Structural Transformation and Growth Slowdowns: Japan in the 90s

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Abstract

This paper argues that the growth slowdown in Japan in the 1990s was a consequence of a structural transformation set in motion by the emergence of lower cost producers of manufacture goods. Prior to the 1990s Japan had achieved a significant cost advantage in producing various manufacture goods, which led to an allocation of resources towards this sector. Indeed, the fraction of resources in the manufacture sector in Japan exceeded that of other countries in a similar stage of development. The emergence of largely populated developing countries, such as China, lowered the profitability of the manufacture sector in Japan, which required a substantial reallocation of labor and capital resources from the manufacture to the service sector. This process of structural transformation led to the growth slowdown in Japan during the 1990s. This paper contains a thorough analysis of the data to support this argument and develops a model to capture the various dependencies observed in the data and to make the interpretation of the data precise.

1 Introduction

Why countries experience growth slowdowns is a question that has become important. Growth slowdowns, by which I mean a fall in the growth rate of aggregate output that is well beyond the usual business cycle frequency, almost by definition has significant welfare implications. The US experienced such a slowdown in the 1970s, many countries in Latin America experienced a slowdown in the 1980s, and Japan experienced a slowdown in the 1990s (and it is not entirely clear that this slowdown has been reversed in either Latin America or Japan). Evidently growth slowdowns are experienced not only by countries on an uncertain path of development, but also by some of the richest countries in the world. Although there are likely to be many causes for a growth slowdown, it seems that all countries are subject to such an experience.

This paper takes a close look at one particular growth slowdown–Japan in the 1990s–and attempts to extract some general lessons than may be important for all countries. Principally, what is the source of the shock that profoundly affected such a strong economy for over a decade? How did this shock reverberate through the various sectors of Japan's economy? Why did this shock lead to a growth slowdown? What was unique about Japan so that they were particularly hard hit by such a shock? What lessons does this experience offer to the rest of the world?

The evidence, documented here, seems to indicate that the source of the shock was the emergence of largely populated, low cost producers of manufacture goods. The emergence of these countries had the effect of lowering the price of manufacture goods, which led Japan to begin a process of reallocating resources to the service sector. It is this process of structural transformation that seems to have led to the growth slowdown in Japan. In particular, it seems the growth slowdown was due in part to the fall in the price of manufacture goods, which led to a fall in the production of manufacture goods, and in part due to the fall in the price of service goods that followed from the attempted allocation of resources towards this largely non-traded sector, which dampened the rise of the service sector. Japan was uniquely exposed to such a shock as they were more heavily invested in the production of manufacture goods than almost any other developed country; additionally, they seem to have had little growth in the efficiency of producing service goods. The general lesson is that trade-induced structural transformations set in motion by sudden changes in relative prices may play an important role in explaining growth slowdowns.

Due either to the central mechanism in the model or the subject of the application, this

paper is related to various strands in the literature. As just described, this paper highlights the interplay between trade and the structural transformation of economies, in particular the structural transformation that involves the manufacture and service sectors. A growing related literature highlights the interplay between growth and the structural transformation of economies. Those papers that explicitly include a manufacture and service sector include Baumol (1967, 1985), Echevarria (1997), Kongsamut, Rebelo, and Xie (2001), and Rogerson (2003).[1] An important internal mechanism of the model is the general equilibrium affect on the service sector that stems from a change in the price of goods produced in the manufacture sector. As such, this paper is also closely related to the much older literature on the joint determination of an economy's allocation of resources and its terms of trade. As this literature is both enormous and well known, I will only refer to one such paper that incorporates a non-traded sector, which is the classic paper by Dornbusch, Fischer, and Samuelson (1977). Clearly, this paper is also closely related to the literature on the difficulties of the financial sector in Japan during the 1990s, such as Caballero, Hoshi, and Kashyap (2004). Surely the financial sector played an important role in deepening the growth slowdown, so in this sense this literature is complementary to this paper. And lastly, since this paper addresses issues related to the productivity of firm's in different sectors in Japan, this paper is related to recent productivity-based explanations of Japan's growth slowdown, such as Hayashi and Prescott (2002) and Fukao, et. al., (forthcoming).

Section 2 reviews the basic facts of Japan's growth slowdown in the 90s. Here special attention will be given to the different performance of the manufacture and service sectors. Section 3 develops a model that is designed to capture the main features of Japan's growth slowdown. This section develops various qualitative results, and examines the quantitative fit of the model to data. Section 4 offers some concluding remarks. An appendix introduces a non-competitive aspect to the model which allows the model to address the declining profitability of Japanese firms during the growth slowdown.

[1] A variety of papers focus on structural transformation involving the agricultural and manufacture sectors, such as Glomm (1992), Matsuyama (1992), Goodfriend and McDermott (1995), Laitner (2000), Caselli and Coleman (2001), Gollin, Parente, and Rogerson (2001), and Hansen and Prescott (2002). Pasinetti (1981) is a monograph that generally deals with the issue of structural change and technological progress.

2 The Basic Facts of Japan's Growth Slowdown

Fig. 1 shows the overall level of real GDP in Japan from 1970 to 2002. Data in Fig. 1 are taken directly from the OECD's Industrial Structural Analysis (STAN) database. Here we see the growth slowdown that began in 1992 and that has lasted at least through 2002. Fig. 1 also shows real value-added in the manufacture and service sectors. Output in the service sector expanded continuously throughout this time, whereas output in the manufacture sector stopped growing and indeed contracted somewhat during this time. Any explanation of Japan's growth slowdown would seem to have to address the different behavior of the manufacture and service sectors.

Figs. 2 and 3 show the real capital stock and employment in the manufacture and service sectors.[2] The capital stock data displayed in Fig. 2 is based on the Japan Industry Productivity (JIP) Database, which consists of annual information on 84 sectors from 1970 to 1998; 45 sectors are manufacture (non-service) sectors, while 39 sectors are service sectors. Here we see a slowdown in capital accumulation in the manufacture sector beginning in 1992. Capital accumulation slowed down slightly in the service sector too, but the slowdown was larger in the manufacture sector. The employment data displayed in Fig. 3 is based on the World Bank's World Development Indicators (WDI). Fig. 3 shows that there was an absolute fall in employment (number of workers) in the manufacture sector beginning in 1992 and lasting at least through the end of the sample period (2002).[3] In contrast, employment in the service sector continued to rise during this time.

Why would the manufacture sector have contracted so much relative to the service sector beginning in 1992? Fig. 4 shows the return to capital in the manufacture sector relative to that in the service sector. Here return to capital is measured, using data from the JIP database, as $(py - wn - m)/k$, where py = (nominal) value of output, wn = payment to labor, m = payment for intermediate goods, and k = value of capital. The numerator is meant to measure rk, so dividing by k should back out r. The difference of returns should cancel out any common inflation term. This figure shows a steady rise in the relative return to capital in the manufacture sector from 1974 until 1991, but a sharp drop in the return to capital beginning in 1992 and lasting at least through 1998 (there was a drop in 1990,

[2]Except for the STAN database, or where otherwise mentioned explicitly, by manufacture sector I will always mean all sectors except the service sectors.

[3]Employment in the JIP database is an index of man-hours that aggregates employment by gender, age, and educational attainment obtained from a variety of sources. The fall in employment following 1992 is also evident in this data.

but a rise in 1991). Evidently something happened to dramatically lower the profitability of capital invested in the manufacture sector.

Fig. 5 shows the price of manufacture goods relative to service goods and Fig. 6 shows the behavior of total factor productivity (TFP) in the manufacture and service sectors.[4] Both time series are obtained from JIP. Fig. 5 shows no significant break from the downward trend (this downward trend is evident in most countries) in the relative price of manufacture to service goods from 1974 onwards. From Fig. 6 we see that there was a dip in manufacture TFP from 1992 to 1994, but by 1997 the ratio of manufacture to service TFP was about what it was in 1991. The manufacture-service relative price and total factor productivity time series seem consistent with each other in that a change in relative total factor productivity would have affected the relative cost of producing manufacture versus service goods, and hence would have affected their relative price. That there is no observed change in relative price reinforces the finding that there is no change in relative total factor productivity.[5] Hence, it does not appear that the behavior of TFP in Japan can explain the different performance of the manufacture and service sectors.[6]

To get a sense of trends in the overall size of the service sector relative to total employment in Japan, and to compare these trends to those in other economies, Fig. 7 shows employment in the service sector relative to total employment in Japan from 1980 to 2001, and Fig. 8 shows Japan's position relative to other OECD economies in 1990. As in Fig. 3, employment is measured as number of workers and is taken from WDI. As in most economies, employment in the service sector in Japan expanded continuously throughout this period, beginning at 54 percent in 1980 and rising to 64 percent by 2001. Note that there was a slight acceleration in service sector employment as a percent of overall employment beginning in 1993. From Fig. 8 we see that for countries with a similar per-capita GDP, service sector

[4]These TFP numbers are not adjusted for labor quality.

[5]Note, though, that the downward trend in the relative price of manufacture goods is consistent with the observation from Fig. 6 that total factor productivity in manufacturing has grown faster than total productivity in the service sector in Japan.

[6]Hayashi and Prescott (2002) and Fukao, et.al., (forthcoming) examine the role of TFP in Japan's growth slowdown. Both studies find that the behavior of TFP can explain some, but not all, of the growth slowdown in Japan. As it relates to this paper's attempt to explain the overall growth slowdown in Japan, it seems reasonable to argue, as does the labor-hoarding literature, that a significant portion of measured TFP is actually capturing other influences on production. Moreover, as just argued, it seems that the behavior of TFP cannot explain the structural transformation that seems to be an important feature of the overall growth slowdown.

employment ranged from about 55 percent to 71 percent, with Japan at 58 percent. It seems that as Japan entered the 1990s it was more heavily invested in the manufacture sector than other economies with a similar level of per-capita GDP (the only country with a similar per-capita GDP that had lower service-sector employment was Austria).

Fig. 9 shows some trends in the pattern of exports in Japan (as well as China). These series are taken from the International Monetary Fund's World Economic Outlook Database. Here we see that Japan's share of world exports expanded steadily from 1960 onwards. This trend peaked in 1986 and fell somewhat from 1986 to 1990, rose until 1993 and then began a sustained fall through 2002. In contrast, China experienced a small rise in its world export share from 1970 until 1993, but following 1993 experienced a dramatic rise in its world export share. Indeed, many have characterized the recent time period in China as one of "export-led growth." This pattern of Japan's world export share falling at the same time as China's rising seems to also be reflected in more disaggregate data. Disaggregated trade data for 1976-1999 for 28 manufacturing industries is available from the Trade and Production Database, which is described in Nicita and Olarreaga (2002). A typical profile is in Fig. 10, which shows a rise in China's export share, and a fall in Japan's export share, beginning in the early 1990s for Fabricated Metal Products. Of the 28 industries in this dataset, 23 correlations between the two countries' export shares over time are negative; the mean correlation is -.49 and the median correlation is -.73.

Before continuing an examination of Japanese data, let's take a closer look at events in China. Fig. 11 shows the dramatic rise in labor productivity in Chinese manufacturing that began in the 1990s. Here I simply took real value added in Secondary Industry (which is manufacturing plus construction) from the Chinese Statistical Yearbook (CSY) and divided it by the Number of Workers in Secondary Industry, also obtained from CSY.[7] Based on these numbers, labor productivity rose by an average of 17.5 percent per year from 1990 to 2000. Fu (2004) reports that labor productivity in the export industries in China grew 26 percent faster than in total manufacturing from 1990 to 1997.

