

An Exploration of the Japanese Slow Down during the 1990s

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February 2008

I. Introduction

Two striking aspects of the Japanese stagnation of the 1990s are its severity and especially its persistence. Over the 1983-1991 period, TFP grew at a more than respectable rate of 2.4 percent. It fell to an average of 0.2 percent for 1991-2000.

We know from Cogley and Nason (1995) that the persistence in real business cycles models comes from the persistence of the shocks. However, none of the shocks that arguably have hit the Japanese economy seem to have persisted for a decade. This implies that a successful account of the Japanese stagnation requires a model where the propagation mechanisms generate a significant amount of persistence.

One such approach is to modify a simple real business cycle model to allow for endogenous productivity as in Comin and Gertler (2006). This approach provides a unified explanation for the co-movements of TFP, technology diffusion and R&D over the short and medium term. To capture endogenous productivity dynamics, I follow Comin and Gertler (2006) and use a variation of Romer's (1990) model of R&D expanding the variety of intermediate goods extended to allow for an endogenous rate of adoption of new technologies.

The analysis in Comin and Gertler (2006), however, is restricted to a one-country framework. A more accurate model of the Japanese economy should recognize the impor-

tance of foreign factors such as technology, competition, and trade policy in the Japanese economy. Braun et al. (2006), for example, provide evidence on the importance of the adoption of foreign technology for Japanese growth. In particular they show that there is a strong positive correlation between lagged US R&D and Japanese TFP growth. Hence, the relevance of developing a multi-country model where high frequency domestic or international real shocks are propagated into the medium term by the endogenous development and diffusion of new technologies.

Working in a two-country framework is also necessary to account for the real exchange rate dynamics which surely played a crucial role in amplifying the shocks that triggered the stagnation. Countries are linked by two mechanisms. First, intermediate goods can be traded internationally. Second, since there may be barriers to trade, the producer of an intermediate good may choose to locate part of the production of the intermediate good overseas.

This environment is rich enough to analyze the effects of several shocks that hit the Japanese economy during the late 80s and early 90s.

- Direct and Indirect trade barriers were erected in the US and other developed economies to curb the increase in market share by Japanese producers. The Plaza Accord in 1985 marks the beginning of a series of measures in this direction. Trade barriers induced Japanese producers to offshore part of their operations. For example, by 1994, Japan's Big 4 car manufacturers were producing over three million cars outside Japan. This represents 30 percent of their total production. The decline in domestic activity reduced domestic aggregate demand and the value of adopting and developing new technologies. In this way, the trade barriers confronted by Japanese producers may have led to a significant and persistent decline in TFP. The other shocks I study, can also affect TFP through their effect on aggregate demand.
- Labor market regulation that restricted the length in the workweek was passed in 1988. This increased labor market real rigidities leading to a decline in aggregate demand.
- Japanese firms experienced an increase in the competition faced in the US and European markets from the entry of producers from other Asian countries that had

caught up technologically. This reduced the margins Japanese firms made in these markets and led to a reduction in domestic demand.

The goal of this paper is to explore the potential of each of these shocks both statistically and with the help of a model that will allow us to assess the quantitative relevance of each hypothesis. the rest of this paper is organized as follows. section 2 describes some of the facts relevant for a theory of the Japanese slow down. Section 3 describes the model features. Section 4 describes some simulation exercises. Section 5 concludes.

II. Facts

In this section, I present a series of facts with two purpose in mind. First, to describe the main features of the data that I consider a model of the Japanese slowdown should account for. Second, to motivate the mechanisms built in in the model.

Figure 1 presents the evolution of GNP per working age person¹ detrended with a linear trend given by the average post-war growth rate of the same variable in the U.S. which has been approximately two percent per year. In this and most of the subsequent figures, I take 1990 as the base year. This Figure illustrates clearly the magnitude of both the post-war catch up and the slow down of growth during the 1990s. between 1960 and 1990 per working age person GNP grew at an average rate of 4.6 percent per year. This rate declined to 0.7 percent per year during the lost decade.

Prescott and Hayashi (2003) show that the slowdown in TFP growth (or GNP growth) during the 1990s was not due to a constraint in investment due to a lack of capital to finance profitable investment projects. In particular, they show that there was no decline during the 1990s in investment by non-financial corporations as a share of GDP. The collapsed in the banking system, however, forced firm to find other sources of funds different from the bank loans that had helped finance 52 percent of the investment by non-financial corporations. These were a higher corporate savings rate and the sale of the land and financial assets that had been built during the 80s. Prescott and Hayashi (2003) also show that small firms, which rely more on bank loans, used cash and deposits as a buffer to finance their investment.

¹That is defined as persons with ages between 20 and 69 years.

As argued by Parente and Prescott (2002), the slow down in growth is driven by a large part by the slow down in TFP growth. Figure 2 compares the evolution of TFP in Japan and the U.S. both detrended at the post-war rate of 1.02 percent per year. Despite the impressive performance of US TFP during the 60s, Japan closed a significant part of the gap with the U.S. Between 1970 and 1990, Japan continued to close the gap while growing faster than the US long-run average. The 1990s, however, is a different story. While US managed to sustain long-run TFP growth, Japan's TFP grew significantly slower at 0.6 percent per year.

One interesting question raised by Fukao et al. (2004) concerns whether the slow down in Japanese TFP growth was driven by the performance of the service or manufacturing sectors. Figure 3 addresses this issue and shows that manufacturing was the main culprit for the TFP slow down during the 90s. Figure 4 provides more disaggregated evidence of the three largest sectors within durable manufacturing. These are general machinery, other electrical machinery and motor vehicles. The slow down in TFP growth in these three sectors is quite dramatic. Other electrical machinery was the sector with fastest growing TFP between 1970 and 1990, while for most of the 1990s, TFP was flat. Motor vehicles did not experience any TFP growth during the 90s, while in general machinery the growth rate was negative.

Two of the most significant sources of TFP growth in developed economies are innovation and technology adoption. Figures 5 and 6 show that Japanese R&D spending also suffered a significant slow down after 1990. Figure 7 shows that the growth rate of real wages in research activities slowdown more than in the rest of the sectors.

Figures 8 and 9 show the diffusion of computers and internet in Japan and compares it to the diffusion in the U.S. and in South Korea. Computers and the internet are the most significant technologies during the 1990s. part of their significance resides in their generality which makes them important to many activities in many different sectors of the economy. Thus, they provide a good proxy for the overall technology adoption in the economy.

During the 1990s the gap in computer adoption between Japan and the U.S. increased. The slow path in computer adoption in Japan is reflected by the fact that Korea, a significantly poorer economy, surpassed Japan in computers per capita. An almost identical picture emerges from the diffusion of internet.

The question that these findings beg to ask is why did R&D and the speed of adoption decline in Japan. It is natural to think that this decline was driven by a decline in the profitability of the investments to improve technology. But, what drove this lower profitability?

In this paper we will consider the relevance of three possible shocks. (i) Direct and indirect trade barriers imposed on Japan in order to accelerate the appreciation of the Yen. (ii) A wage markup shock which affects the wedge between the marginal product of labor and the marginal rate of substitution between consumption and leisure. (iii) A decline in the profitability of Japanese manufacturing firms due to the competition of China and other emerging economies.

Figure 10 plots the evolution of the Dollar-Yen exchange rate. Between 1971 and 1985 the Yen appreciated by 31 percent in nominal and 35 percent in real terms. During the next ten years, the rate of appreciation of the Yen accelerated. Specifically, between 1985 and 1995, the Yen appreciated by 60 percent in nominal and 66 percent in real terms. This appreciation of the Yen had a toll in the profitability of Japanese manufacturing companies. Figure 11 plots the evolution of the aggregate profit rate, while Figure 12 plots the operating income over gross output for services and non-service sectors. In Figure 11 we can observe how aggregate profitability declined since the late 80s. In non-service sectors, this decline reached a minimum in 1994, briefly recovered in 1996 and went down again in 1998.

However, despite the decline in profitability, the share of durable manufacturing in total Japanese employment did not decline much. Figure 13 shows the contrast with the US. While the employment share of durable manufacturing in Japan declined only from 14 to 12 percent between 1970 and 1998, in the US, it declined from 17 to 10 percent during the same period. The comparison is even more striking when focusing on car manufacturing (Figure 14). The US car manufacturing share declined from 1.4 to 1.14 between 1980 and 1998, while the Japanese increased from 1.8 to 2 percent between 1970 and 1998.

One response to the appreciation of the Yen was to export manufacturing jobs outside Japan. Table 1 shows the number of jobs offshored by Japanese companies in various sectors as a share of the domestic employment in the sector in 1987 and 1998. In manufacturing, as a whole, this share increased from 6 to 17 percent. In durable manufacturing,

the change was from 8 to 21 percent of the domestic labor force. In car manufacturing, the change was even more dramatic. By 1998, the number of employees in foreign Japanese plants represented 35 percent of the employment in domestic plants.

Another potentially important shock for the Japanese cycles are markup shocks. These are defined as the wedge between the marginal product of labor and the marginal rate of substitution between consumption and leisure. To compute this variable it is necessary to make some parametric assumptions about the utility and production functions. I assume a Cobb-Douglas production function and a unit elasticity between consumption and leisure. Of course, demographic and other very slow moving variables may be affecting this measure of the markup. I filter these using a Band-Pass filter that keeps cycles with periods between 2 and 100 quarters. Figure 15 plots the filtered markup for Japan, the U.S. and the US minus Japan markup, which can be interpreted as a measure of the relative demand in Japan. In this figure we can see that the Japanese relative demand was low during the first half of the 70s and between 1988 and 2000. In this later period, the gap in the markups was not as large as in the initial period, but the period over which Japan displayed a higher markup was longer.

I conclude this empirical exploration of the Japanese economy by exploring the connection between aggregate demand, TFP and the exchange rate. In theory, an increase in Japanese TFP should lead to an appreciation of the Yen since Japanese exports become more attractive to foreigners. Similarly, a lower demand in Japan than in the US should lead to an appreciation of the Yen since the US firms and consumers will demand (at a given exchange rate) more Japanese products than American products the Japanese demand. Table 2 reports the regressions where the dependent variables in column 1 and 2 are, respectively, the annual real and the nominal exchange rates. There are three main conclusions from these tables. As predicted by the theory, Japanese TFP appreciates the Yen, while higher demand in Japan depreciates it. These effects are significant and strong. What is more surprising is the explanatory power of these two variables. The R^2 when the dependent variable is the nominal exchange rate is 94 percent, while when it is the real exchange rate it is 96 percent.

This high R^2 provides strong evidence in favor of endogenizing the exchange rate and using shocks to the markup as a source of fluctuations in the economy.

III. The model

Model features:

- Two asymmetric countries (i.e., the U.S. and Japan) that trade intermediate goods used to produce new capital. Throughout the paper we index the two countries by the index $c \in \{U, J\}$, where U denotes the U.S. and J denotes Japan.
- Endogenous development of these intermediate goods in both countries as in ?.
- Endogenous determination of the range of intermediate goods that are suitable for export between the two countries.
- Endogenous transfer of production of intermediate goods between the two countries (i.e., FDI).
- Monopolistic competition in the production of final goods.
- Low persistence wage markup shocks.

