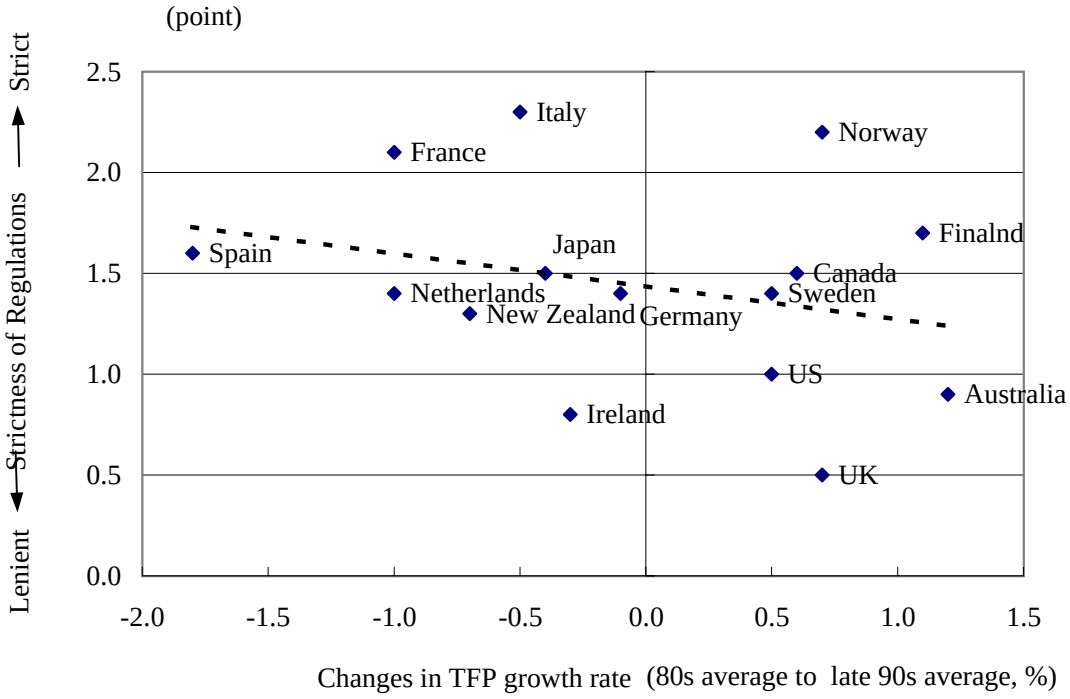


Note: The "IT investment ratio" is IT investment / GDP.
Resource: Bassanini, Scarpetta and Visco (2000), Daveri(2000),
Credit Suisse First Boston Securities(2000)

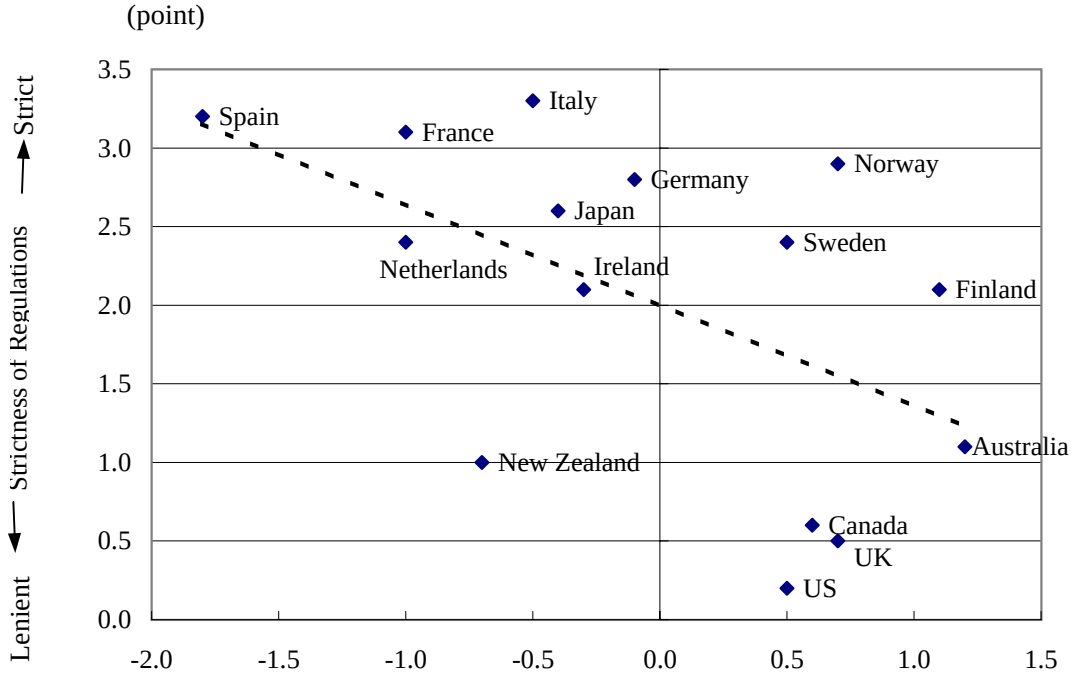
(Chart22)

The Correlation between TFP and Regulations

(1) The Correlation between TFP and Strictness of Product Market Regulations



(2) The Correlation between TFP and Strictness of Labor Market Regulations



Source: Bassanini, Scarpetta and Visco (2000), Nicoletti, Scarpetta and Boylaud (1999)