To get a sense of how the price of Japan's export goods were affected by these trends, Fig. 12 graphs Japan's terms of trade, which is the price of its exports relative to its imports. This time series was obtained from the Bank of Japan. Also graphed in Fig. 12 is the price of Japan's exports in dollars (the price of its exports in Yen times the nominal US Dollar/Yen exchange rate) relative to the Producer Price Index in the US (obtained from the Bureau

[7]CSY did not separate out construction from manufacturing for both output and employment.

of Labor and Statistics), which is meant to measure the relative price of Japan's export goods on the world market. Both times series tell roughly the same story. Beginning around 1972/73, the relative price of Japan's exports fell until the mid 80s. From the mid 80s until the late 80s the relative price of Japan's exports rose, but it fell again from the late 80s to the early 90s. After a rise in the early 90s, the relative price of Japan's exports began a sustained fall from around 1994/95 until the end of the observation period (mid 2004). The sustained fall beginning in 1994/95 seems to line up reasonably well with the fall in Japan's trade and acceleration in China's trade beginning in 1994. However, the relative return to capital and output in the manufacture sector began to fall in 1992. Moreover, any story relating the fall in the price of Japan's exports to the downturn in Japan must also be consistent with the fall in the price of Japan's exports from the early 70s until the mid 80s, which was a period of strong growth for Japan.

3 A Model of Japan's Growth Slowdown

Here's the story, and the motivation for the model laid out in this section. During the 70s and 80s Japan had developed a significant productivity and thereby cost advantage in producing manufacture goods. Consequently, Japan allocated significant resources to this sector. The sustained rise in productivity and market share during this time is consistent with the falling price of Japan's exports on the world market. The emergence of China (and other countries) as a large and growing low cost provider of manufacture goods in the 90s required a significant structural transformation of Japan's economy away from the production of these goods.[8] Consequently, output and employment fell in the manufacture sector in Japan in the 90s.[9] As resources were re-allocated from the manufacture to the service sector, prices in the (non-traded) service sector fell. Indeed, the manufacture-service relative price in Japan must be unrelated to events in China, as the relative price in Japan must reflect the relative costs of producing the two goods in Japan, and with the same cost of capital, wage rate, and an unchanged ratio of total factor productivities across the two

[8]To be sure, it is unlikely that China and Japan competed directly in the final goods market. A significant volume of trade is due to trade in intermediate goods (computer chips, for example), so it seems more plausible to argue that a larger fraction of the value of traded final goods were accounted for by China.

[9]Output in the manufacture sector in Japan started to fall somewhat before the dramatic rise in China's exports, but that seems likely due to the recession in the US and Europe in the early 90s. The recession dates are 90-91 for the US, 92-93 for France, 91-94 for Germany, and 90-92 for the UK.

sectors, the relative cost does not change.[10] As a consequence of the fall in service-sector prices, the expansion of the service sector was less than the decline in the manufacture sector, hence output overall fell. The rest of this paper makes this story and related statements precise, and demonstrates that the model can qualitatively account for the relevant facts regarding Japan's growth slowdown.

Since the facts to be explained are trends over relatively long periods of time, it seems appropriate to simplify the exposition and model the dynamics in a deterministic, perfect-foresight setting. To separately consider the relative price of exports to imports (i.e., the terms-of-trade) from the relative price of service to manufacture goods, which is an important distinction in the data, the model will consist of two traded goods and one non-traded good. One traded good will be a good manufactured by Japan, and the non-traded good can be thought of as a service good. To capture the emergence of largely populated countries, I will model the world as consisting of a domestic economy, one foreign economy, and the rest of the world. By domestic economy I have in mind Japan. By foreign country I have in mind many of the largely-populated, developing countries that began to pursue market-oriented reforms during this time, although for specific data and timing of events I largely have in mind China. Hence, the model will be a variant of a 3 good, 3 country model of trade. This model will be consistent with perfect competition in which the allocation of resources is based solely on efficiency.

3.1 Good 1

Good 1 is internationally traded, and can either be consumed or invested to add to the domestic capital stock. This is the numeraire good, so $p_1 = 1$. This good can be borrowed at the internationally given real interest rate $r > 0$, which is assumed to be constant over time.

3.2 Good 2

Good 2 is a non-traded good that is used in final consumption. This good cannot be stored, so we can think of it as a service good. In the domestic economy this good is produced with

[10] More precisely, as shown in the text, if factor shares across the two sector differ, then the ratio of manufacture prices to some power relative to service prices to some power will be unchanged. If factor shares are the same, then the relative price will be unchanged.

capital and labor using a Cobb-Douglas production function,

$$y_2 = A_2 k_2^{\nu} n_2^{1-\nu}, \tag{1}$$

where y_2 is the quantity of Good 2 that is produced, k_2 and n_2 are the capital stock and labor supply, respectively, used to produce Good 2, and A_2 is the level of efficiency (TFP) in using these inputs to produce Good 2. This good is produced and sold in a perfectly competitive market. Denote the price of this good in units of good 1 by p_2. Denote the rental rate on capital by ρ (which equals $r + \delta$, where δ equals the rate at which the capital stock depreciates). Denote domestic wages in units of good 1 by w. Profits are thus given by

$$\pi_2 = p_2 A_2 k_2^{\nu} n_2^{1-\nu} - \rho k_2 - w n_2. \tag{2}$$

Firms choose quantities to maximize the present value of profits, which in this case is equivalent to choosing quantities to maximize profits each period. In a competitive equilibrium factors are paid their marginal product, so in equilibrium

$$\rho = \nu p_2 A_2 \left(\frac{k_2}{n_2}\right)^{\nu-1}, \tag{3}$$

and

$$w = (1-\nu) p_2 A_2 \left(\frac{k_2}{n_2}\right)^{\nu}. \tag{4}$$

Use eqs. (3) and (4) to write the solutions for k_2 and w as functions of p_2 and n_2 as:

$$k_2 = \left(\frac{\nu p_2 A_2}{\rho}\right)^{\frac{1}{1-\nu}} n_2 \tag{5}$$

and

$$w = (1-\nu)\left(\frac{\nu}{\rho}\right)^{\frac{\nu}{1-\nu}} (p_2 A_2)^{\frac{1}{1-\nu}}. \tag{6}$$

Using eq. (5), output can be written as

$$y_2 = (A_2)^{\frac{1}{1-\nu}} \left(\frac{\nu p_2}{\rho}\right)^{\frac{\nu}{1-\nu}} n_2. \tag{7}$$

Given the constant-returns-to-scale assumption and the output price p_2, total output is entirely driven by the supply of labor. However, the relative price of output to capital entirely determines the capital-labor ratio and thereby also the real wage rate in units of Good 1.

A similar structure for the foreign economy determines k_2^*, w^*, and y_2^* as functions of n_2^*, p_2^*, and A_2^*. More for notational convenience than anything else, I assume ν is the same across countries.

3.3 Good 3

Good 3 is a traded good. I will assume that only the domestic and foreign country produce this good and sell it to the rest of the world. Like Good 2, in the domestic economy this good is produced with capital and labor using a Cobb-Douglas production function:

$$y_3 = A_3 k_3^{\sigma} n_3^{1-\sigma}. \tag{8}$$

Also like Good 2, this good is sold in a perfectly competitive market. Denote the price of this good in units of good 1 by p_3. Profits are thus given by

$$\pi_3 = p_3 A_3 k_3^{\sigma} n_3^{1-\sigma} - \rho k_3 - w n_3. \tag{9}$$

Given prices, the analysis of this industry is identical to that of Good 2, so here I will just repeat the allocation of resources that were derived for Good 2:

$$k_3 = \left(\frac{\sigma p_3 A_3}{\rho}\right)^{\frac{1}{1-\sigma}} n_3 \tag{10}$$

$$w = (1-\sigma)\left(\frac{\sigma}{\rho}\right)^{\frac{\sigma}{1-\sigma}} (p_3 A_3)^{\frac{1}{1-\sigma}}. \tag{11}$$

$$y_3 = (A_3)^{\frac{1}{1-\sigma}} \left(\frac{\sigma p_3}{\rho}\right)^{\frac{\sigma}{1-\sigma}} n_3. \tag{12}$$

As for Good 2, I will assume a similar structure for the foreign economy.

3.4 Consumers

Consumers in the domestic economy choose an infinite sequence $\{c_{1t}, c_{2t}, c_{3t}\}_{t=0}^{\infty}$ to solve the following problem:

$$max \Sigma_{t=0}^{\infty} \beta^t (\omega_1 \log c_{1t} + \omega_2 \log c_{2t} + \omega_3 \log c_{3t}) \tag{13}$$

subject to:

$$\Sigma_{t=0}^{\infty} q_t (c_{1t} + p_{2t} c_{2t} + p_{3t} c_{3t}) = W_0, \tag{14}$$

where

$$\omega_1 + \omega_2 + \omega_3 = 1, \tag{15}$$

each $\omega_i > 0$, $0 < \beta < 1$ is the subjective discount factor, c_{1t}, c_{2t}, and c_{3t} are the consumption of Goods 1, 2, and 3 respectively, W_0 is initial wealth, and q_t is the price of Good 1 in period t relative to its price in period 0. Households inelastically supply their endowment of labor

to firms, and they choose the firms that offer the highest wage rate. The aggregate supply of labor is given by n. Worldwide interest rates are assumed to be constant, so that

$$q_t = \left(\frac{1}{1+r}\right)^t. \tag{16}$$

Given W_0, the solution to the household's problem can be written in closed form as

$$c_{1t} = [\beta(1+r)]^t(1-\beta)\omega_1 W_0, \tag{17}$$

$$c_{2t} = [\beta(1+r)]^t(1-\beta)\omega_2 \frac{W_0}{p_{2t}}, \tag{18}$$

$$c_{3t} = [\beta(1+r)]^t(1-\beta)\omega_3 \frac{W_0}{p_{3t}}. \tag{19}$$

Note that $t\beta^t \to 0$ as $t \to \infty$ for any $0 < \beta < 1$, so the objective function is well defined at these policy functions. To simplify matters, for the rest of this paper I will assume $\beta = 1/(1+r)$. Initial wealth (for the entire economy) equals the value of initial assets, say A_0, plus the present value of all current and future wage income:

$$W_0 = A_0 + \Sigma q_t w_t n. \tag{20}$$

Consumers in the foreign economy behave in a similar way, with parameters ω_1^*, ω_2^*, ω_3^*, and initial wealth W_0^*..

The above analysis determines the demand for various goods from the domestic and foreign economies. To determine the price of Good 3, though, we need to know the worldwide demand for Good 3. Here I will simply assume an inverse worldwide demand schedule denoted by

$$p_3 = P(y_3 + y_3^*), \tag{21}$$

where $P : \Re_+ \to \Re_+$ is a continuously, strictly-decreasing function, y_3 is the amount of this good supplied by the domestic country, and y_3^* is the amount of this good supplied by the foreign country.[11]

3.5 Equilibrium

An equilibrium is a sequence of prices, production levels, and consumption levels such that firms maximize profits given their technology, households maximize utility subject to their

[11] It would be a straightforward extension towards realism to model y_3 and y_3^* as distinct goods that compete with each other on the world market. The demand functions could then be specified as $y_3 = Q(p_3, p_3^*)$ and $y_3^* = Q^*(p_3, p_3^*)$. I'm not sure anything is gained by this approach at this level of abstraction, but at some level it might make sense to pursue this detail.

budget constraint (or, as in the case for Good 3, the quantity supplied lies on that good's worldwide demand curve), and markets clear. It turns out to be convenient to examine the equilibrium in the following way. First fix the level of wealth in each country. Then, for a given relative price of Good 3 in each period, we can determine quantities and remaining prices such that all markets clear except for that of Good 3. In this sense we can determine the excess worldwide demand for Good 3. An overall equilibrium can then be characterized as a sequence of prices $\{p_{3t}\}$ such that the market for Good 3 clears. The set of possible equilibria for this economy is then just the set of equilibria traced out by varying the level of wealth in each country.