A. Output

A.1. Final output

There is a final output composite which can be used for:

- consumption
- investment
- government spending
- R&D
- adapting intermediate goods to export to the other country and investing in transferring the production of the intermediate goods to the other country.

This final output composite is a CES aggregator of N_{ct} differentiated final goods:

$$Y_{ct} = \left[\int_0^{N_{ct}} Y_{ct}(j)^{\frac{1}{\mu_{ct}}} dj \right]^{\mu_{ct}} \quad (1)$$

where $Y_{ct}(j)$ is the output of final good producer j . We assume $\mu_c > 1$, where μ_c is inversely related to the price elasticity of substitution across goods. In the symmetric equilibrium that follows, μ_c will be the gross markup that each final producer will charge. We allow the markup to be different across the two countries. We also allow the number of final goods firms in each country N_{ct} to be time varying to satisfy a free entry condition every instant. This scenario yields pro-cyclical net entry.

A.2. Final goods firms

Final goods are produced by differentiated final producers. Final producers produce their differentiated goods using a Cobb-Douglas production function with labor and capital as inputs as follows:

$$Y_{ct}(j) = (1 + g)^t (u_{cjt} K_{cjt})^\alpha L_{cjt}^{1-\alpha} \quad (2)$$

where g is the exogenous growth rate of disembodied productivity. Each firm faces a competitive labor market and competitive rental market for capital. Following ? we assume that the rate of depreciation of capital δ is increasing in utilization rate, as described below.

B. Capital

B.1. Final Capital Good Composite

Capital is produced using final output. In particular, new capital is a composite J_{ct} that combines the capital produced by N_{ct}^K retailers indexed by r according to the following CES aggregator:

$$J_{ct} = \left(\int_0^{N_{ct}^K} J_{ct}(r)^{\frac{1}{\mu_{ct}^K}} dr \right)^{\mu_{ct}^K} \quad (3)$$

with $\mu_c^K > 1$. We allow the retailer markup to be different across the two countries. As with the final goods retail market, we will subsequently endogenize N_{ct}^K in order to

obtain pro-cyclical net entry. In booms more retailers will produce new capital and the price of capital will drop given the increased supply. Therefore, the pro-cyclicity of N_{ct}^K contributes to the counter-cyclicity of the relative price of capital.

B.2. Final Capital Goods Firms

Each retailer r produces $J_{ct}(r)$ units of new capital by combining A_{ct} differentiated intermediate capital goods available for production in country c according to the following production function:

$$J_{ct}(r) = \left(\int_0^{A_{ct}} I_{ct}^r(s)^{\frac{1}{\theta}} ds \right)^\theta \quad (4)$$

with $\theta > 1$ and where $I_{ct}^r(s)$ denotes the number of units of intermediated good s used by retailer r . As with final goods, there are efficiency gains in producing new capital from increasing the number of intermediate inputs A_{ct} . These efficiency gains are the source of embodied technological change and are manifested in a fall in the relative price of capital. In section C.1 we characterize the endogenous development of new intermediate capital goods.

B.3. Intermediate capital goods producers

Each intermediate capital producer s uses one unit of final output composite to manufacture one unit of the differentiated input $I_{ct}^r(s)$. Given the demand function, profit maximization implies that each of these firms sets the price as a fixed markup θ over the wage rate.

C. R&D

The life cycle of an intermediate good is as follows. It is first invented in country $U(J)$. After successfully completing and adoption process, it becomes suitable for use also in country $J(U)$, and it starts becoming exported from $U(J)$ to $J(U)$. Finally, after successfully completing another investment, its production can be transferred to country $J(U)$. From that moment on, the intermediate good is produced in country $J(US)$ and it is

used for the production of domestic capital². New intermediates result from investing the final output composite into research and development activities. To finance their research activities, researchers borrow from households. They pay out the remaining profits as dividends to households who own the equity stakes in their respective enterprises.

C.1. Creation of new intermediate goods

The benefit to an innovator from developing a new product is given by the market price of the patent to produce an intermediate good that at this point can only be sold locally in the innovator's original country. We denote this by v_{ct} . We assume that the flow of new local products generated by each innovator p (i.e., $A_{ct+1}^l(p) - A_{ct}^l(p)$) in country c depends linearly on the research and development funds $S_{ct}(p)$ invested by innovator p as follows:

$$A_{ct+1}^l(p) = \varphi_{ct} S_{ct}(p) + (1 - \phi)(1 - \lambda_{ct}^g) A_{ct}^l(p) \quad (5)$$

where φ_{ct} is the productivity of the R&D as perceived by the individual innovator and ϕ is the fixed probability that any innovation becomes obsolete. As in ?, the linear formulation permits a simple decentralization of the innovation process. We differ from Romer, however, by having the innovation technology use as input a final good composite of capital and labor, as opposed to just labor. Doing so enhances the ability of the model to generate pro-cyclical R&D, as is consistent with the evidence presented in ? among others.

Individual innovators take the path of φ_{ct} as given. We assume that φ_{ct} depends on the aggregate stock of innovations in each country, A_{ct}^l , the wholesale value of the capital stock $P_{ct}^I K_{ct}$, aggregate research and development expenses S_{ct} as follows:

$$\varphi_{ct} = \chi A_{ct}^l \left(\frac{S_{ct}}{P_{ct}^I K_{ct}} \right)^{\rho-1} (P_{ct}^I K_{ct})^{-1} \quad (6)$$

with $0 < \rho \leq 1$ and where χ is a scale parameter. As with ?, there is a positive spillover of the current stock of innovations on the creation of new products, i.e. φ_{ct}

²We assume that once the production of an intermediate good has been transferred from one country to the other, the corresponding output will not be transferred back to the first country. In other words, we assume FDI is used to serve a foreign market and not for production de-location

increases linearly in A_{ct}^l . The formulation differs from Romer in two respects. First, the productivity of the R&D technology is scaled by the wholesale value of the capital stock (i.e., $P_{ct}^I K_{ct}$). Intuitively, the cost of producing new inventions rises proportionately over time with the scale of economic activity, as measured by the capital stock. This scaling factor ensures that the equilibrium growth rate of new projects is stationary. Secondly, we introduce an aggregate congestion to R&D conducted through the factor $(S_{ct}/P_{ct}^I K_{ct})^{\rho-1}$. This permits us flexibility in calibrating the impact of R&D on innovation in a way that is consistent with the evidence.

The linearity of the R&D technology as perceived by the individual researchers together with a free entry assumption implies that each new product developer p must break even. As a result, the resources invested in R&D by the p^{th} innovator satisfy the following arbitrage condition:

$$(1 - \phi)R_{ct}^{-1}E_t v_{ct+1} - \frac{1}{\varphi_{ct}} = 0 \quad (7)$$

where E_t is the expectation operator, the left-hand side is the discounted marginal benefit from an innovation for country c and the right-hand side is the marginal cost in units of final output. We denote by v_{ct} the market value of the patent to produce an intermediate good that can be produced and sold only in country c . The following expression represents this value:

$$v_{ct} = \max_{x_{ct}} \{ \pi_{ct} - x_{ct}^g + R_{ct}^{-1}(1 - \phi)E_t [\lambda_{ct}(\Gamma_{ct}^g x_{ct}^g)v_{ct+1}^g + (1 - \lambda_{ct}(\Gamma_{ct}^g x_{ct}^g))v_{ct+1}] \} \quad (8)$$

where x_{ct}^g is the number of units of final output spent by the innovator in country c in adapting the intermediate good for use in the second country, $\lambda_{ct}(\Gamma_{ct}^g x_{ct}^g)$ is the associated probability of a successful adaptation where the function $\lambda_c(\cdot)$ satisfies $\lambda_c' > 0$, $\lambda_c'' < 0$, v_{ct}^g is the market value of the patent to produce a global intermediate good (i.e., an intermediate good that can be exported from country d to country f where d, f denote the domestic and foreign country respectively), and Γ_{ct}^g is the time-varying slope parameter, taken as exogenous by the innovator, and equal to:

$$\Gamma_{ct}^g = \frac{b^g}{(P_{ct}^I K_{ct} / A_{ct}^l)}$$

where b^g is a positive constant and A_{ct}^l is the stock of locally available intermediate goods.

D. Exporting Technology

A domestic innovator can invest resources x_{ct}^g to make an intermediate good suitable for use in the second country so that it can be exported. Intermediate goods suitable to export are defined global. At the margin the owner of the patent rights of an intermediate good adjusts conversion expenditures until the marginal expenditure (one unit of final goods output) equals the expected marginal benefit defined in the right-hand side of the following expression:

$$1 = R_{ct+1}^{-1} \Gamma_{ct}^g (1 - \phi) \lambda'_{ct}(\Gamma_{ct}^g x_{ct}^g) (v_{ct+1}^g - v_{ct+1}) \quad (9)$$

Since, in equilibrium, all patents owners are symmetric, we can denote the rate of conversion of local into global intermediate goods by $\lambda_{ct}^g = \lambda_{ct}(\Gamma_{ct}^g x_{ct}^g)$.

The law of motion for the number of global intermediate inputs produced by country c is then:

$$A_{ct}^g = (1 - \phi) \lambda_{ct-1}^g A_{ct-1}^l + (1 - \phi) (1 - \lambda_{ct-1}^T) A_{ct-1}^g \quad (10)$$

where λ_{ct}^T denotes the probability that an intermediate good's production is transferred from the original country to the other. We assume that a domestic innovator who owns the right to export an intermediate good, can further invest $e_t x_{*t}^T$ units of final output and transfer the production of the global intermediate good abroad. With e_t we denote the real exchange rate between the two countries: i.e., the number of units of domestic final output per unit of foreign output. With x_{*t}^T we denote the units of foreign output invested by the domestic innovator in order to transfer the production of the global intermediate good abroad.

The value of a global intermediate good is then:

$$v_{ct}^g = \max_{x_{ct}^g} \pi_{ct}^g - e_t x_{ct}^{T*} + R_{ct}^{-1}(1 - \phi) E_t [\lambda_{ct}(\Gamma_{ct}^T x_{*t}^T) v_{ct+1}^T + (1 - \lambda_{ct}(\Gamma_{ct}^T x_{*t}^T)) v_{ct+1}^g] \quad (11)$$

with:

$$\Gamma_{ct}^T = \frac{b^T}{(P_{ct}^I K_{ct} / A_{ct}^g)}$$

where $b^T > 0$. We denote with v_{ct}^T the value of an intermediate good produced abroad. Since in equilibrium all patents owners are symmetric, we can denote the rate of transfer of production of global intermediate goods by one country to the other with $\lambda_{ct}^T = \lambda_{ct}(\Gamma_{ct}^T x_{*t}^T)$.

At the margin, the owner of the right to transfer production abroad adjust transfer expenditures until the marginal expenditure equals the marginal benefit defined in the right hand side expression:

$$1 = R_{ct+1}^{-1} \Gamma_{ct}^T (1 - \phi) \lambda'_{ct}(\Gamma_{ct}^T x_{ct}^T) (v_{ct+1}^T - v_{ct+1}^g) \quad (12)$$

and the value of an intermediate good produced by home in the foreign country is:

$$v_{ct}^T = \pi_{ct}^T + R_{ct+1}^{-1} (1 - \phi) E_t v_{ct+1}^T \quad (13)$$

The law of motion of the number of goods produced abroad by each country is as follows:

$$A_{ct}^T = (1 - \phi) \lambda_{ct-1}^T A_{ct-1}^g + (1 - \phi) A_{ct-1}^T$$

Since global intermediate goods developed in the foreign country together with intermediate goods produced locally by foreign firms can be used for production in the home country, the total number of intermediate goods available for the production of capital goods in country c is:

$$A_{ct} = A_{ct}^l + A_{ct}^g + A_{ct}^T + A_{ft}^g + A_{ft}^T \quad (14)$$

E. Free Entry

We now characterize the determination of the quantity of firms, N_{ct} and N_{ct}^K for both the retail output and retail capital goods sectors. Entry takes place until at the margin gross profits equal operating costs. We assume that retail output firms must pay a per period operating cost Ψ_{ct} and the retail capital goods firms must pay Ψ_{ct}^K . The free entry condition for each sector is given by, respectively:

$$\frac{\mu_c - 1}{\mu_c} P_{ct}(j) Y_{ct}(j) = \Psi_{ct} \quad (15)$$

$$\frac{\mu_c^k - 1}{\mu_c^k} P_{ct}^k(r) J_{ct}(r) = \Psi_{ct}^K \quad (16)$$

where the left side of each equation is gross profits. We assume that firms take operating profits costs as given. The operating costs drift up over time proportionately with the wholesale value of capital stock to ensure balanced growth:

$$\Psi_{ct} = b P_{ct}^I K_{ct} \quad (17)$$

$$\Psi_{ct}^k = b_K P_{ct}^I K_{ct} \quad (18)$$

One possible interpretation of this formulation is that operating costs are proportionate to the sophistication of the economy, as measured by the wholesale value of the capital stock.

F. Households

There is a representative household that consumes, supplies labor and saves. It may save by either accumulating capital or lending to innovators domestically or internationally. The household also has equity claims in all domestic monopolistically competitive firms. It makes one period loans to innovators and also rents capital that it has accumulated directly to firms. Markets are incomplete and only one-period risk free bonds are available. Following ?, we assume agents must pay fees to domestic financial intermediaries when adjusting their bond holdings. We assume these fees to be a quadratic function of the

stock of bonds. Further, we assume that financial intermediaries rebate the revenues from bond adjustment fees to domestic households. Finally, bonds issued by households in country c are denominated in the currency of country c .

Let C_{ct} be consumption and μ_{ct}^w be a preference shifter. Then the representative household in country c maximizes the present discounted utility as given by the following expression:

$$E_t \sum_{i=0}^{\infty} \beta^{t+i} [\ln C_{ct} - \mu_{ct}^w \frac{(L_{ct}^{\zeta+1})}{\zeta+1}] \quad (19)$$

The budget constraint in units of consumption of country c is as follows:

$$\begin{aligned} C_{ct} + B_{ct} + e_t B_{*t} + \frac{\eta}{2}(B_{ct})^2 + \frac{\eta}{2}(B_{*t})^2 - F_{ct} = \\ = \omega_{ct} L_{ct} + \Pi_{ct} + [D_{ct} + P_{ct}^K] K_{ct} - P_{ct}^k K_{ct+1} + R_{ct} B_{ct-1} + R_{*t} (e_t B_{*t-1}) - T_{ct} \end{aligned} \quad (20)$$

where Π_{ct} reflects the profits of monopolistic competitors paid out fully as dividends to households, T_{ct} reflects lump sum taxes and B_{ct} and B_{*t} are holdings of domestic and foreign bonds for households in country c . Hence, B_{ct} and B_{*t} are issued by a household in country c in the home and foreign market respectively. Households suffer a cost of adjusting holdings of home and foreign bonds equal to $\frac{\eta}{2}[(B_{ct})^2 + (B_{*t})^2]$ and receive a fee rebate which they take as given equal to $F_{ct} = \frac{\eta}{2}[(B_{ct})^2 + (B_{*t})^2]$. We assume the parameter η is positive and identical across countries. Further, we assume there is no cost of adjusting equity holdings. The Euler equations for bond holdings will pin down the equilibrium interest rates in each country.

Since each country is populated by a unitary mass of identical households that in equilibrium make the same choice, domestic and foreign holding of each bond must add up to zero. Therefore, the following two bond-market clearing conditions hold in equilibrium:

$$\begin{aligned} B_{ct} + B_{ct}^* &= 0 \\ B_{*t} + B_{*t}^* &= 0 \end{aligned}$$

If we consider the budget constraint obtained by aggregating across the total number of households of country c , we get the following law of motion for net foreign assets:

$$B_{ct} + e_t B_{*t} = R_{ct} B_{ct-1} + R_{*t} (e_t B_{*t-1}) + \omega_{ct} L_{ct} + \Pi_{ct} + [D_{ct} + P_{ct}^K] K_{ct} - P_{ct}^k K_{ct+1} - C_{ct} - T_{ct} \quad (21)$$

If we subtract from (21) the corresponding expression for country $*$, taking into account the equilibrium conditions in (??), we get an expression for country c 's net foreign asset accumulation as a function of interest income and the cross country differentials between labor income, dividends, return from capital, taxes and consumption:

$$B_{ct} + e_t B_{*t} = R_{ct} B_{ct-1} + R_{*t} (e_t B_{*t-1}) + \frac{1}{2} (\omega_{ct} L_{ct} - e_t \omega_{*t} L_{*t}) + \frac{1}{2} (\Pi_{ct} - e_t \Pi_{*t}) + \frac{1}{2} ([D_{ct} + P_{ct}^K] K_{ct} - e_t [D_{*t} + P_{*t}^K] K_{*t}) + \frac{1}{2} (P_{ct}^k K_{ct+1} - e_t P_{*t}^k K_{*t+1}) - \frac{1}{2} (C_{ct} - e_t C_{*t}) - \frac{1}{2} (T_{ct} - e_t T_{*t}) \quad (22)$$

The current account for country c is simply equal to the changes in aggregate bond holdings in the two countries:

$$CA_{ct} = B_{ct} - B_{ct-1} + e_t (B_{*,t} - B_{*,t-1}) \quad (23)$$

and by the bond-market clearing conditions (??) we have that:

$$CA_{ct} + e_t CA_{*t} = 0$$

Households in two countries lend funds to innovators which raise research and development funds S_{ct} in country c . Hence, the aggregate funds raised by innovators in country c is equal to $S_{ct} = B_{ct} + B_{*t}^*$.

G. Government

Government spending is financed with lump sum transfers:

$$G_{ct} = T_{ct} \tag{24}$$

We assume the government does not issue bonds neither domestically nor internationally.

IV. Potential shocks

- Japanese trade quotas in the US.
- Domestic labor market frictions.
- Domestic barriers to entry faced by Japanese producers.
- Foreign competition.
- Plaza Accord and the exchange rate between the dollar and the yen
- FDI

V. Symmetric equilibrium

Let's define the shares T_{ut} and T_{jt} for the U.S (u) and Japan (j):

$$T_{ut} = 1 + \frac{A_{ut}^g}{A_{ut}^l} + \frac{A_{jt}^g}{A_{ut}^l} \left(\frac{P_{jt}e_t}{\delta P_{ut}} \right)^{-\frac{1}{\theta-1}} + \frac{A_{jt}^T}{A_{ut}^l}$$

$$T_{jt} = 1 + \frac{A_{jt}^g}{A_{jt}^l} + \frac{A_{ut}^g}{A_{jt}^l} \left(\frac{P_{ut}}{\delta P_{jt}e_t} \right)^{-\frac{1}{\theta-1}} + \frac{A_{ut}^T}{A_{jt}^l}$$

In steady state for country $c = \{u, j\}$:

$$\frac{A_{ct}}{A_{ct-1}} = \frac{A_{ct}^l}{A_{ct-1}^l} = \frac{A_{ct}^g}{A_{ct-1}^g} = \frac{A_{ct}^T}{A_{ct-1}^T} = ga_c + 1$$

Let's define the following aggregate variables:

$$\begin{aligned}\Pi_{ct}^l &= A_{ct}^l \pi_{ct}^l \\ \Pi_{ct}^g &= A_{ct}^g \pi_{ct}^g \\ \Pi_{ct}^T &= A_{ct}^T \pi_{ct}^T\end{aligned}$$

Then we can write:

$$\begin{aligned}\frac{A_{jt}^g}{A_{ut}^l} &= (1 - \phi) \lambda_j^g \frac{A_{jt}^l}{A_{ut}^l} \frac{1}{ga_j + 1} [1 - (1 - \phi)(1 - \lambda_j^T) \frac{1}{ga_j + 1}] \\ \frac{A_{jt}^T}{A_{ut}^T} &= (1 - \phi) \lambda_j^T \frac{A_{jt}^g}{A_{ut}^l} \frac{1}{ga_j + 1}\end{aligned}$$

Local profits³:

$$\begin{aligned}\Pi_{ut}^l &= (1 - \frac{1}{\theta}) \frac{inv_{ut}}{\mu_{uk}} T_{ut}^{-1} \\ \Pi_{jt}^l &= (1 - \frac{1}{\theta}) \frac{inv_{jt}}{\mu_{jk} T_{jt}^{-1}}\end{aligned}$$

Global profits:

$$\begin{aligned}\Pi_{ut}^g &= (1 - \frac{1}{\theta}) \left(\frac{inv_{ut}}{\delta \mu_{uk}} T_{ut}^{-1} \frac{A_{ut}^g}{A_{ut}^l} + \frac{e_t inv_{jt}}{\mu_{uk}} T_{jt}^{-1} \frac{A_{ut}^g}{A_{jt}^l} \left(\frac{e_t P_{ut}}{P_{jt} \delta} \right)^{-\frac{1}{\theta-1}} \right) \\ \Pi_{jt}^g &= (1 - \frac{1}{\theta}) \left(\frac{inv_{ut}}{e_t \mu_{jk}} T_{ut}^{-1} \frac{A_{jt}^g}{A_{ut}^l} \left(\frac{P_{jt}}{e_t \delta P_{ut}} \right)^{-\frac{1}{\theta-1}} + \frac{inv_{jt}}{\mu_{jk} \delta} T_{jt}^{-1} \frac{A_{jt}^g}{A_{jt}^l} \right)\end{aligned}$$

Foreign direct investment profits:

$$\Pi_{ut}^T = (1 - \frac{1}{\theta}) \left(\frac{inv_{ut}}{\mu_{uk}} T_{ut}^{-1} \frac{A_{ut}^T}{A_{ut}^l} + \frac{e_t inv_{jt}}{\mu_{jk}} T_{jt}^{-1} \frac{A_{ut}^T}{A_{jt}^l} \left(\frac{e_t P_{ut}}{P_{jt}} \right)^{-\frac{1}{\theta-1}} \right)$$

³With inv_{ct} we denote aggregate new investment in country c at time t as described in equation (3)

$$\Pi_{jt}^T = (1 - \frac{1}{\theta}) \left(\frac{inv_{jt}}{\mu_{jk}} T_{jt}^{-1} \frac{A_{jt}^T}{A_{jt}^l} + \frac{inv_{ut}}{e_t \mu_{uk}} T_{ut}^{-1} \frac{A_{jt}^T}{A_{ut}^l} \left(\frac{P_{jt}}{e_t P_{ut}} \right)^{-\frac{1}{\theta-1}} \right)$$