To derive an excess worldwide demand function for Good 3, equate eqs. (6) and (11) to derive

$$(1-\nu)\left(\frac{\nu}{\rho}\right)^{\frac{\nu}{1-\nu}}(p_2A_2)^{\frac{1}{1-\nu}} = (1-\sigma)\left(\frac{\sigma}{\rho}\right)^{\frac{\sigma}{1-\sigma}}(p_3A_3)^{\frac{1}{1-\sigma}}. \tag{22}$$

This equation, along with a corresponding one for the foreign country, gives the prices p_2 and p_2^* that are consistent with the price p_3. An equilibrium in the Good 2 market is such that $y_2 = c_2$, which, by equating eqs. (7) and (18), yields the relation

$$(A_2)^{\frac{1}{1-\nu}}\left(\frac{\nu p_2}{\rho}\right)^{\frac{\nu}{1-\nu}} n_2 = (1-\beta)\omega_2\frac{W_0}{p_2}. \tag{23}$$

This equation, along with a corresponding one for the foreign country, determines n_2 and n_2^* that are consistent with the price p_3.[12] Once n_2 and n_2^* are determined we have also determined $n_3 = n - n_2$ and $n_3^* = n^* - n_2^*$. Given p_3 and n_3, eq. (12) determines the supply of y_3 from the domestic economy. In a corresponding way the supply of y_3^* is determined. Write these solutions as $y_3 = y_3(p_3)$ and $y_3^* = y_3^*(p_3)$, so that the worldwide supply of Good 3 is given by $y_3(p_3) + y_3^*(p_3)$. The worldwide demand for Good 3 is determined by eq. (21), so the excess demand is just the worldwide demand minus the supply. Equivalently, an equilibrium corresponds to a price p_3 such that

$$p_3 = P(y_3(p_3) + y_3^*(p_3)) \tag{24}$$

The following lemma uses these results to establish the existence of an equilibrium price for a given level of wealth.

Lemma 1. For a given level of wealth, there exists a sequence of prices $\{p_{2t}, p_{2t}^*, p_{3t}\}$ such that all markets clear each period.

[12]Note that if this procedure leads to $n_2 > n$ then set $n_2 = n$ and let p_2 solve eq. (23); similarly for n_2^*.

Proof. We only need to show that there exists a price p_3 such that eq. (24) holds. Let's first show that the worldwide supply function is a strictly-increasing function of p_3. To see this, note from eq. (22) that a rise in p_3 leads to a rise in p_2 and from eq. (23) that a rise in p_2 leads to a fall in n_2. Hence, a rise in p_3 leads to a rise in n_3. From eq. (12) we thus see that a rise in p_3 (along with the associated with in n_3) leads to a rise in y_3. Since a corresponding relation holds for the foreign country, the worldwide supply function is a strictly-increasing function of p_3. It is easy to establish that $y_3(0) + y_3^*(0) = 0$. Since $P(0) > 0$ and P is a strictly-decreasing function, there exists a unique solution p_3 that solves eq. (24). **Q.E.D.**

4 A Growth Slowdown and Structural Adjustment

Does this model explain the growth slowdown in Japan in the 90s? To answer this question, I have in mind tracing out the behavior of the model in response to trends in productivity that capture the idea that China transitioned from a stagnant economy to an economy on a path of convergence to the levels of productivity in Japan. First I will examine qualitatively how the model responds to a rise in the productivity of manufacture goods production in China. I will then fit the model to data and more fully examine the quantitative properties of the model.

4.1 Qualitative Properties of the Model

The following lemma summarizes the main properties of the model that describe the response of various prices and quantities to rise in A_3^* over time.

Lemma 2. For a fixed level of wealth, W_0 and W_0^*, in response to a rise in A_3^* over time (holding fixed A_2^*, A_2, and A_3) it follows that n_2, y_2, and y_3^* rise, y_3, n_3, w, p_2, and p_3 fall, and k_2 and $p_3^{\frac{1}{1-\sigma}}/p_2^{\frac{1}{1-\nu}}$ do not change.

Proof. Without a change in prices, in response to a rise in A_3^* it follows that $y_3^*(p_3)$ will rise. Since the arguments in the proof of Lemma 1 show that the right side of eq. (24) is a strictly-increasing function of p_3 (when at least one country produces Good 3), it follows that p_3 must fall. By eq. (22) p_2 must fall, and by eq. (23) n_2 must rise (and n_3 must fall). Since p_3 and n_3 fall, by eqs. (10)-(12) k_3, w, and y_3 must fall. Since p_2 falls, from eqs. (7) and (23) we see that y_2 rises. From eqs. (5) and (22) we see that k_2 remains the same. Since neither A_2 nor A_3 changed, from eq. (22) we see that $p_3^{\frac{1}{1-\sigma}}/p_2^{\frac{1}{1-\nu}}$ does not change. **Q.E.D.**

In addition to these results, the following relation will be quite useful in terms of thinking about the overall slowdown in the Japanese economy.

Lemma 3. For a given level of wealth, W_0 and W_0^*, a rise in A_3^* leads to a fall in $p_2y_2 + p_3y_3$.

Proof. From eqs. (7) and (23) we see that p_2y_2 depends only on wealth, which is assumed not to change. We already established that both p_3 and y_3 fall, so p_3y_3 falls. Consequently, $p_2y_2 + p_3y_3$ falls. **Q.E.D.**

Under the slightly stronger assumption that $\sigma = \nu$, we can derive even stronger results. First, from eq. (22) it follows that

$$\frac{p_3}{p_2} = \frac{A_2}{A_3}. \tag{25}$$

Hence, if $\sigma = \nu$ then the relative price p_3/p_2 does not vary with changes in A_3^*. Second, using this result, along with eqs. (7) and (12), yields

$$p_2y_2 + p_3y_3 = \left(\frac{\sigma}{\rho}\right) n(A_3p_3)^{\frac{1}{1-\sigma}}. \tag{26}$$

Here again we see that a fall in p_3 leads to a fall in $p_2y_2 + p_3y_3$: a fall in p_3 leads to a fall in GDP in units of the import Good 1.

Table 1 summarizes the qualitative results just derived, and compares these implications to the data. Evidently the model qualitatively matches a variety of important features of the data.

4.2 Quantitative Properties of the Model

Here I will examine some quantitative properties of the model.[13] Simulating the model will require choosing values for the following parameters for both Japan and China: ν, σ, ρ, ω_1, ω_2, ω_3, n, a level of wealth W_0, initial values of A_2, A_3, and parameters that describe the evolution of A_2 and A_3 over time. In addition to the above parameters, we need to choose a worldwide real interest rate r, and we need to parameterize the worldwide demand function for Good 3.

I will assume a linear inverse worldwide demand schedule for Good 3 given by

$$P(y_3 + y_3^*) = \alpha - \gamma(y_3 + y_3^*), \tag{27}$$

[13]Solving the model numerically is a rather straightforward implementation of the methods used to examine the model qualitatively. The computer code is available upon request.

where $\alpha > 0$, $\gamma > 0$, y_3 is the amount of this good supplied by the domestic country, and y_3^* is the amount of this good supplied by the foreign country. Hence, we need to choose values for the parameters α and γ as well.

For ν and σ I will assume the usual input shares such that $\nu = .33$ and $\sigma = .33$. I will set $r = .02$ (recall $\beta = 1/(1+r)$ so $\beta = .98$), $\rho = .05$ (which imply an annual depreciation rate of .03), which are within the range of values commonly used in the literature. The parameters ω_1, ω_2, and ω_3 determine the fraction of consumption represented by domestically produced manufacture goods, service goods, and import goods. In the data for Japan for 1990, obtained from the Bank of Japan, the consumption of service goods was 114,745.8 billion yen, imports were 41,568.4 billion yen, and durable + nondurable minus imports equalled 75,763.6 billion yen. From these I derive $\omega_1 = .18$, $\omega_2 = .49$, and $\omega_3 = .33$. For symmetry I will assume the same values of these parameters for China.

I will normalize $n = 1$ and set $n^* = 10$ as China's labor force is about 10 times that of Japan (as reported in WDI, Japan's labor force in 1990 was about 64 million workers and China's was about 670 million workers). As for the initial values of the productivity levels, I will normalize $A_2 = 1$ and $A_3 = 1$, and set A_2^* and A_3^* to match the ratio of per-capita GDP in China to Japan and to match the ratio of employment in the service to manufacture sectors in China (as reported in WDI, Japan's per-capita PPP-adjusted GDP in 1990 is about 23,000 dollars, whereas that in China is about 1,600 dollars; according to the China Statistical Yearbook 2001, the fraction of employment in the service sector in China in 1990 was about 10 percent). The parameter α determines the overall size of the manufacture sector; I will set this parameter so that the fraction of labor in this sector in Japan, n_3, equals .42 (as in the data for Japan for 1990).

As for the trends in productivity, I will estimate constant growth rates for total factor productivity in both sectors in Japan (which, based on Fig. 6, seems a reasonable approximation). Denote the growth rate in Japan of total factor productivity in the service sector by h_2 and in the manufacture sector by h_3. I will assume no growth in productivity growth rates in China during a stagnant period, after which China's productivity converges to that of Japan. The rate of convergence for A_2^* is model as

$$A_{2t}^*/A_{2t} = 1 - \varphi_2 e^{-g_2(t-t_0)}, \tag{28}$$

where convergence begins one period after t_0, and φ_2 is set to match the ratio of productivities in the last period of stagnation. Note that if half the gap between productivity levels is closed

in $\bar{t}_2$ periods, then

$$g_2 = \frac{\log(2)}{\bar{t}_2}. \tag{29}$$

I will assume a similar parameterization for the process for A_3^*. I will somewhat arbitrarily (but of course reasonably) choose $\bar{t}_2 = 200$ (so that there is very slow convergence of productivity in the service sector) and $\bar{t}_3 = 40$ (so that China closes half the gap in manufacture TFP every 40 years).

The remaining parameter is γ. This parameter determines how fast the price p_3 falls as worldwide output $y_3 + y_3^*$ expands. In particular, it determines how much p_3 falls at production in China y_3^* rises, so this parameter determines the extent to which Japan must accommodate events occurring in China. Given the other parameters, setting this parameter to .1 will allow the model to quantitatively match how much output in the manufacture sector in Japan falls in response to a rise in productivity in the manufacture sector in China. Table 2 summarizes the parameter values just mentioned. Note that the simulation requires specifying a level of wealth for Japan and China. As it turns out, in terms of how the time series change over time, the results do not much depend on the level of wealth. The values reported in Table 2 are a somewhat arbitrary choice.

Figs. 13-18 summarize the results of the simulation. Fig. 13 graphically displays the productivity levels in Japan over time, and Fig. 14 displays the productivity levels in China (as can be seen in this figure, the first 10 periods in China is the period of stagnation, and the period of convergence begins in period 11). Here we see that the driver for the results is a kink in the growth rate of productivity in China. Fig. 15 shows that one consequence is a fall in manufacture output (y_3) and a rise in service output (y_2). Also shown in Fig. 15 is the fall in overall output as measured by $p_2^0 y_2 + p_3^0 y_3$, where p_2^0 and p_3^0 are prices in year 1 (the fall in overall output using current relative prices is even larger). Fig. 16 shows that the capital stock in the manufacture sector falls. Fig. 17 shows that labor expands in the service sector whereas it contracts in the manufacture sector (evidently, though, the model misses the secular rise in employment in the service sector). Finally, as derived theoretically and shown in Fig. 18, the change in the growth rate in China has no effect on the relative price of manufacture to service goods in Japan. As in the data, this relative price exhibits a downward trend because productivity growth in the manufacture sector is higher than productivity growth in the service sector. It seems that this simulation captures many of the main results of Japan's slowdown in the 1990s.

Let's summarize why the model is able to match up with various features of the data.

Prior to the 1990s Japan had a larger fraction of its labor force allocated to the manufacture sector than almost all countries in a similar stage of development. The model suggests that this is due to the productivity advantage Japan had acquired in the production of manufacture goods. In the early 1990s the return to capital invested in the manufacture sector began to fall as the rise in foreign supply of goods led to a fall in the price of manufacture goods. Over time Japan's best response was to curtail production and reallocate resources from the manufacture to the service sector. These features show up in both the data and the model.[14] In terms of the effect on total output in the model, recall that output in the manufacture sector falls in the model and that output in the service sector rises (as in the data). However, note that as resources are allocated to the service sector, the price of services (which is a non-traded good) falls. Indeed, in the model the relative price of manufacture to service goods does not change in response to a rise in the foreign supply of manufacture goods. This fall in the price of service goods somewhat deters a shift of resources into this sector. The model predicts, as is observed, that the rise in output in the service sector is insufficient to offset the fall in output in the manufacture sector, so that the value of total output falls.

4.3 What was Unique about Japan?

An important and interesting question that leads naturally from this paper is the question of what was unique about Japan so that it alone seems to have been so profoundly affected for so long. Why did not some of the other relatively developed countries in the region, such as South Korea, Taiwan, or Singapore, or some other developed countries in the rest of the world, face similar consequences? Here, I suspect that the size of Japan and the amount of resources it had invested in the production of manufacture goods may have some relevance to this question. China may also have hurt the export markets of South Korea, Taiwan, and Singapore, but the demand stimulated by China was more than sufficient to make up for these lost markets. Japan, on the other hand, was too large relative to China to have been sufficiently stimulated by the emergence of China (at least during that time). As for other developed countries, as just mentioned they had relatively fewer resources devoted to the production of manufacture goods, so they were not as exposed as Japan was to the emergence of low-cost producers of manufacture goods.

[14] The model cannot capture a fall in the return to capital invested in the manufacture sector, as there are no profits in this version of the model with perfect competition. The version of the model in the appendix addresses this issue.

5 Conclusions

Post-war Japan is surely one of the 20th century's outstanding examples of miraculous growth. From 1950 to 2000 Japan's real per-capita GDP expanded by a factor of 10,[15] during which time Japan transformed itself from a developing country to one of the richest in the world. In doing so, Japan achieved amazing gains in productivity; in many cases Japan even surpassed the level of productivity of the most developed countries. As in most economies, including all developed economies, the significant gains in productivity seem to have been concentrated in the manufacture sector. For this reason, as economies grow service goods tend to become more and more expensive and consequently economies tend to devote more and more resources to producing these goods. Projecting far beyond the available evidence, Baumol (1967) recognized that eventually most resources will be devoted to the production of service goods, and consequently long-term growth of an economy will be determined by the growth of productivity in that sector. This gradual evolution is something that all developed countries will have to face. How can we understand Japan's growth slowdown that began in the 1990s within this broader context?

As presented in this paper, what is normally a gradual change become an abrupt change in Japan, and one feature of this abrupt change is a growth slowdown. Three events made this change more abrupt in Japan than in other economies. First, as documented in Fig. 8, even though Japan had become one of the richest economies in the world by 1990, it still had significantly more resources devoted to the production of manufacture goods than almost all other developed countries. Second, as documented in Fig. 6, although Japan had achieved significant gains in productivity for producing manufacture goods, it achieved little productivity gains in the service sector. And third, as documented in Fig. 9, China emerged rather suddenly on the world export market. Through the channels highlighted in this paper, these three things together set the stage for the growth slowdown in Japan.

It is surely not the case that Japan is the first country in history to have undergone a trade-induced structural transformation that has led to a growth slowdown. Indeed, although this bears further investigation, the emergence of Japan itself in the 70s and 80s may have played an important role in a similar structural transformation in the US away from the production of manufacture goods and towards service goods. Recall that the 70s was a period of slow economic growth for the US as well, much like that in Japan in the 90s. It is also not likely that Japan will be the last country to experience such a slowdown. Most of

[15]Source: Heston, et.al., 2002, Penn World Tables.

the world's population is poor and has yet to enjoy the benefits of industrialization. Policy reforms can lead to abrupt changes in economic conditions, which will likely have important consequences for other countries in the world. In this sense, the lessons learned by the experience of Japan may be important for understanding a shock that has perhaps played a significant role in the development of some countries, and that has the potential to play an even greater role in shaping the world economy.

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7 Appendix A: The Model with Market Power

The model developed in the paper seems to do well in matching the essential features of the structural transformation and growth slowdown of the Japanese economy in the 90s. However, there is one feature of the data that it cannot match: it cannot match the falling return to capital in the manufacture sector, as in this version of the model with perfect competition firms earn no profits.

One way to get at the falling return to capital is to suppose that Japanese firms were earning quasi-rents in the production and sale of manufacture goods, and Japan's market power eroded over time. To support this argument, note that the available evidence suggests that Japanese firms had achieved significant market power in the sale of manufacture goods. Ariga, Ohkusa, and Nisimura (1999), in examining markups for over 400 major manufacturing firms in Japan, documented evidence of significant market power during the period 1975 to 1994. They estimated an average of 30 percent for the markup of price over marginal cost.

To document that Japan may have lost some market power during the decade of the 90s, I estimated the change in markup during this time period for Japanese manufacturing firms. To do this, I used the relationship between markup and inverse unit labor cost that follows from a Cobb-Douglas production function. For such a production function, the marginal cost of producing an extra unit of output with labor is given by

$$\frac{wL}{(1-\alpha)y} \tag{30}$$

where α is capital's share, wL is the wage bill, and y is real output. For a price of the output good denoted by p, the price/marginal cost markup is then given by

$$markup = (1-\alpha)\frac{py}{wL}, \tag{31}$$

which is proportional to the inverse of unit labor cost. Using this relationship, for all the manufacturing firms in the JIP database, the markup fell by 11 percent from 1990 to 1998.

To capture the falling profits of Japanese firms observed in the data, and to capture a strategic interaction between Japan and China, in this appendix I will model firms in the domestic and foreign countries as playing a Cournot quantity game in serving the world market. The analysis of Goods 1 and 2, and the behavior of consumers, are exactly as before, so here I will just describe the market for Good 3.

7.1 Good 3

As before, assume that Good 3 is a traded good and that only two countries, referred to as the domestic and foreign country, produce this good and sell it to consumers located throughout the world. Now, though, assume that firms in both countries compete in a Cournot game that determines equilibrium production and prices (this assumption also implies that within each country the firms collude). Assume that there are m firms in the domestic country and m^* firms in the foreign country. Also as before, assume a linear inverse worldwide demand schedule given by eq. (27). This good is produced with a Cobb-Douglas production function, as given by eq. (8) for the domestic economy and a similar equation for the foreign country.

The cost function for producing an amount y_3 can be written as

$$c(\theta, y_3) = \theta y_3, \tag{32}$$

where

$$\theta = \frac{\sigma^{-\sigma}(1-\sigma)^{\sigma-1}}{A_3}\rho^{\sigma} w^{1-\sigma}. \tag{33}$$

Profits by domestic firms are thus given by

$$\pi_3 = P(y_3 + y_3^*)y_3 - c(\theta, y_3). \tag{34}$$

Assume, also, that the other country produces this good with a similar profit function, so that

$$\pi_3^* = P(y_3 + y_3^*)y_3^* - c(\theta^*, y_3^*). \tag{35}$$

Firms in each country choose a level of production to maximize their profits, given an assumption regarding the level of production of the remaining firms in their own country as well as firms in the other country. An equilibrium is a production pair (y_3, y_3^*) such that if firms in the domestic economy assume the level of production of all firms in the foreign country of y_3^*, and they assume the level of production of the other firms in the domestic country of $((m-1)/m)y_3$, then they will optimally choose y_3/m, and similarly for foreign firms. This is a standard Cournot game, as developed by Cournot (1987).

The profit maximizing solution for production of Good 3 for each country is

$$y_3 = \frac{m}{1+m+m^*}\frac{\alpha + m^*\theta^* - (1+m)\theta}{\gamma} \tag{36}$$

and

$$y_3^* = \frac{m^*}{1+m+m^*}\frac{\alpha + m\theta - (1+m^*)\theta^*}{\gamma}. \tag{37}$$

The equilibrium price is given by

$$p_3 = \frac{\alpha + m\theta + m^*\theta^*}{1 + m + m^*}, \tag{38}$$

and domestic profits per unit of output are given by

$$\pi_3 - \theta = \frac{\alpha + m^*\theta^* - (1 + m^*)\theta}{1 + m + m^*}. \tag{39}$$

Domestic demand for the factor inputs are given by

$$k_3 = \theta_\rho y_3, \tag{40}$$

$$n_3 = \theta_w y_3. \tag{41}$$

With the assumption of Cobb-Douglas production, properties of the cost function are such that:

$$k_3 = \frac{1}{\gamma A_3}\left(\frac{1-\sigma}{\sigma}\frac{\rho}{w}\right)^{\sigma-1}\frac{m}{1+m+m^*}\frac{\alpha + m^*\theta^* - (1+m)\theta}{\gamma}, \tag{42}$$

$$n_3 = \frac{1}{\gamma A_3}\left(\frac{1-\sigma}{\sigma}\frac{\rho}{w}\right)^{\sigma}\frac{m}{1+m+m^*}\frac{\alpha + m^*\theta^* - (1+m)\theta}{\gamma}. \tag{43}$$

For a given cost of capital and labor, we have determined the optimal level of production, price, profits, and demand for capital and labor.

7.2 Equilibrium

Here it turns out to be convenient to examine the equilibrium in a slightly different way than before. First fix the level of wealth for each country. Then, for a given relative price of Good 2 in each country (for each period), we can determine, again for each country, the optimal allocation of capital and labor to each sector, the wage rate such that the overall demand for labor equals the exogenous supply of labor, and the relative price for Good 3 that firms in both countries will charge. In this way we can compute how the supply of goods depends on the relative prices p_2 and p_2^*. Also, for a given relative price of Good 2 in each period (and the associated price p_3), we can determine the demand for goods. An equilibrium for a given level of wealth is a sequence of relative prices $\{p_{2t}, p_{2t}^*\}$ such that the supply and demand for goods are equal each period (recall that in the previous version of the model we reduced the determination of an equilibrium to finding a sequence of prices $\{p_{3t}\}$ that clears all markets).

7.2.1 The Supply of Goods

Given the relative price p_2 for a particular period, the Good 2 sector completely determines the wage rate w for this economy: the capital market determines the capital-labor ratio in the Good 2 sector, and the capital-labor ratio determines the wage rate. This result is expressed in eq. (6). To show how the allocation of labor depends on p_2, use eq. (6) in eq. (33) to write θ as

$$\theta = D_1 p_2^{\frac{1-\sigma}{1-\nu}}, \tag{44}$$

where

$$D_1 = \rho^{\frac{\nu-\sigma}{\nu-1}} \sigma^{-\sigma} \left(\frac{1-\sigma}{1-\nu}\right)^{\sigma-1} \nu^{\frac{(1-\sigma)\nu}{1-\nu}} \frac{A_2^{\frac{1-\sigma}{1-\nu}}}{A_3}. \tag{45}$$

Use again eq. (6) to show

$$\frac{\rho}{w} = \frac{\nu^{\frac{\nu}{\nu-1}}}{1-\nu} A_2^{\frac{1}{\nu-1}} \left(\frac{\rho}{p_2}\right)^{\frac{1}{1-\nu}} \tag{46}$$

and substitute this result, along with eq. (44), into eq. (43) to write

$$n_3 = D_2 \left(\frac{\rho}{p_2}\right)^{\frac{\sigma}{1-\nu}} (\alpha + m^* D_1^* p_2^{*\frac{1-\sigma}{1-\nu}} - (1+m) D_1 p_2^{\frac{1-\sigma}{1-\nu}}), \tag{47}$$

where

$$D_2 = \frac{1}{\gamma A_3} \left(\frac{1-\sigma}{\sigma} \frac{\nu^{\frac{\nu}{\nu-1}}}{1-\nu} A_2^{\frac{1}{\nu-1}}\right)^{\sigma} \frac{m}{1+m+m^*}. \tag{48}$$

The allocation of labor to the Good 2 sector is then just $n_2 = n - n_3$. Now we have shown explicitly how the wage, the unit cost of producing Good 3, and the allocation of labor depends on p_2.