Current Account Balance:

$$\begin{aligned} CA_{ut} = & \frac{e_t inv_{jt}}{\mu_{uk}} T_{jt}^{-1} \frac{A_{ut}^g}{A_{jt}^l} \left(\frac{e_t P_{ut}}{P_{jt} \delta} \right)^{-\frac{1}{\theta-1}} + \frac{e_t inv_{jt}}{\mu_{jk}} T_{jt}^{-1} \frac{A_{ut}^T}{A_{jt}^l} \left(\frac{e_t P_{ut}}{P_{jt}} \right)^{-\frac{1}{\theta-1}} \\ & - (1 - \frac{1}{\theta}) \left(\frac{inv_{ut}}{\mu_{jk}} T_{ut}^{-1} \frac{A_{jt}^g}{A_{ut}^l} \left(\frac{P_{jt}}{e_t \delta P_{ut}} \right)^{-\frac{1}{\theta-1}} \right) - (1 - \frac{1}{\theta}) \left(\frac{inv_{ut}}{\mu_{jk}} T_{ut}^{-1} \frac{A_{jt}^g}{A_{ut}^l} \left(\frac{P_{jt}}{e_t \delta P_{ut}} \right)^{-\frac{1}{\theta-1}} \right) \quad (25) \end{aligned}$$

Figure 1; Detrended Real GNP per working age population

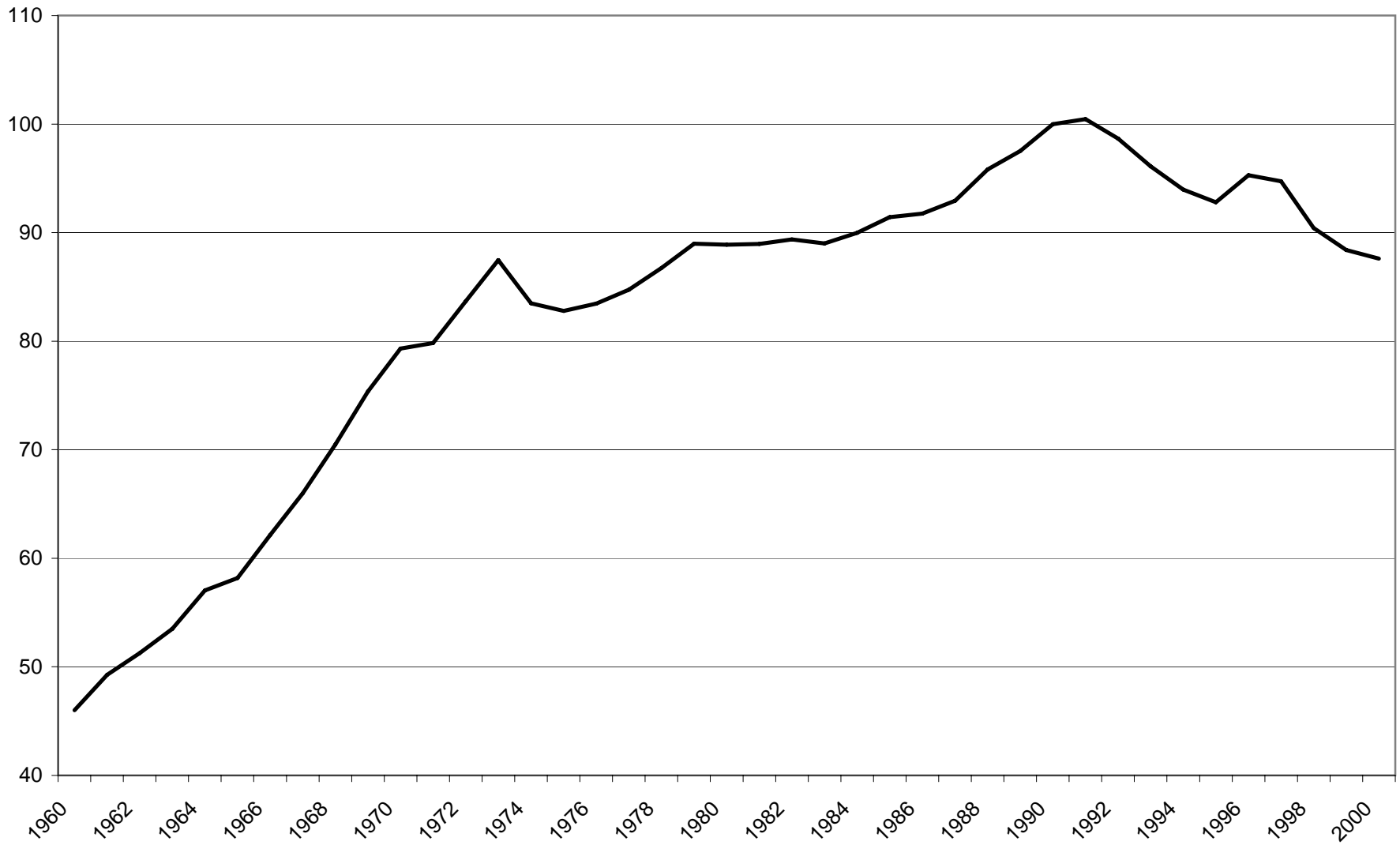


Figure 2: Detrended TFP

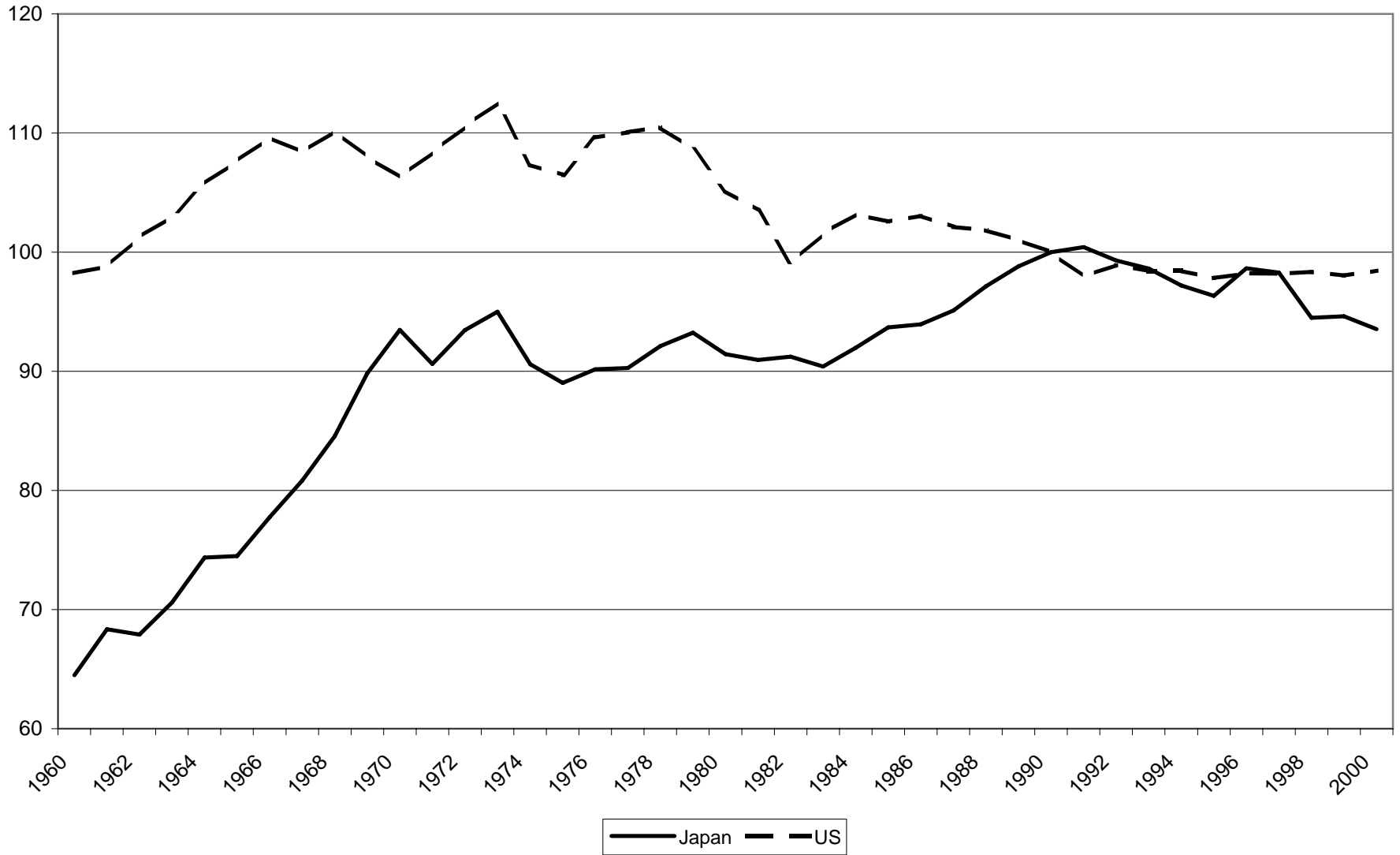


Figure 3: TFP of services and non-services

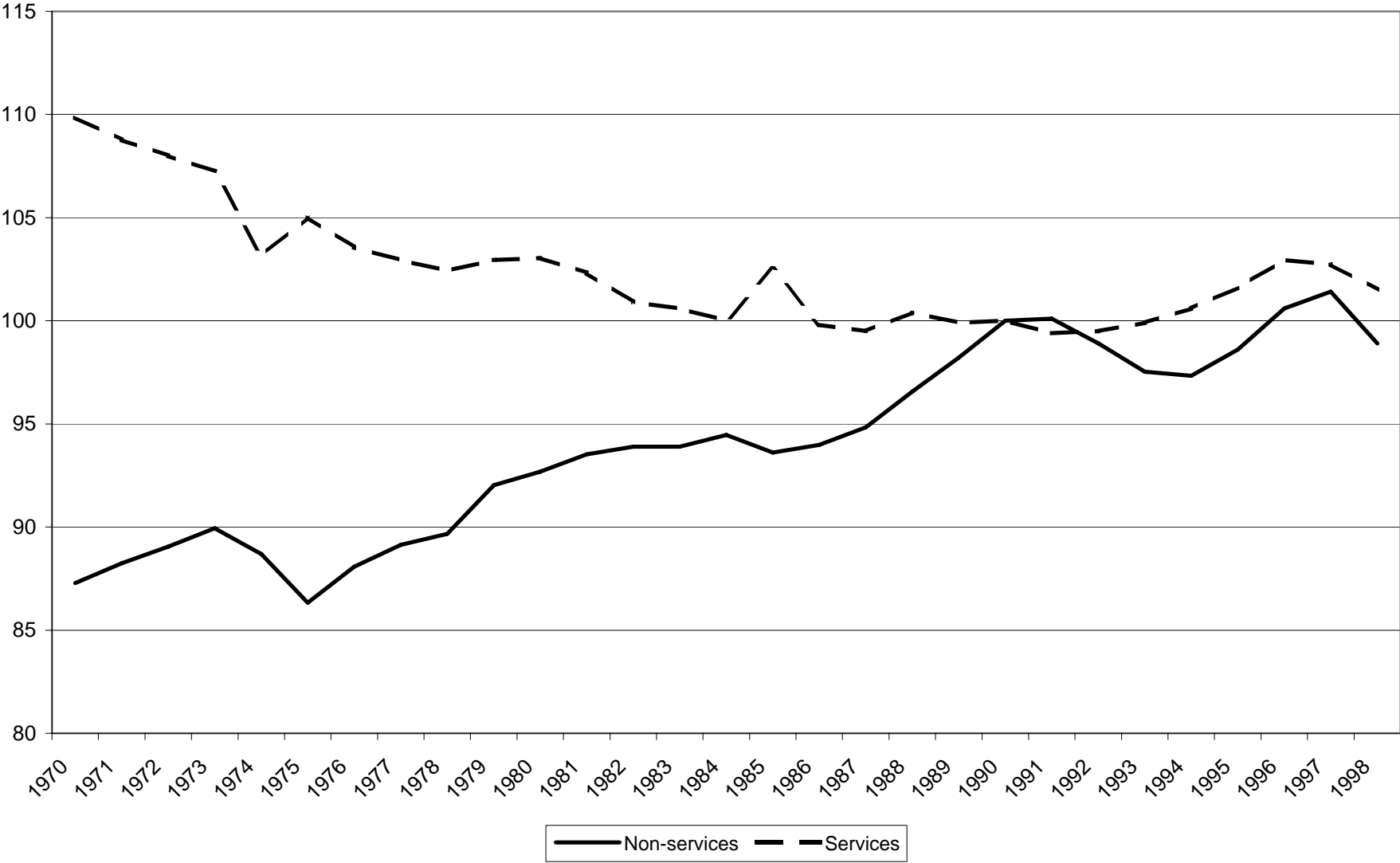


Figure 4: TFP in selected manufacturing sectors

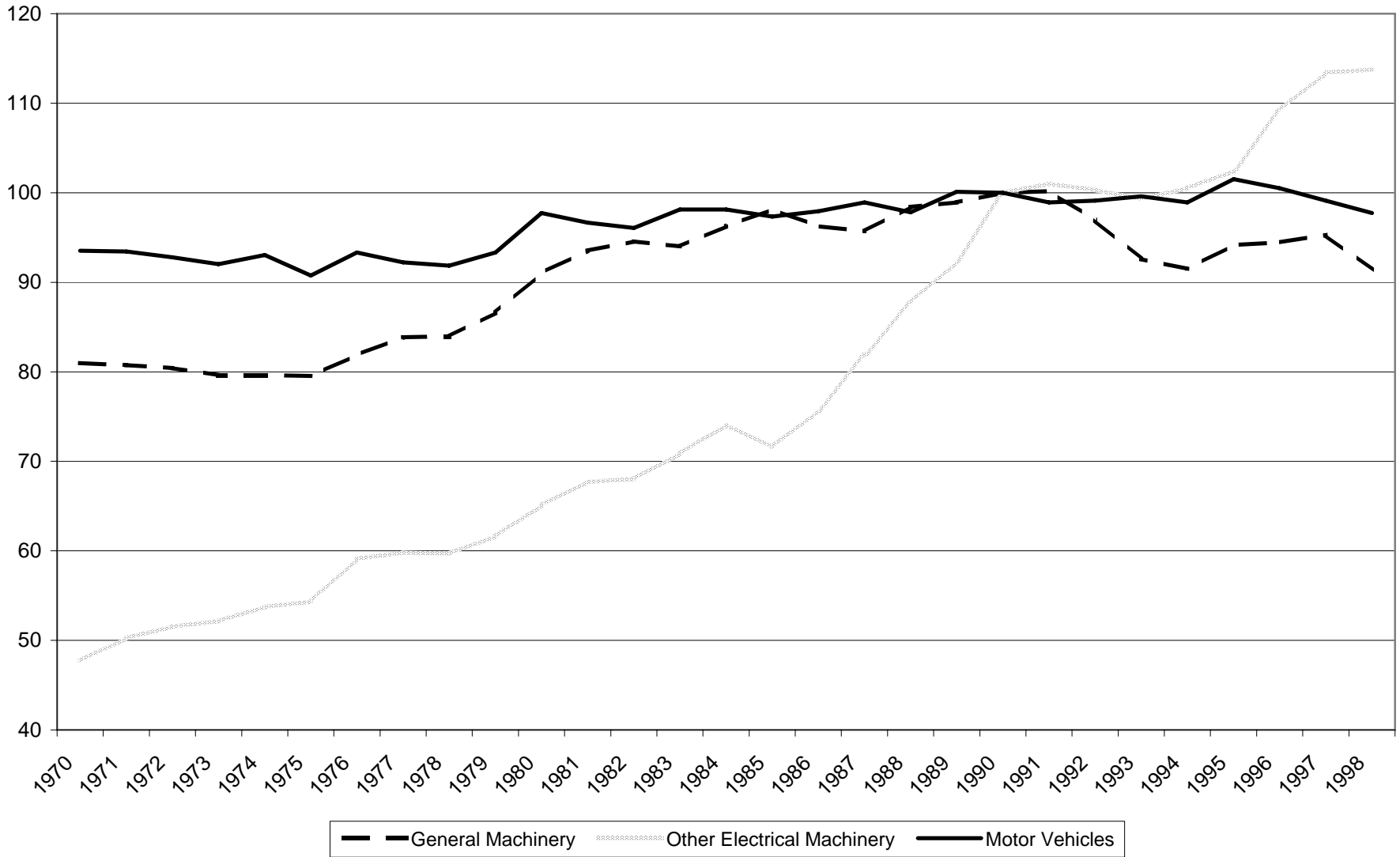


Figure 5: Real expenses in R&D detrended at 2 percent per year

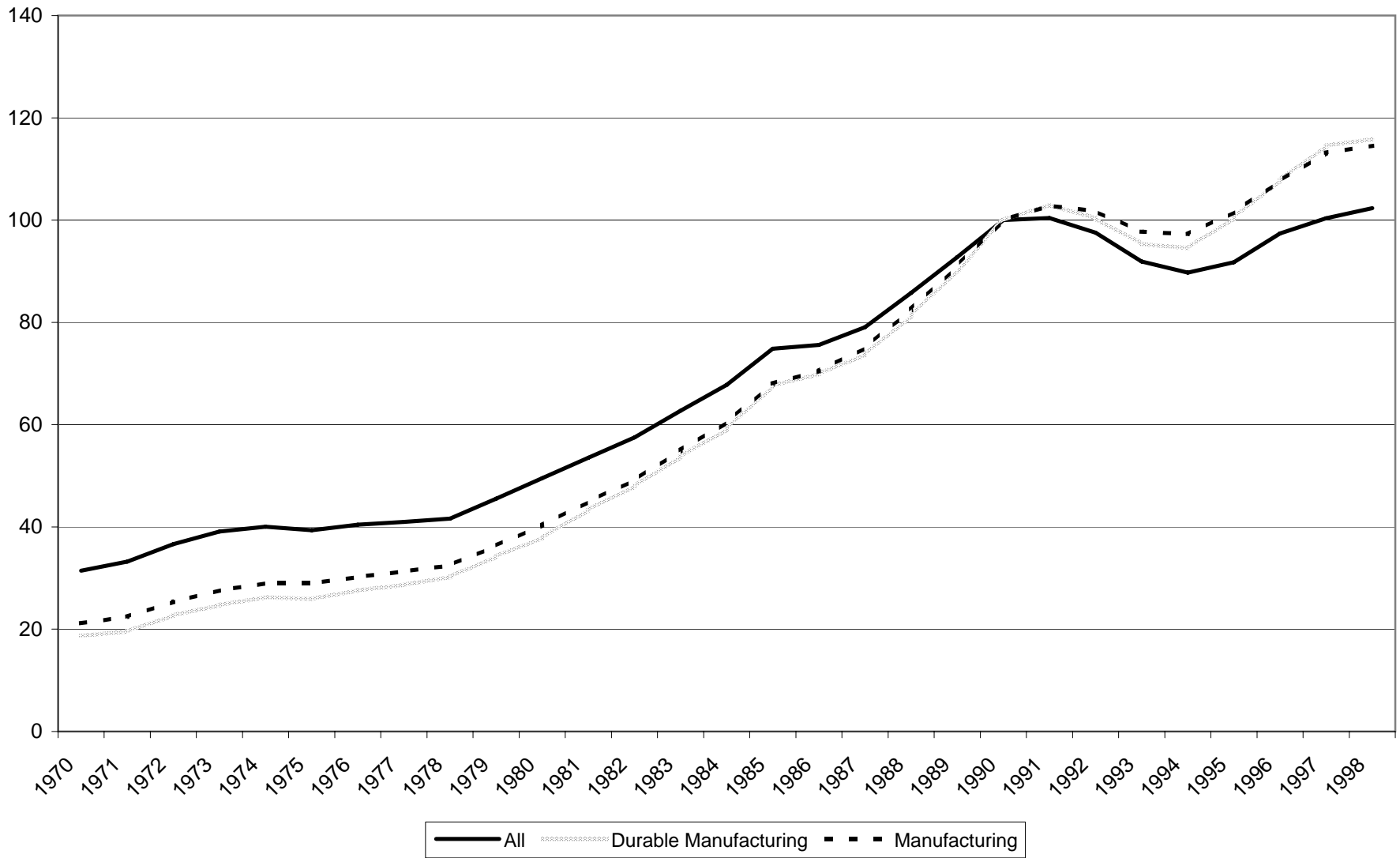