To determine how the supply of Good 2 depends on p_2, use eq. (7) to derive

$$y_2 = A_2^{\frac{1}{1-\nu}} \left(\frac{\nu p_2}{\rho}\right)^{\frac{\nu}{1-\nu}} \left(n - D_2 \left(\frac{\rho}{p_2}\right)^{\frac{\sigma}{1-\nu}} (\alpha + m^* D_1^* p_2^{*\frac{1-\sigma}{1-\nu}} - (1+m) D_1 p_2^{\frac{1-\sigma}{1-\nu}})\right). \tag{49}$$

Using the results just derived, we can also write y_3 as

$$y_3 = \frac{m}{1+m+m^*} \frac{\alpha + m^* D_1^* p_2^{*\frac{1-\sigma}{1-\nu}} - (1+m) D_1 p_2^{\frac{1-\sigma}{1-\nu}}}{\gamma}. \tag{50}$$

7.2.2 The Demand for Goods and Equilibrium Prices

Recall that the demand for goods is given by eqs. (17)-(19). Given the assumptions already made, note that the demand for goods in a particular period, for given levels of wealth, W_0 and W_0^*, depend only on prices in that period (as before). Hence, for given levels of wealth this problem can be solved period by period. An equilibrium can be summarized as prices p_2 and p_2^* for each period such that

$$y_2 = c_2 \tag{51}$$

$$y_2^* = c_2^* \tag{52}$$

in each period, where y_2 is given by eq. (49) (and similarly for y_2^*) and c_2 is given by .eq (18) (and similarly for c_2^*).

Lemma 4. For given levels of wealth W_0 and W_0^*, if $m^*D_1^* - (1+m)D_1 < 0$ and $mD_1 - (1+m^*)D_1^* < 0$, then there exists a sequence of prices $\{p_2, p_2^*\}$ such that eqs. (51) and (52) hold each period.

Proof. The two equations in p_2 and p_2^* can be written as

$$A_2^{\frac{1}{1-\nu}}\left(\frac{\nu p_2}{\rho}\right)^{\frac{\nu}{1-\nu}}\left(n - D_2\left(\frac{\rho}{p_2}\right)^{\frac{\sigma}{1-\nu}}(\alpha + m^*D_1^*{p_2^*}^{\frac{1-\sigma}{1-\nu}} - (1+m)D_1 p_2^{\frac{1-\sigma}{1-\nu}})\right) = (1-\beta)\omega_2\frac{W_0}{p_2}. \tag{53}$$

$$A_2^{*\frac{1}{1-\nu}}\left(\frac{\nu p_2^*}{\rho}\right)^{\frac{\nu}{1-\nu}}\left(n^* - D_2^*\left(\frac{\rho}{p_2^*}\right)^{\frac{\sigma}{1-\nu}}(\alpha + mD_1 p_2^{\frac{1-\sigma}{1-\nu}} - (1+m^*)D_1^*{p_2^*}^{\frac{1-\sigma}{1-\nu}})\right) = (1-\beta)\omega_2\frac{W_0^*}{p_2^*}. \tag{54}$$

For notational convenience I assumed the parameters are the same across the two countries, although this is not essential to the proof. It is straightforward to show that eq. (53) uniquely defines a continuous, strictly-increasing function $p_2 = f(p_2^*)$ for any $p_2^* \geq 0$, and similarly eq. (54) uniquely defines a function $p_2^* = f^*(p_2)$. Note also that $f(0) > 0$ and $f^*(0) > 0$. An equilibrium is a pair of prices p_2, p_2^* such that $p_2 = f(p_2^*)$ and $p_2^* = f^*(p_2)$. If you plot the two functions with the above properties, it is obvious that a solution exists if there exists a pair (p_2, p_2^*) such that $f(\tilde{p}_2^*) < \tilde{p}_2^*$ for every $\tilde{p}_2^* > p_2^*$ and $f^*(\tilde{p}_2) < \tilde{p}_2$ for every $\tilde{p}_2 > p_2$ (if p_2 is on the horizonal axis, f^* starts above the 45 degree line and lands up below, whereas f starts below the 45 degree line and lands up above). The appropriate inequality for the function f is

$$A_2^{\frac{1}{1-\nu}}\left(\frac{\nu p_2}{\rho}\right)^{\frac{\nu}{1-\nu}}\left(n - D_2\left(\frac{\rho}{p_2}\right)^{\frac{\sigma}{1-\nu}}(\alpha + (m^*D_1^* - (1+m)D_1){p_2^*}^{\frac{1-\sigma}{1-\nu}})\right) > (1-\beta)\omega_2\frac{W_0}{p_2}. \tag{55}$$

Since the right side of this inequality is a strictly-decreasing function of p_2 that converges to zero, and the left side is a strictly-positive increasing function of p_2, the conditions of f are met. Likewise, the conditions on f^* are met as well. **Q.E.D.**

Note that the restrictions $m^*D_1^* - (1+m)D_1 < 0$ and $mD_1 - (1+m^*)D_1^* < 0$ hold if the two countries are the same, so the restriction is essentially that the countries are not too dissimilar.

7.3 A Growth Slowdown and Structural Adjustment

Does this version of the model better explain the growth slowdown in Japan in the 90s? To answer this question, let's trace out the effects of a rise in the efficiency of producing manufacture goods in a country that competes with Japan. First I will show that a rise in A_3^* will lead to a fall in θ^*. To simplify the notation, I will refer to the equations for the domestic economy to prove that a rise in A_3 will lead to a fall in θ. The result is summarized in the following Lemma.

Lemma 5. For given levels of wealth, W_0 and W_0^*, a rise in A_3 will lead to fall in θ.

Proof. I will establish the proof by contradiction. Note first that D_1 and D_2 fall but that D_1^* and D_2^* remain the same. Suppose θ rises. From eqs. (44) if follows that p_2 must rise. From eq. (54) we see that p_2^* must rise and hence that θ^* must rise. From eq. (38) it follows that p_3 must rise, and hence that $y_3 + y_3^*$ must fall. As a consequence, either y_3 or y_3^* must fall. If y_3 falls then it is straightforward to show that n_3 falls, n_2 rises, y_2 rises. This is a contradiction, as the supply y_2 rises whereas the demand c_2 falls due to the rise in p_2. If y_3^* falls, then it is also straightforward to show that n_3^* falls, n_2^* rises, y_2^* rises, and c_2^* falls, which is a contradiction. **Q.E.D.**

We have established that a rise in A_3^* leads to a fall in θ^*. Consider, now, the effects of a fall in θ^*.

Lemma 6. For a fixed level of wealth, W_0, in response to a fall in θ^* it follows that y_2, n_2, and y_3^* rise, whereas y_3, n_3, w, θ, p_2, p_3, and π_3 fall.

Proof. Without a change in p_2, in response to a fall in θ^*, by eqs. (47), (49), and (50) we see that y_3 and n_3 fall and y_2 rises. Hence, without a change in p_2 there will be an excess supply of Good 2. Since y_2 falls with a fall in p_2 and c_2 rises with a fall in p_2, the equilibrium response is for p_2 to fall and y_2 to rise.

It is not yet clear, though, if y_3 falls, as the fall in θ^* leads to a fall in y_3 and the fall in p_2 leads to a rise in y_3. To see that y_3 must fall as an equilibrium response, suppose p_2

fell to the point where y_3 did not change from its initial value. From eqs. (50) and (47) we see that in such a case n_3 must rise. Consequently n_2 must fall. From eq. (49) y_2 must then fall, which is a contradiction. Hence, it must be that y_3 falls as an equilibrium response.

From eq. (49) we see that the only way y_2 can rise and p_2 can fall is if n_2 rises and consequently n_3 falls.

By eq. (44) it follows that θ falls, and by eq. (38) p_3 falls. From eq. (6) it follows that w falls (and so too does w/p_2). Since y_3 falls, by eq. (36) it follows that $\theta^* - 2\theta$ falls, and hence by eq. (39) that π_3 falls. In the long run, though, the fall in profits π_3 does not lead to a fall in the return to capital, as the capital stock falls as well.

Note also that since $\theta^* - 2\theta$ falls it follows that $2\theta - \theta^*$ rises. Combined with the result that θ falls, it follows that $\theta - 2\theta^*$ rises. Consequently, by eq. (37) y_3^* rises. **Q.E.D.**

The central implication of the model regarding quantities and prices are similar to those derived before. The additional implication, which this version of the model was designed to address, was the fall in firm profits in the 90s. From Lemma 6 we see that the model predicts this observation as one of the responses to a fall in θ^*.

Table 1

Comparison of Qualitative Results to the Data

	Model	Data
n_3/n_2	fall	fall
k_3/k_2	fall	fall
y_3/y_2	fall	fall
p_3/p_2	no change from trend	no change from trend
A_3/A_2	no change from trend	no change from trend
y_3^*	above trend	above trend

Table 2

Parameter Values

	Japan	China
ν	0.33	0.33
σ	0.33	0.33
ρ	0.05	0.05
ω_1	0.18	0.18
ω_2	0.49	0.49
ω_3	0.33	0.33
n	1.00	10.00
W_0	2000	2000
A_{20}	1.00	0.17
A_{30}	1.00	0.53
h_2	0.00066	
h_3	0.00679	
g_2		0.0035
g_3		0.0173

	World Economy
r	0.02
α	7.8
γ	.1

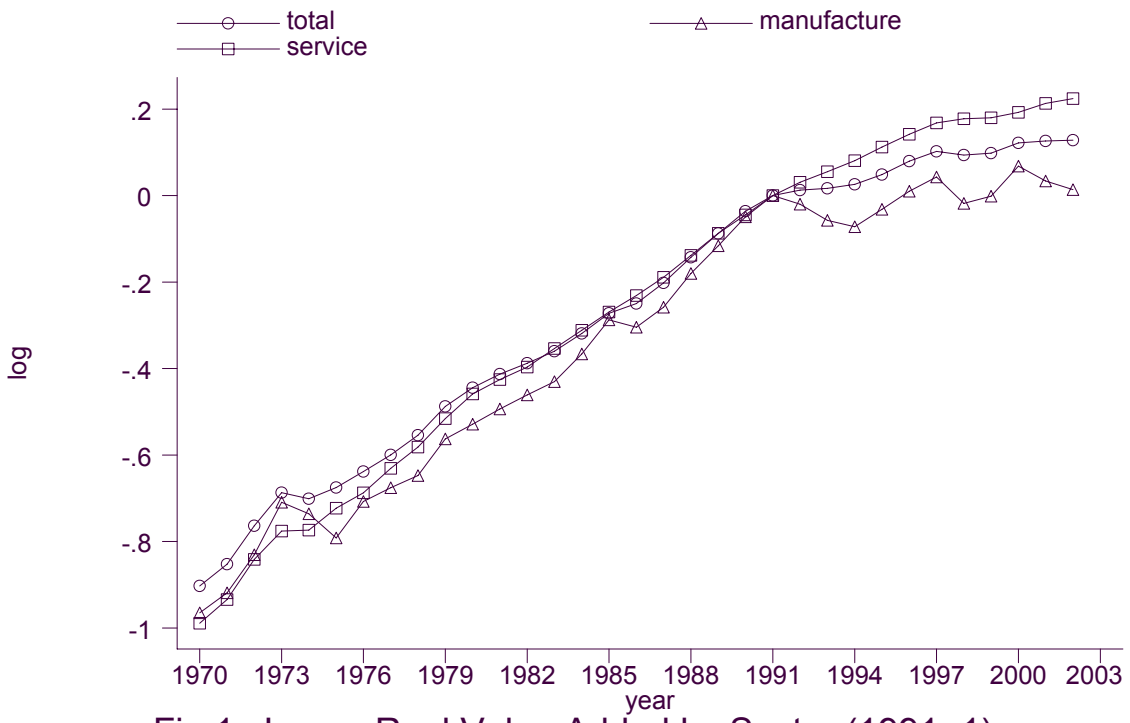

Fig 1: Japan: Real Value Added by Sector (1991=1)