Figure 6: Real R&D Expenditures detrended at 2 percent

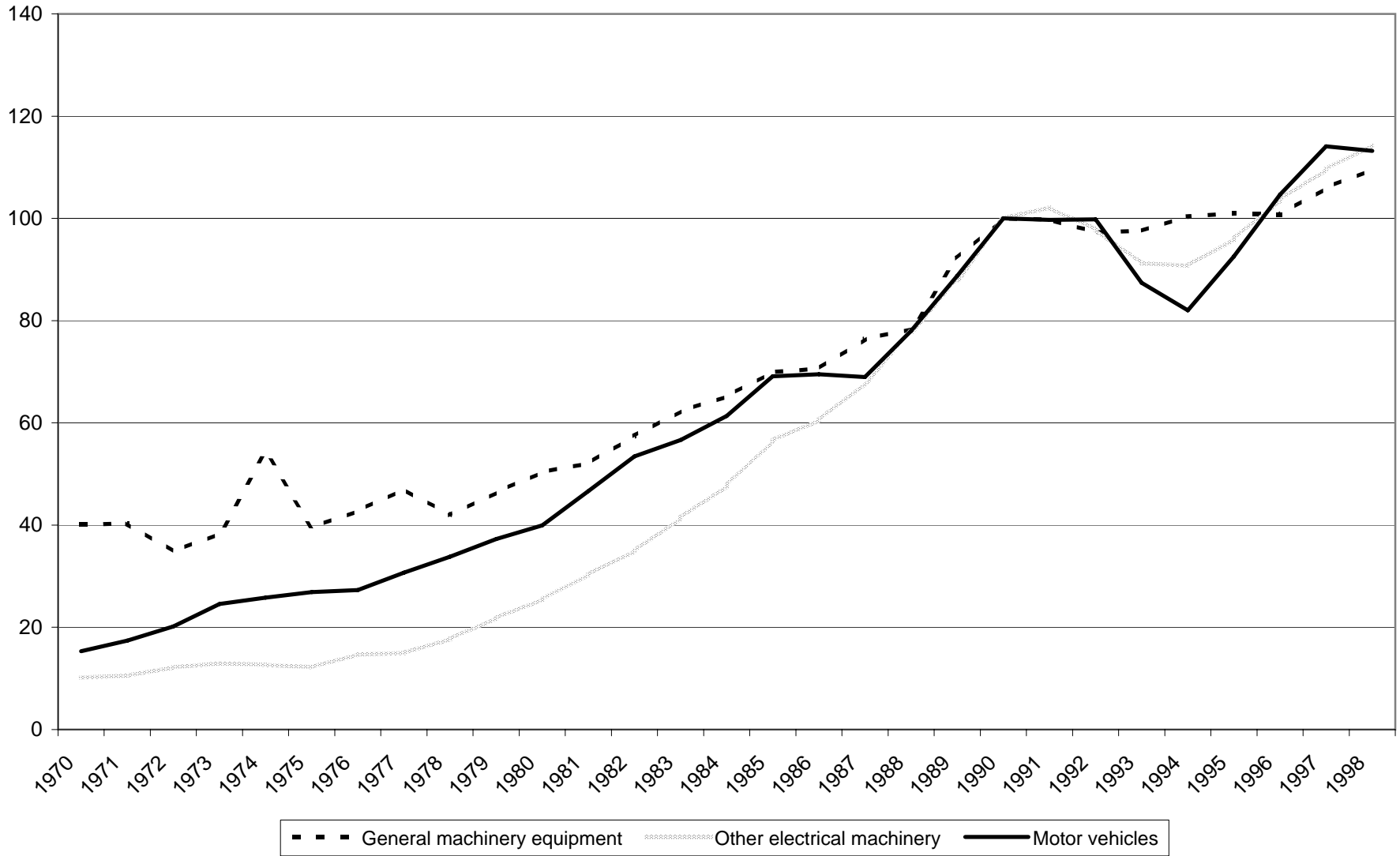


Figure 7: Real Wage rates



Figure 8: Computers per capita

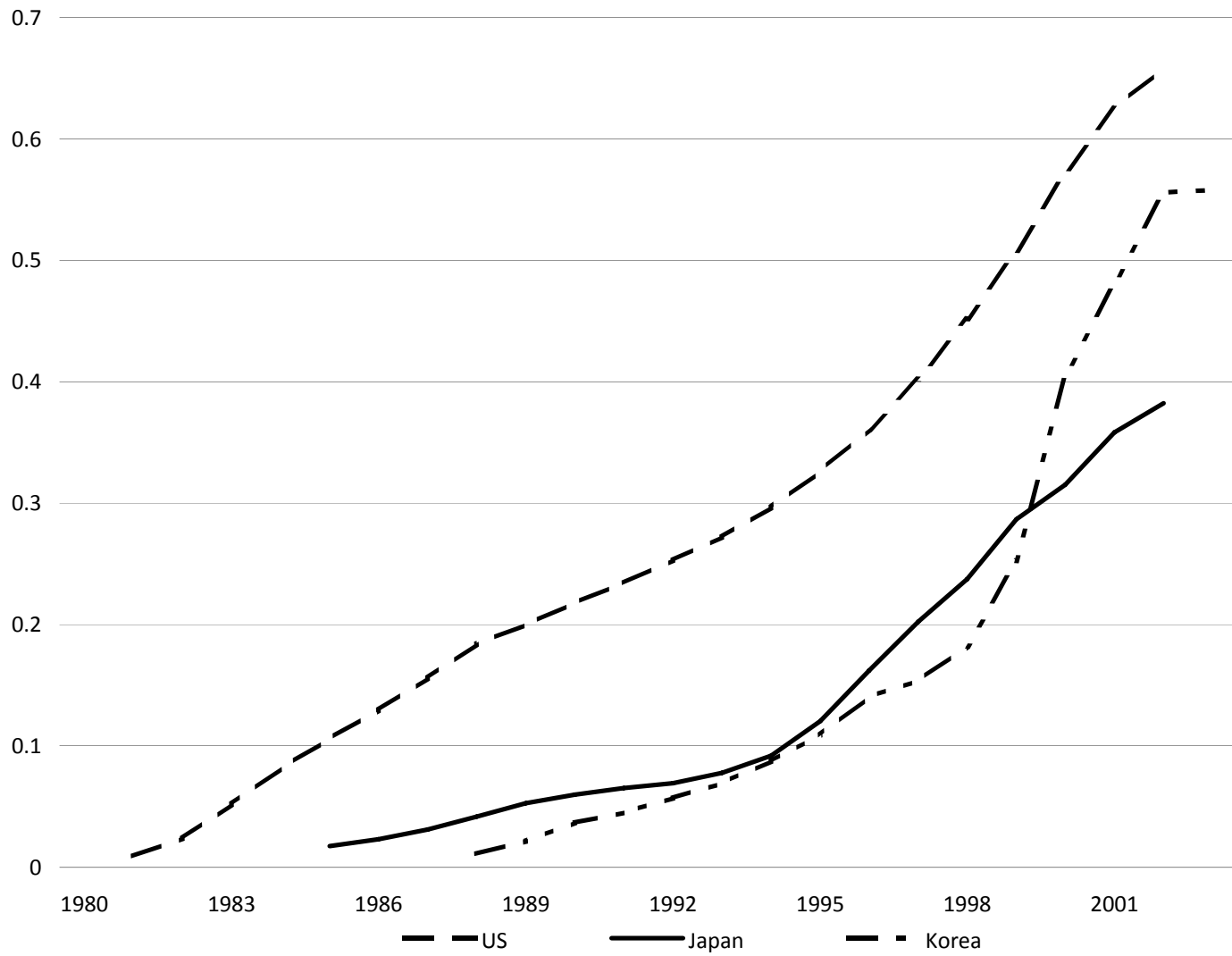


Figure 9: Internet Users per capita

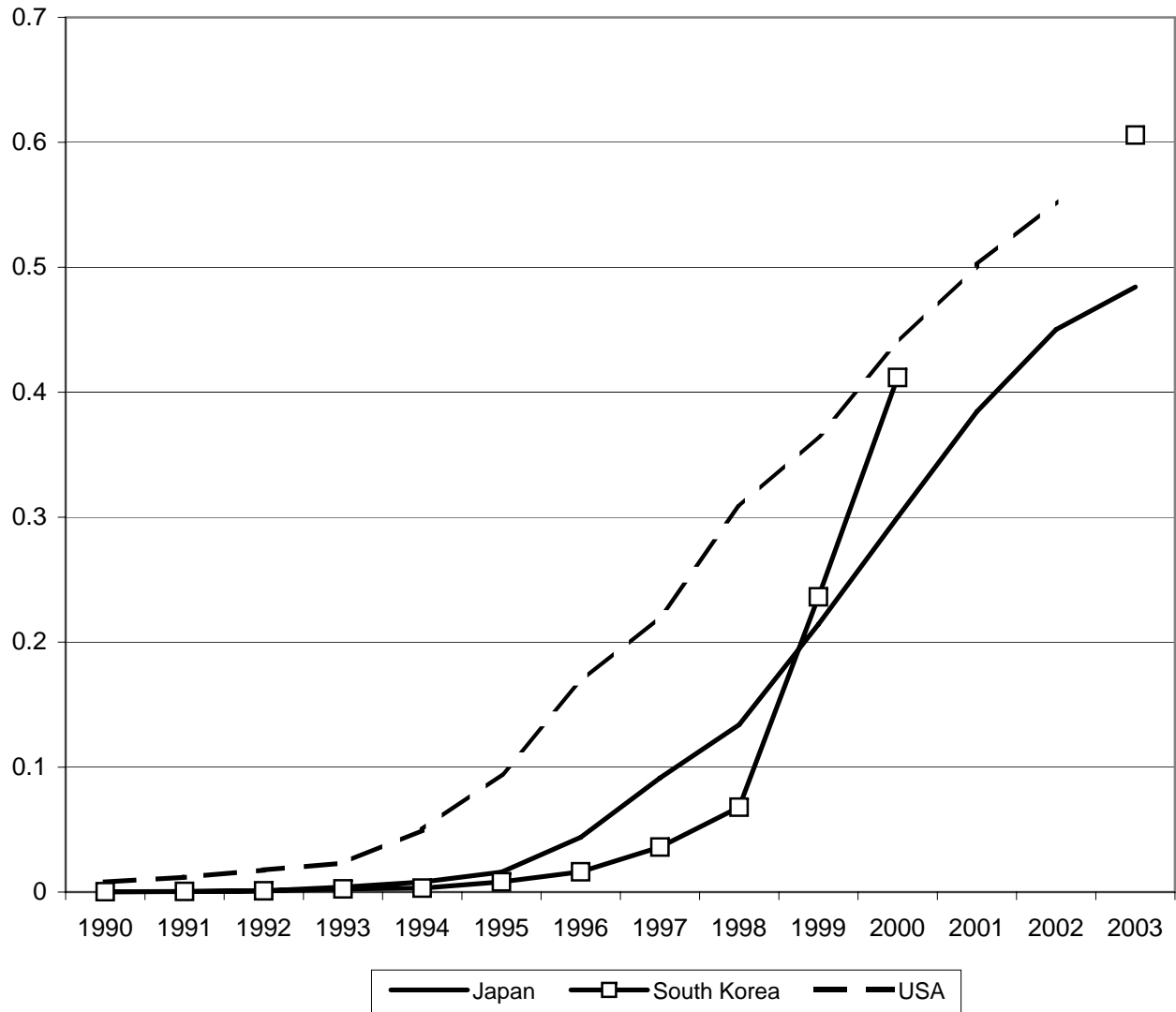


Figure 10: Yens per dollar

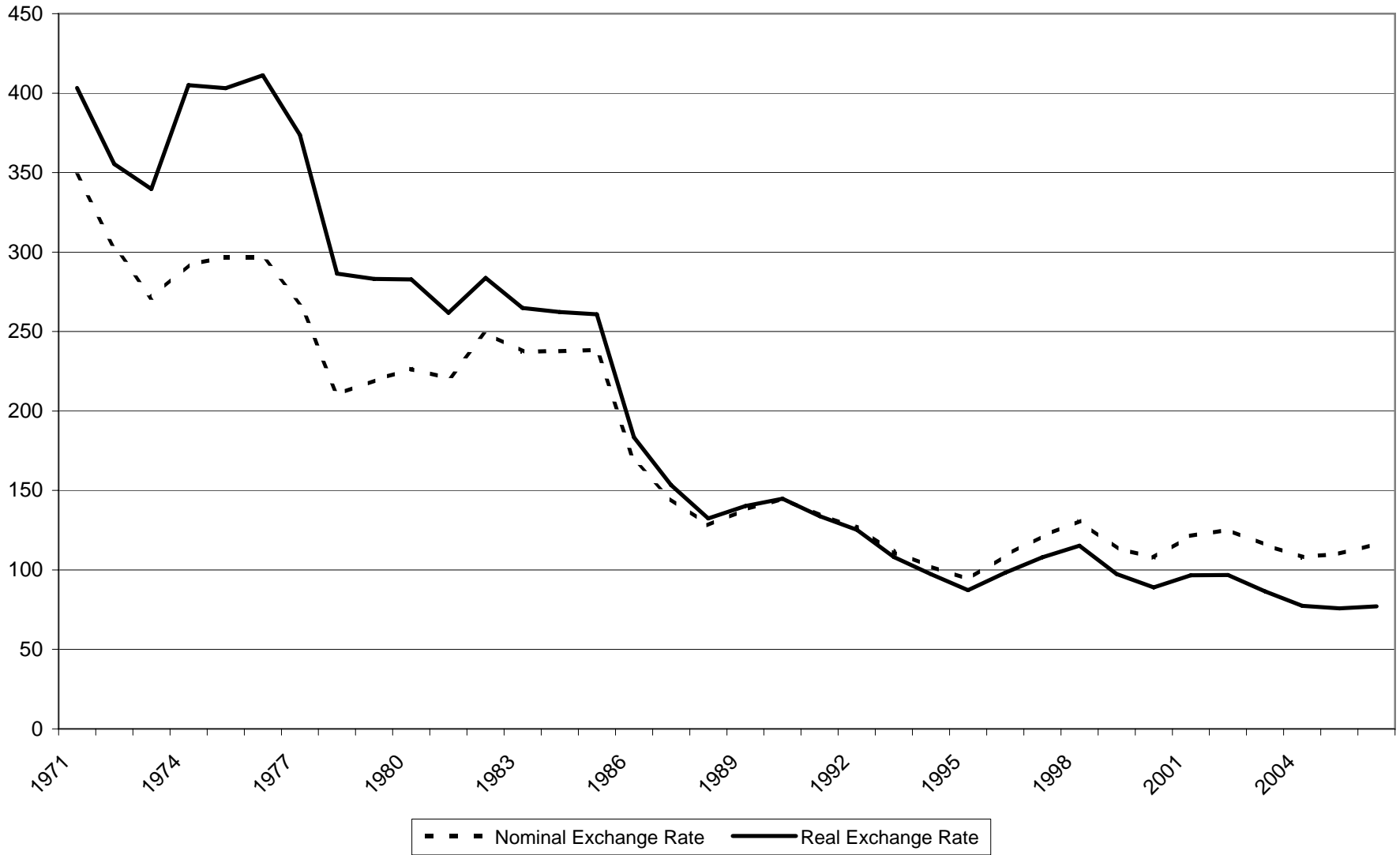


Figure 11: corporate operating surplus over GDP

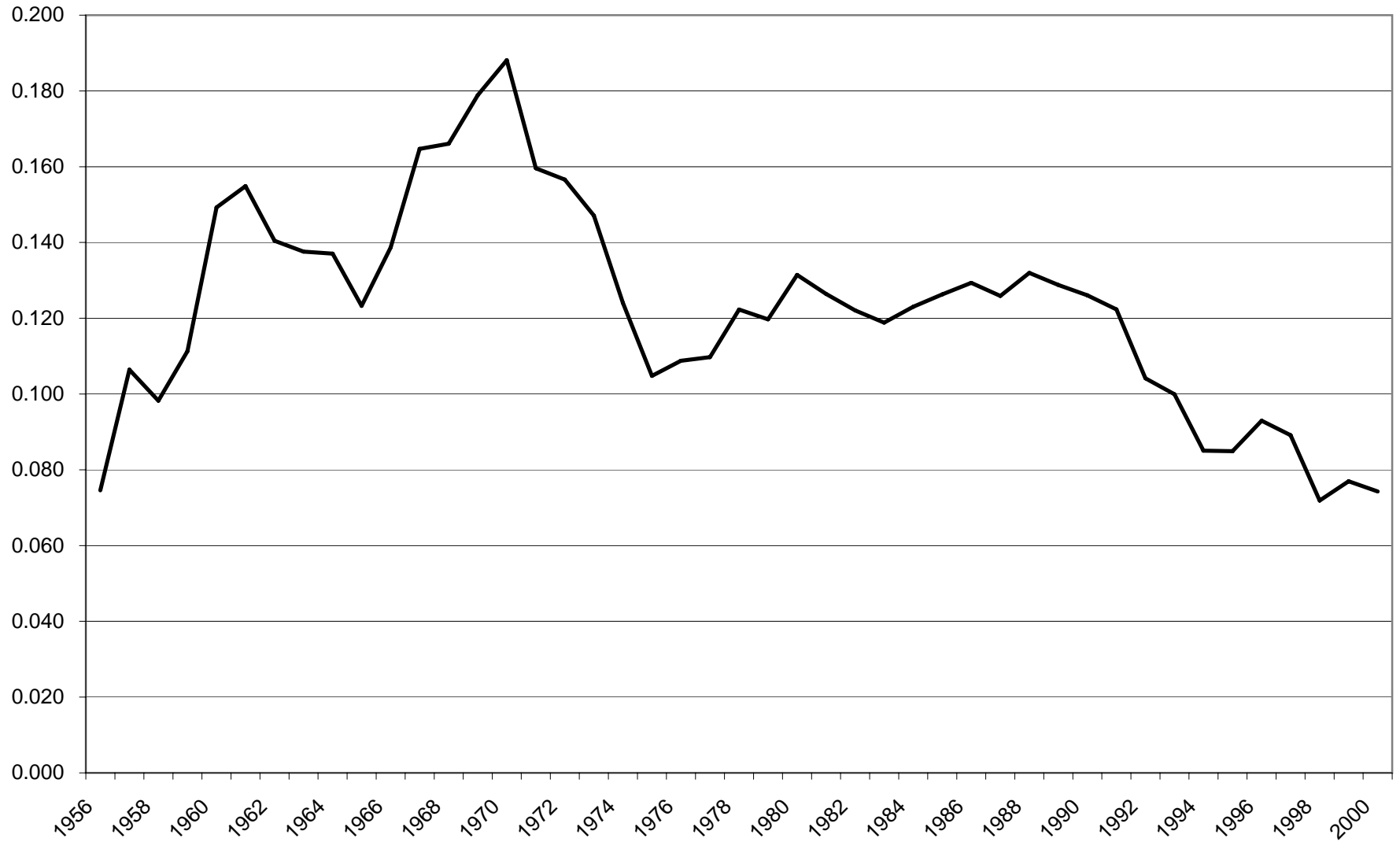