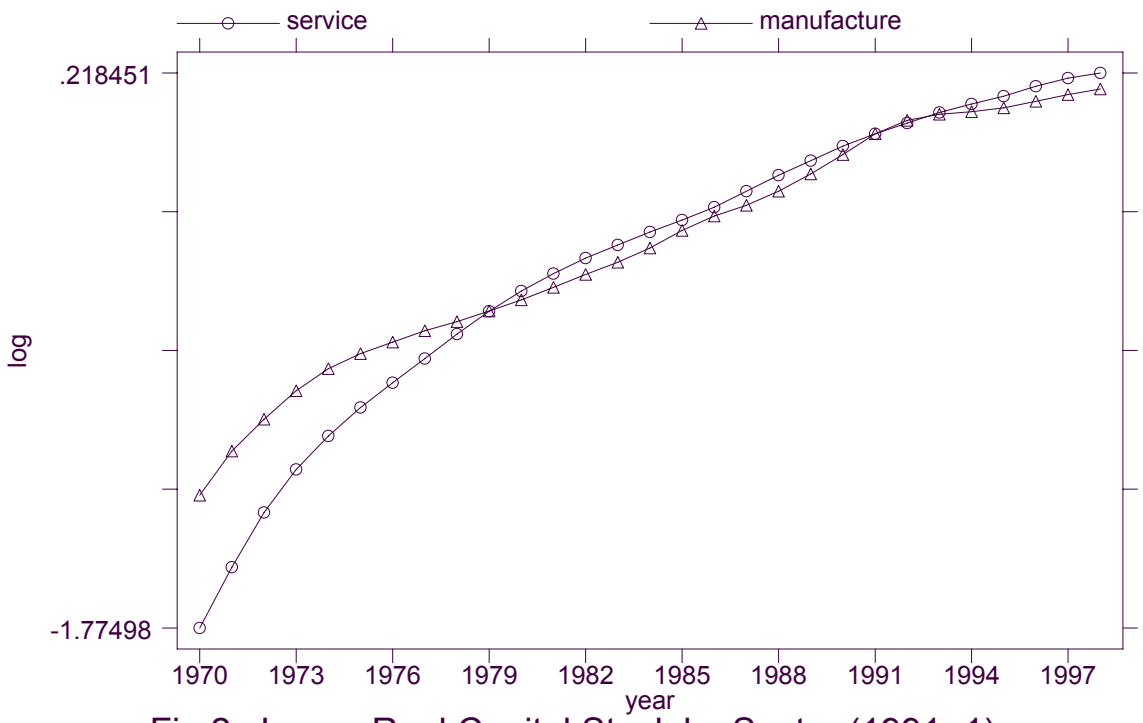

Fig 2. Japan: Real Capital Stock by Sector (1991=1)

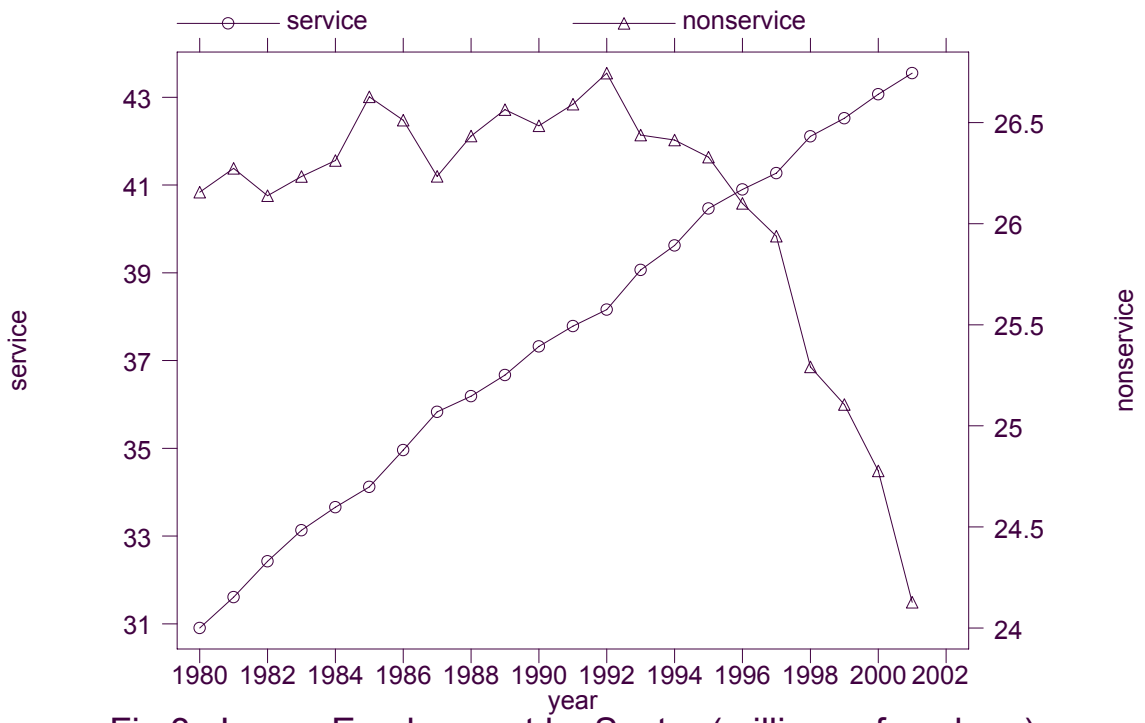

Fig 3. Japan: Employment by Sector (millions of workers)

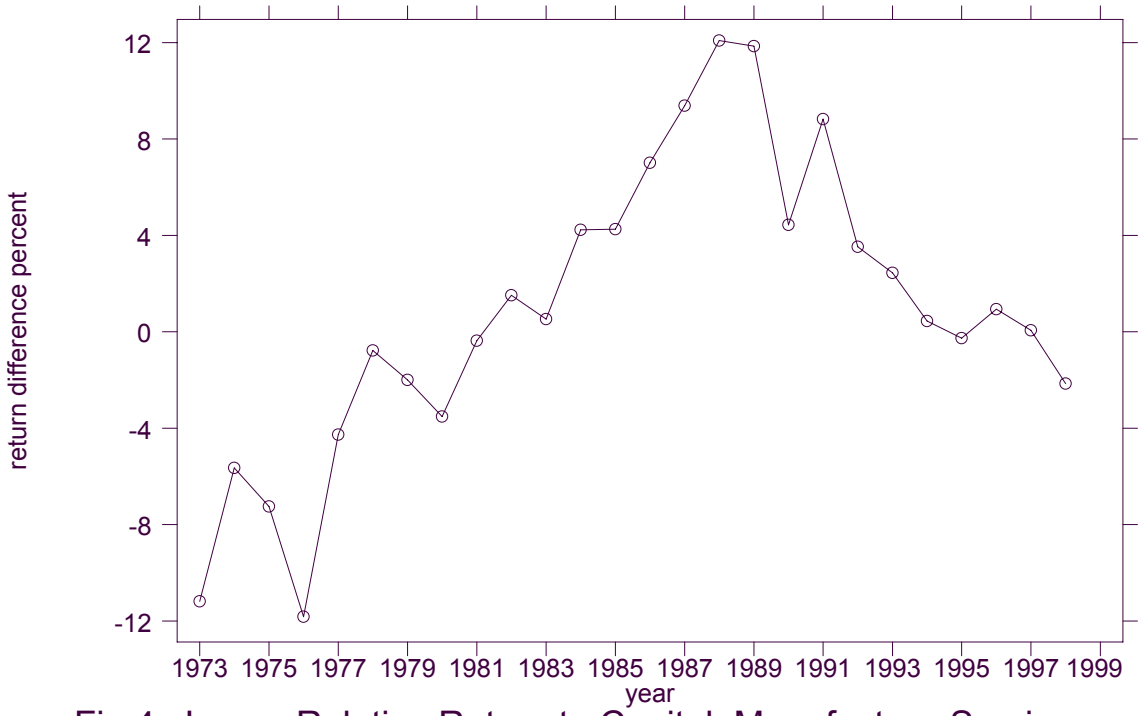

Fig 4. Japan: Relative Return to Capital, Manufacture-Service

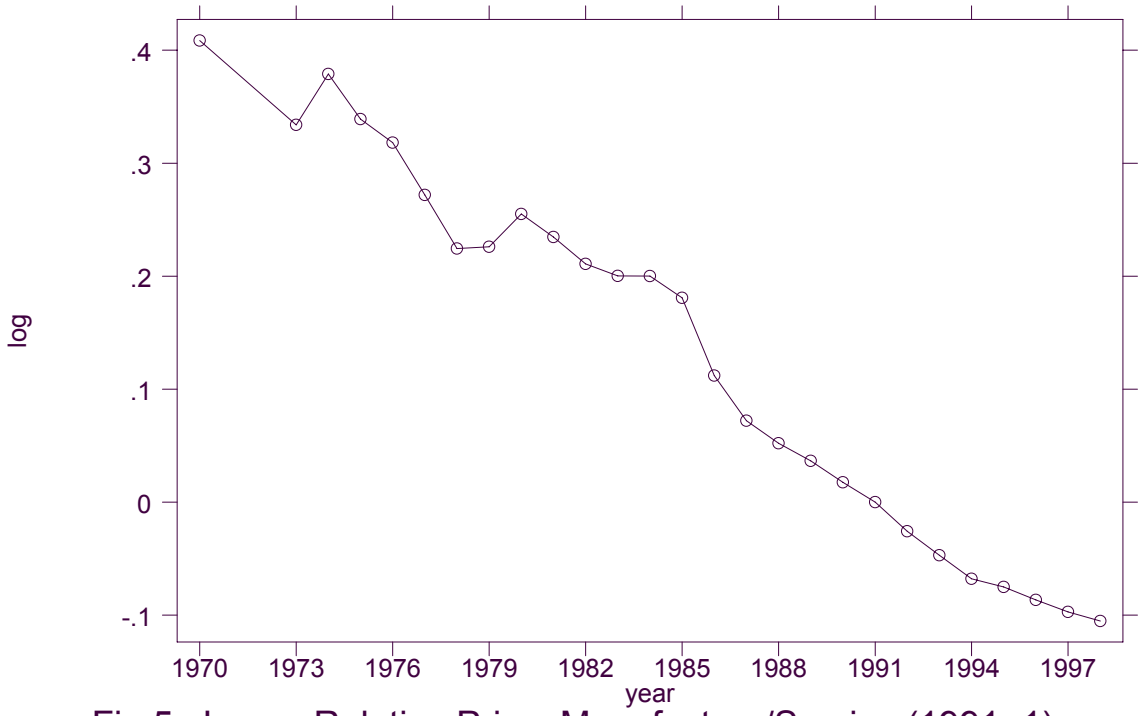

Fig 5. Japan: Relative Price, Manufacture/Service (1991=1)

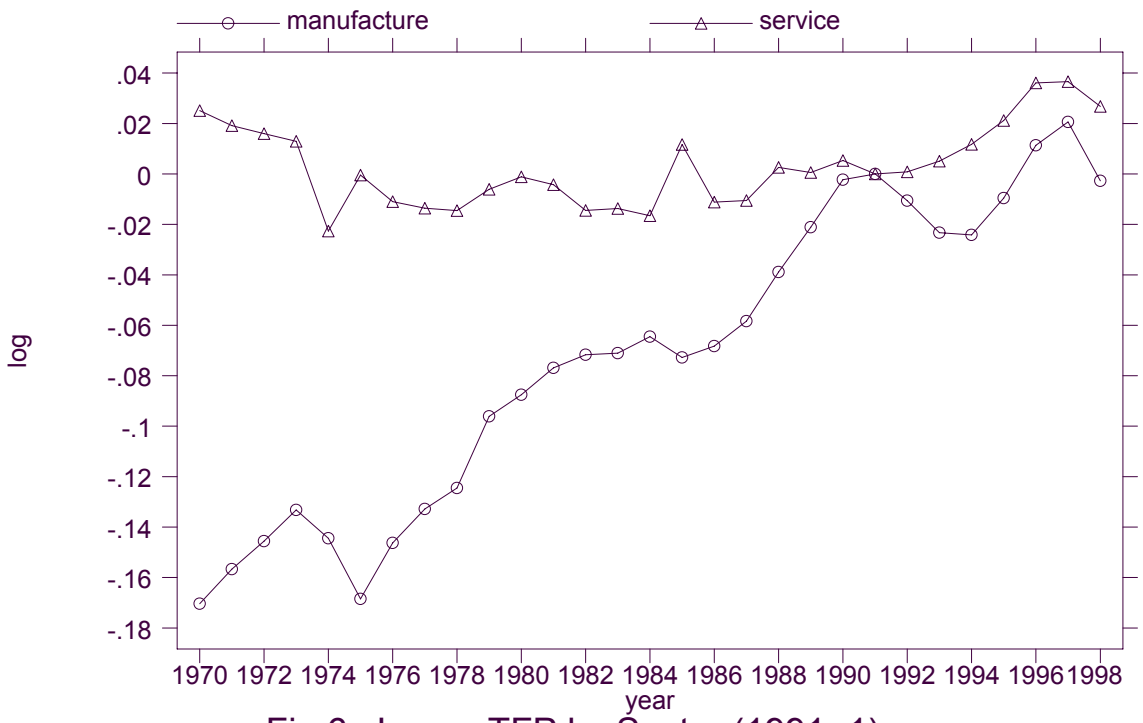

Fig 6. Japan: TFP by Sector (1991=1)