Figure 12: Operating income over gross output

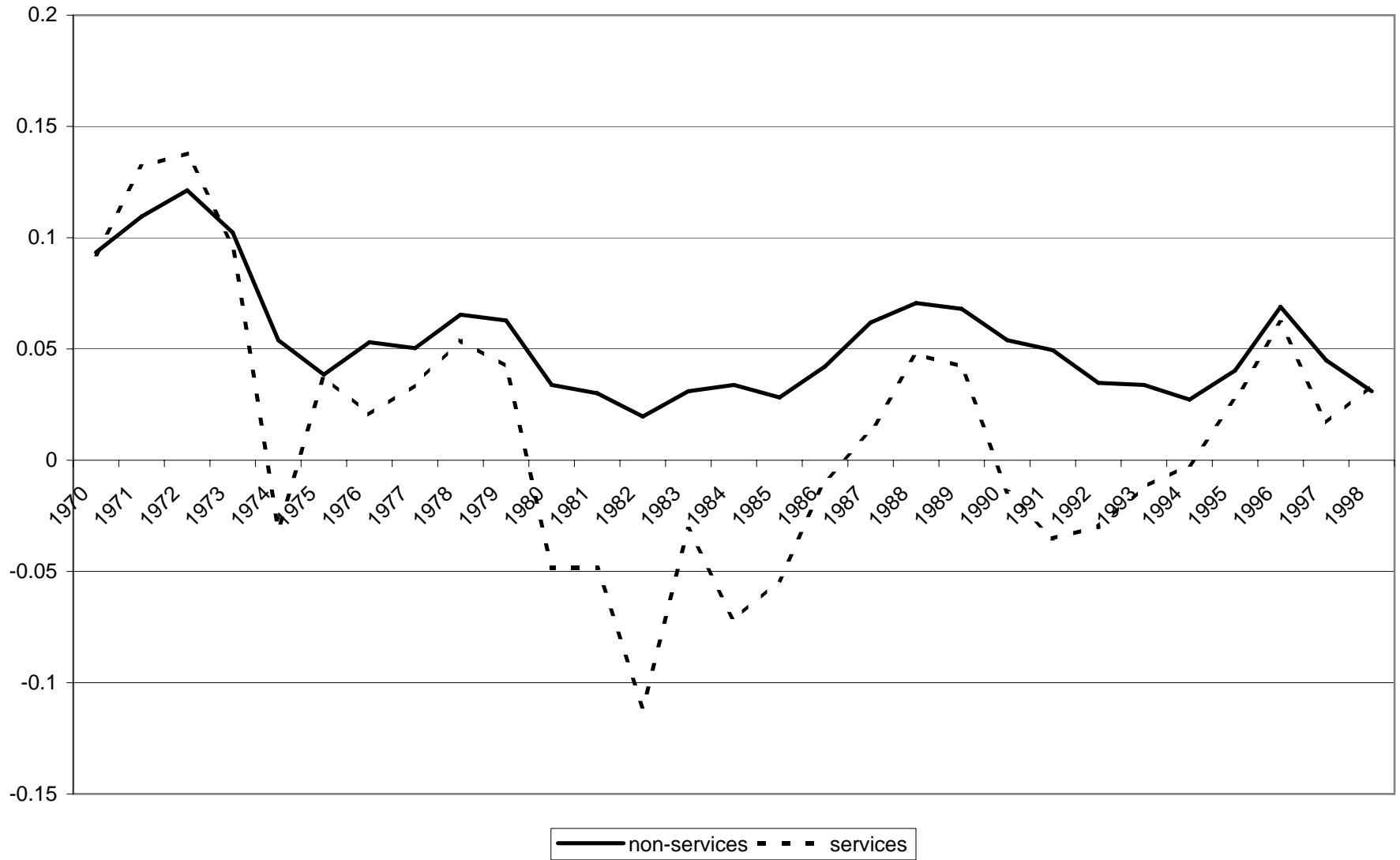


Figure 13: Employment Share in Durable Manufacturing

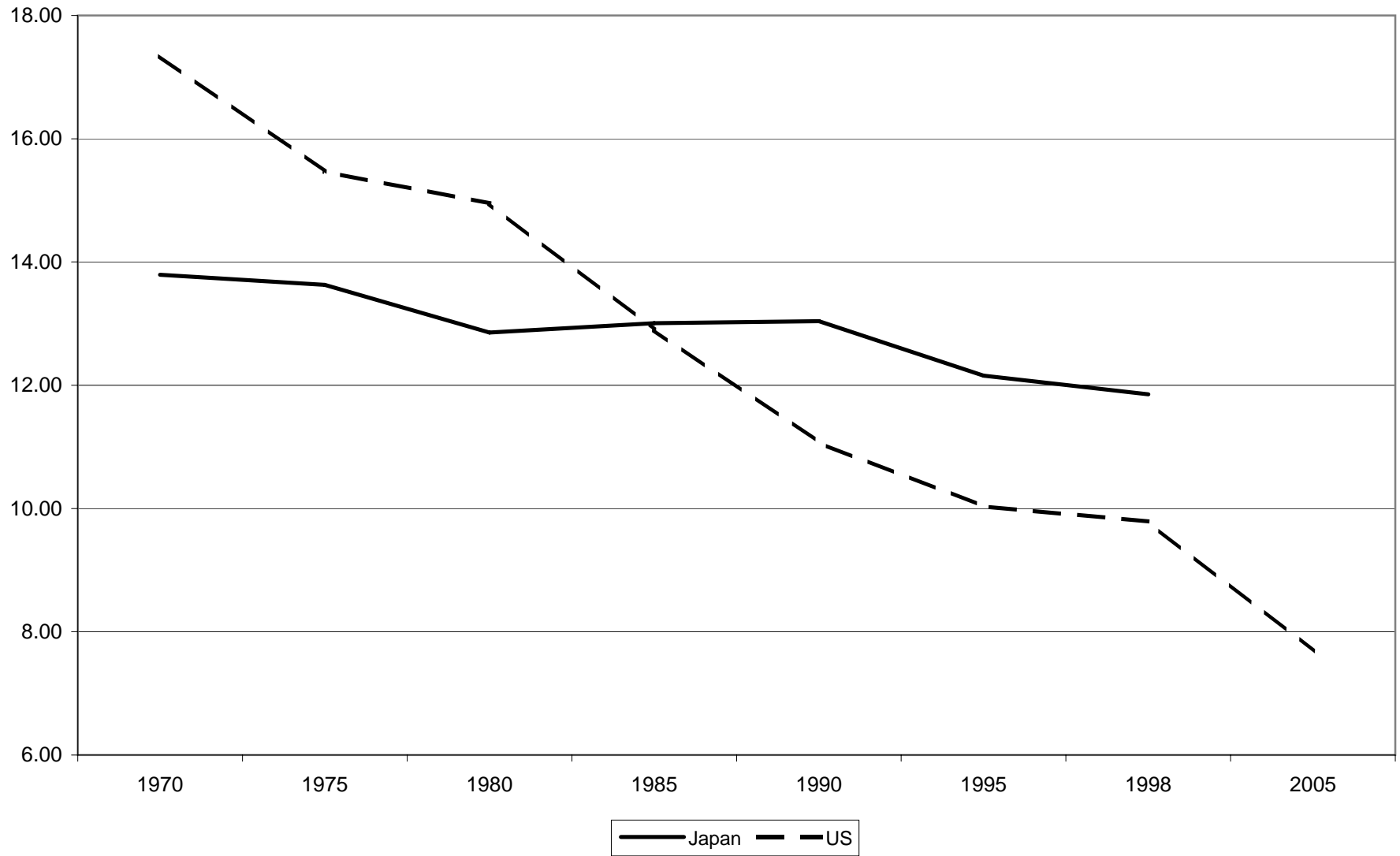


Figure 14: Employment Share in Motor Vehicles Manufacturing

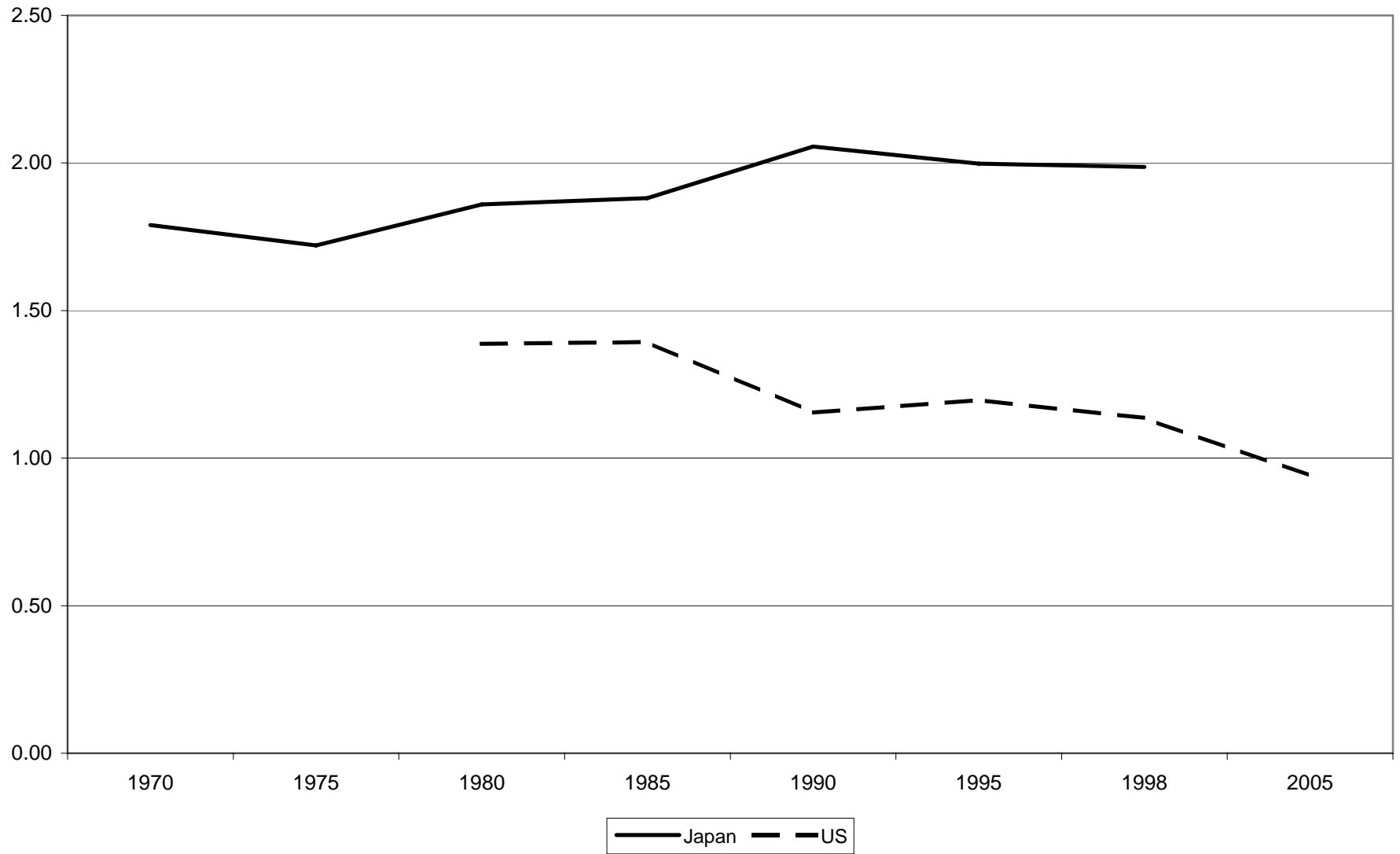


Figure 15: Markups and relative Japanese demand

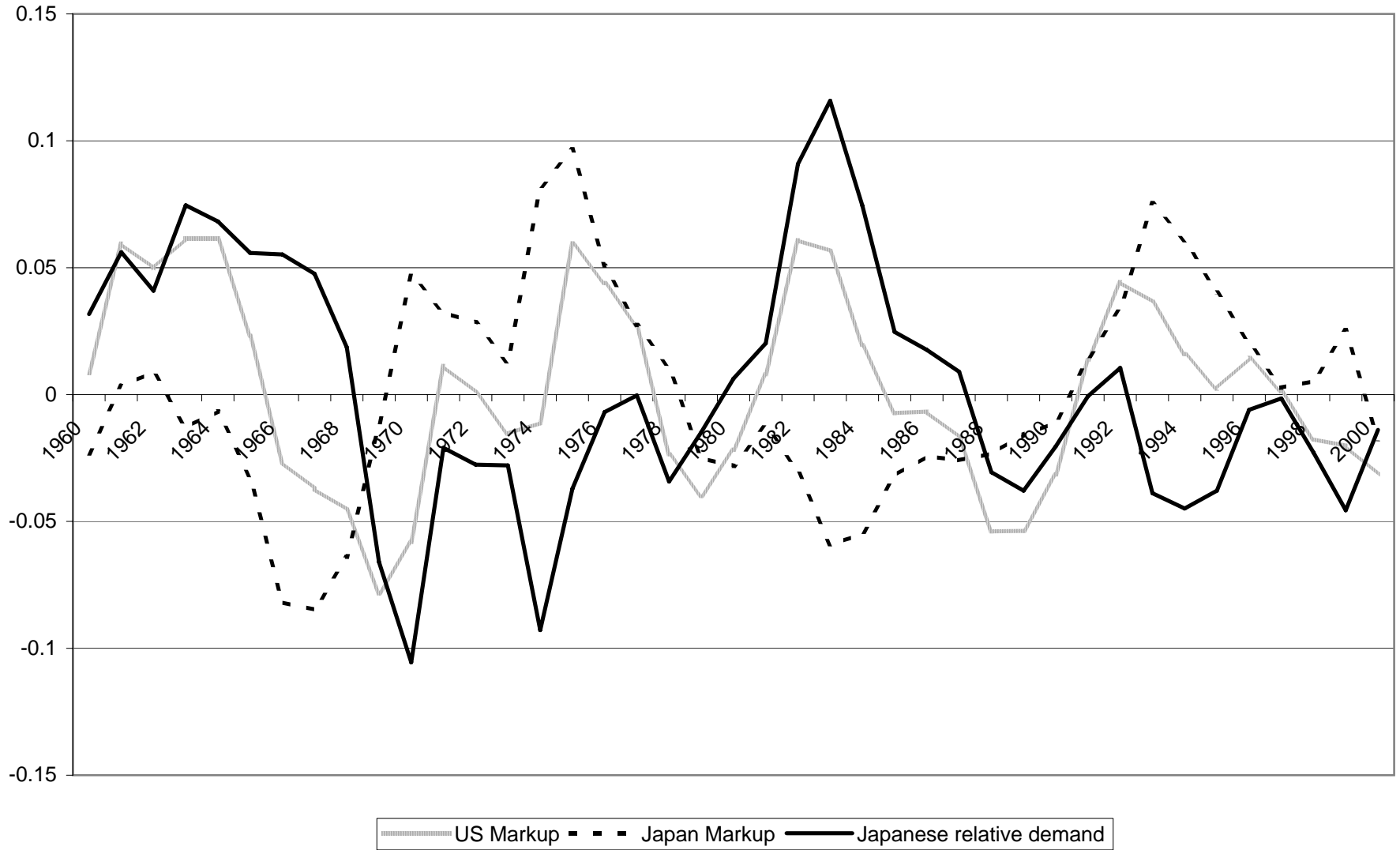


Table 1: Jobs outsourced as share of domestic employment in the sector

	<u>1987</u>	<u>1998</u>
Manufacturing	6.41	17.15
Durable Manufacturing	8.27	21.15
Motor Vehicles	10.46	35.65
General Machinery Equipment	2.90	8.88

Table 2: Determinants of the Yen-Dollar exchange rate

<u>Dependent variable</u>	<u>Nominal Exchange Rate</u>	<u>Real Exchange Rate</u>
(log) TFP Japan	-3.28 (23.01)	-4.52 (27.11)
Japanese relative demand	1.11 (3.06)	0.82 (92.03)
N	30	30
R ²	0.94	0.96

Note: Confidence intervals computed with robust standard errors in parenthesis