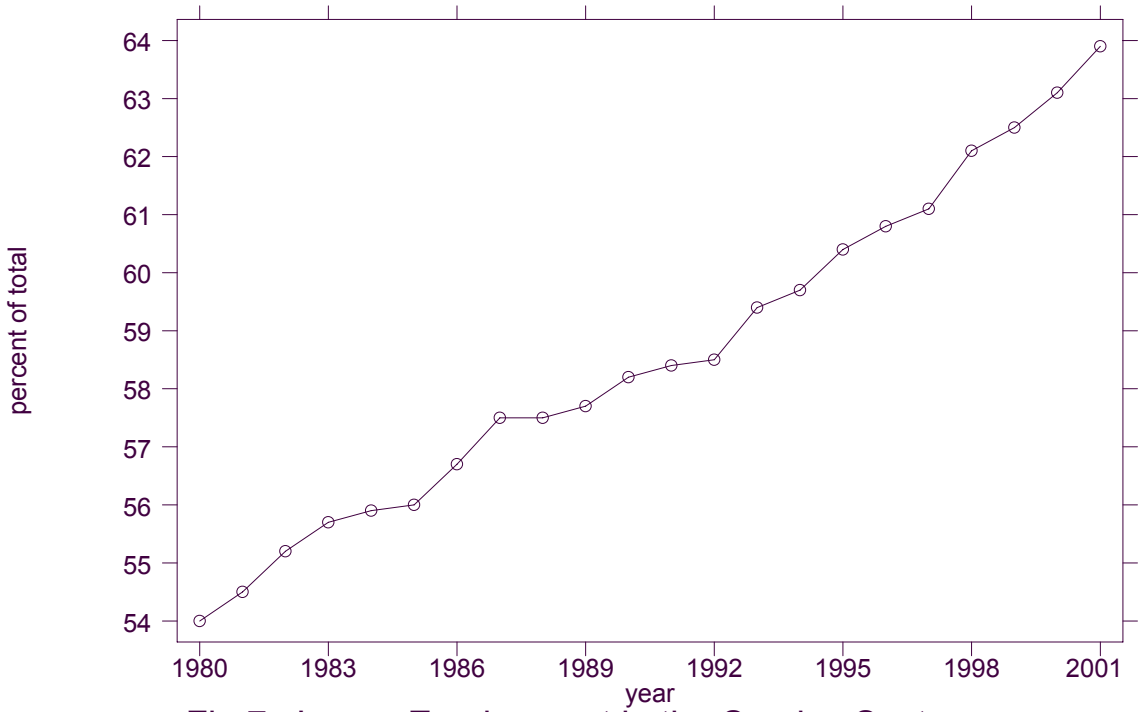

Fig 7. Japan: Employment in the Service Sector

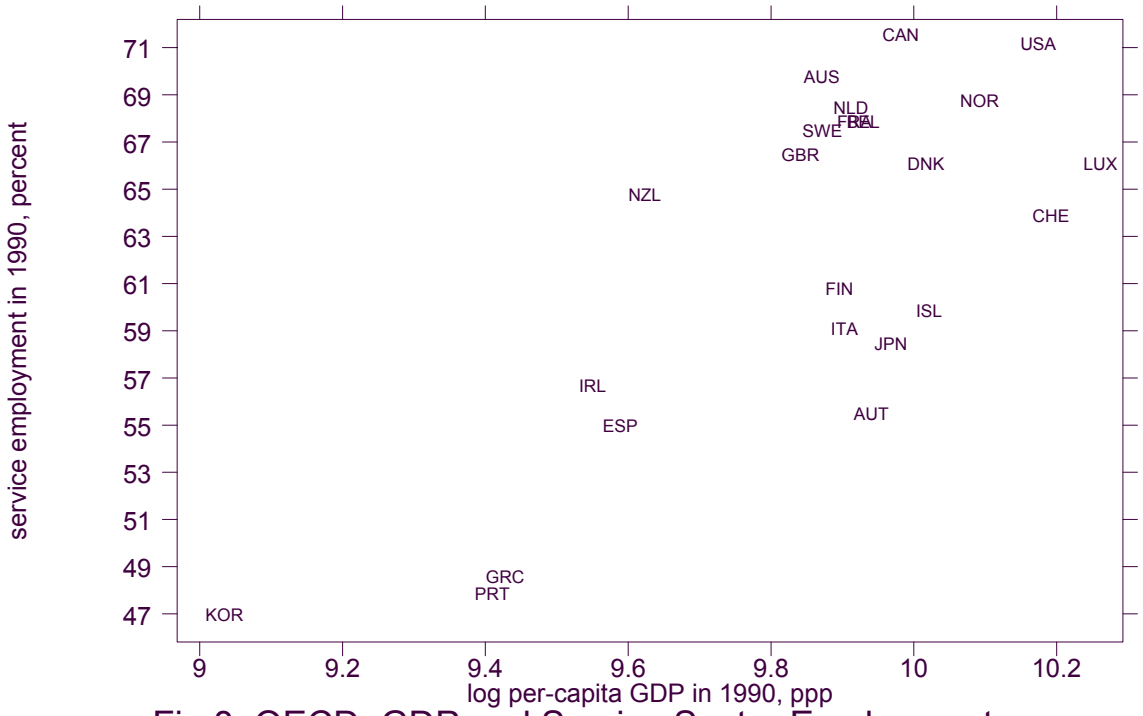

Fig 8. OECD: GDP and Service Sector Employment

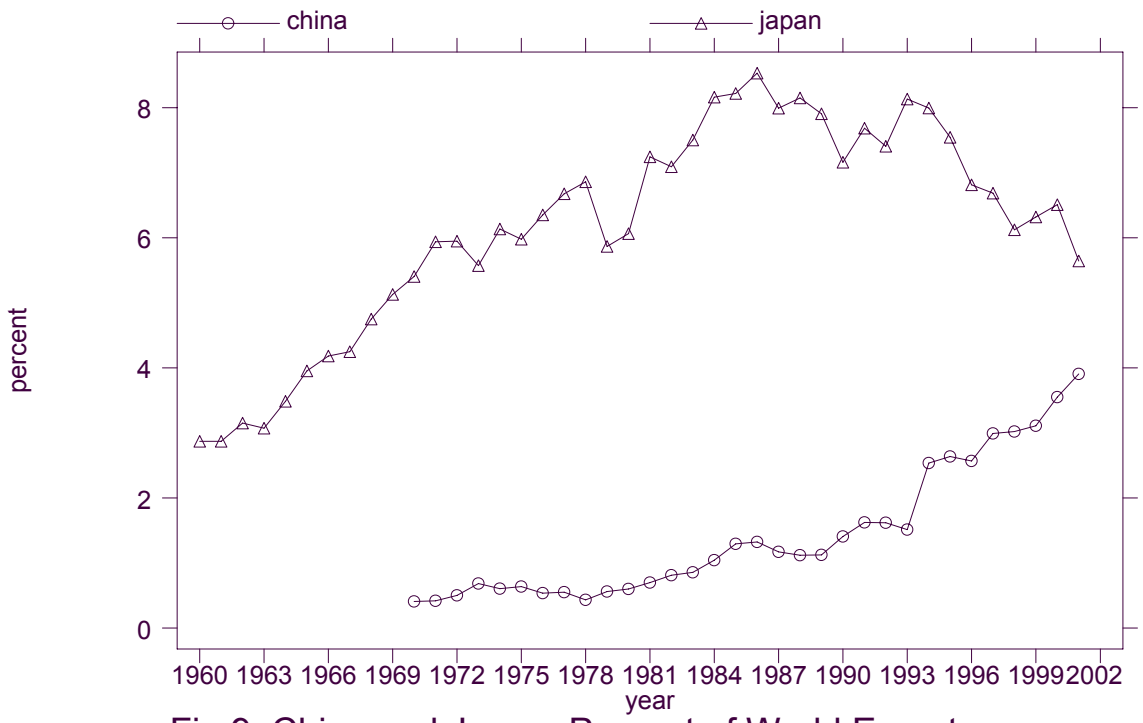

Fig 9. China and Japan: Percent of World Exports

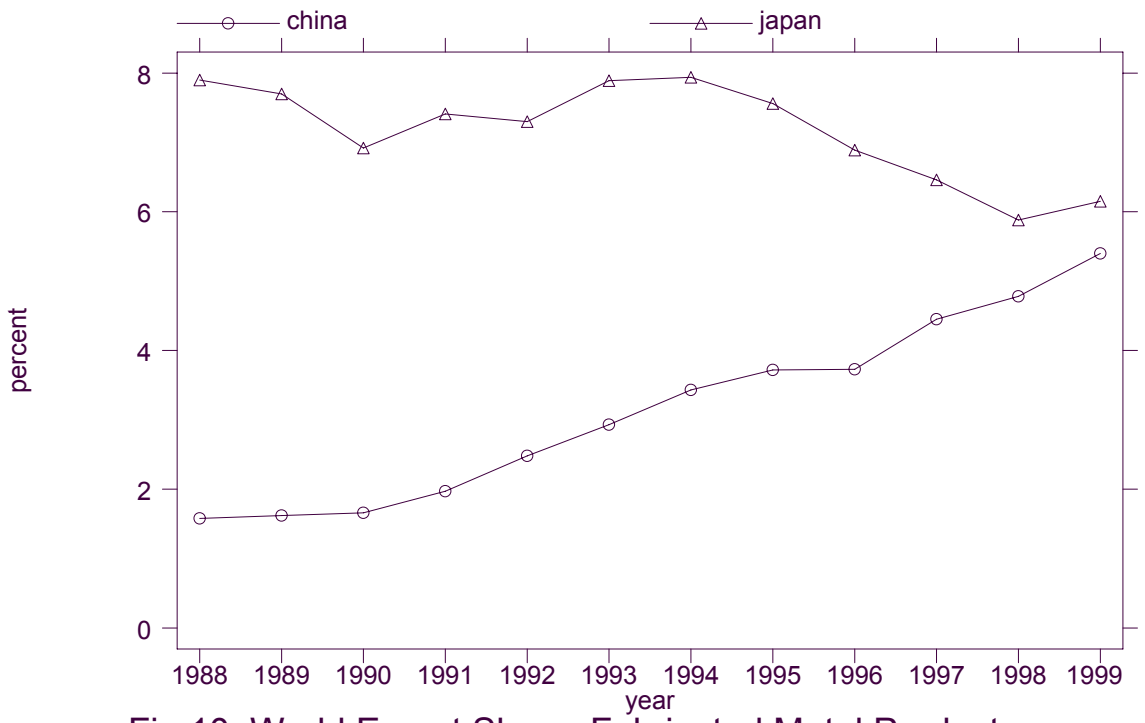

Fig 10. World Export Share: Fabricated Metal Products

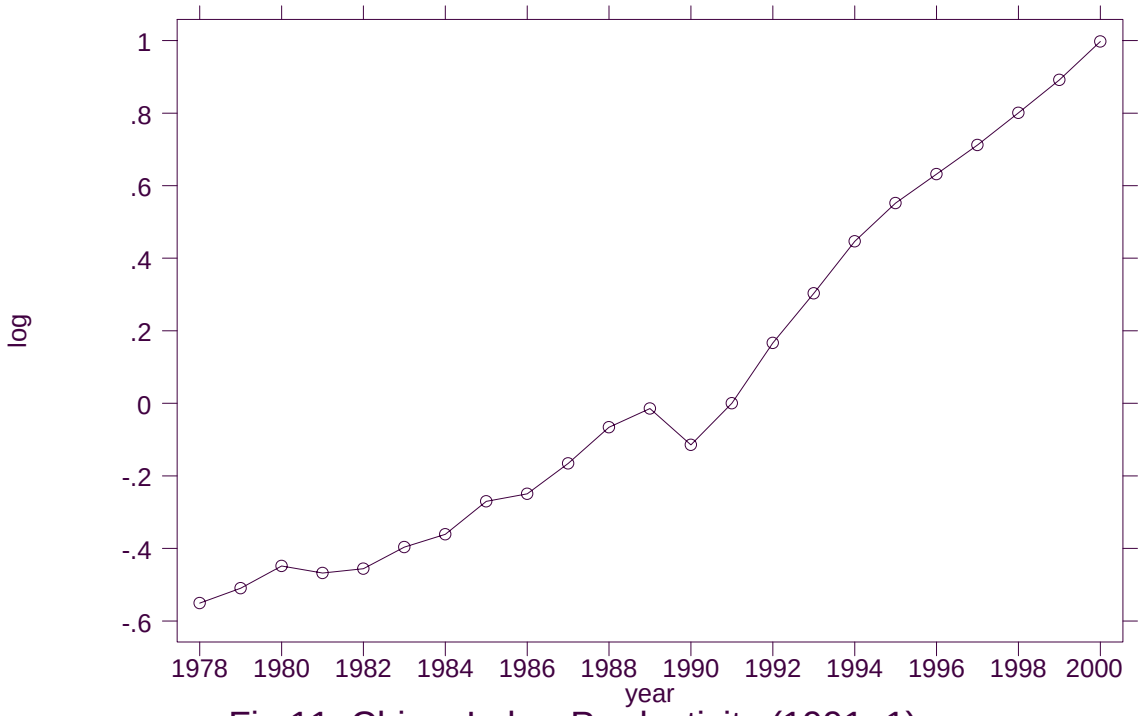

Fig 11. China: Labor Productivity (1991=1)

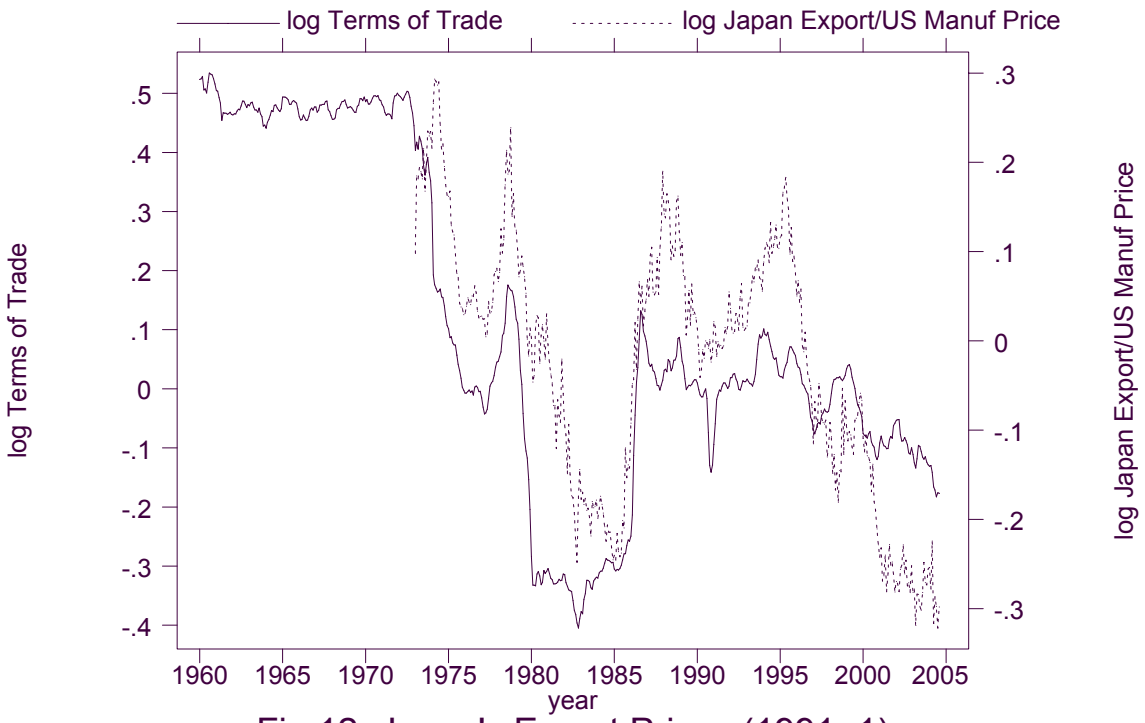

Fig 12: Japan's Export Prices (1991=1)

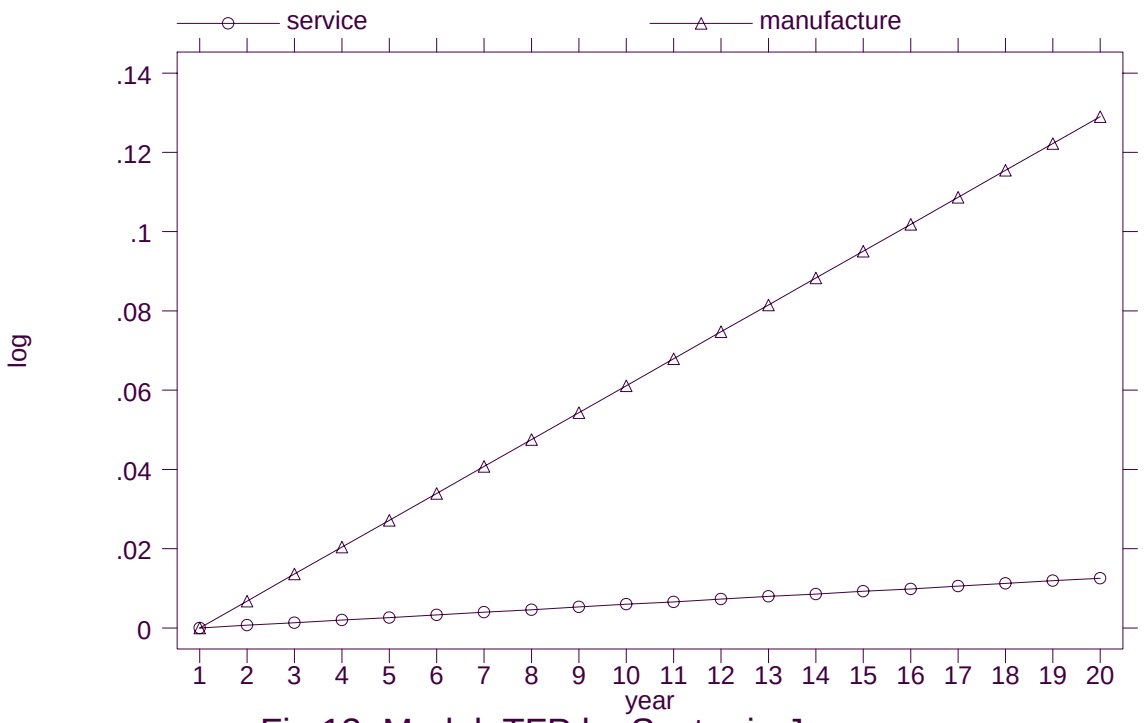

Fig 13: Model: TFP by Sector in Japan

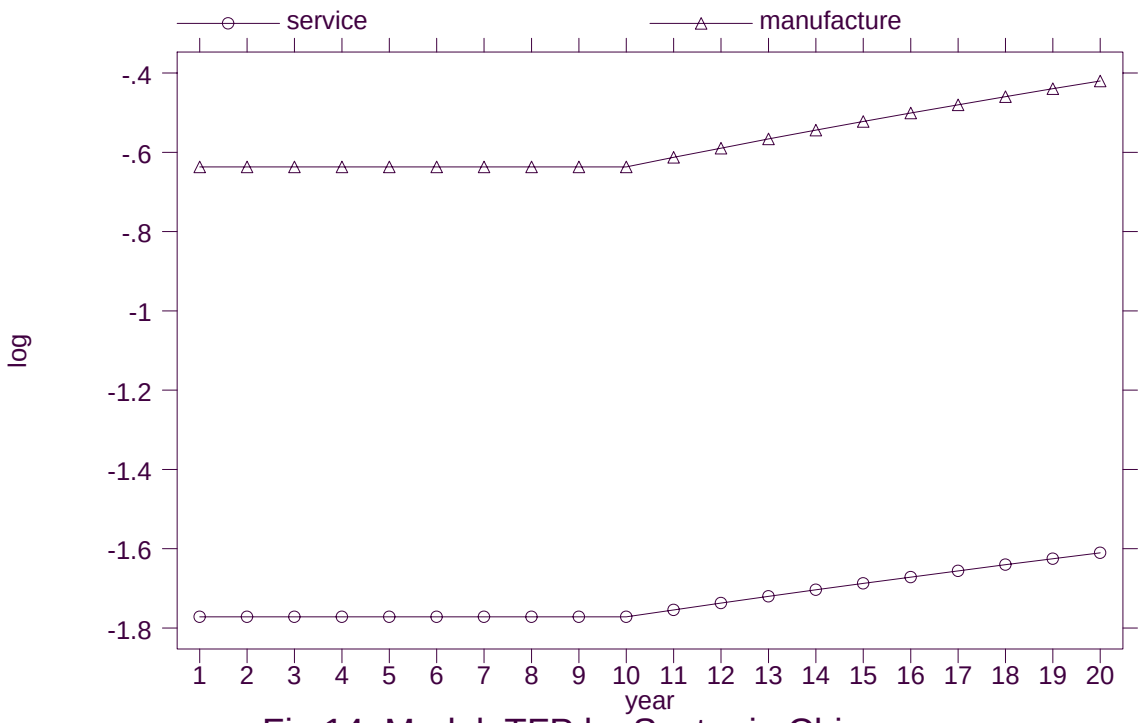

Fig 14: Model: TFP by Sector in China

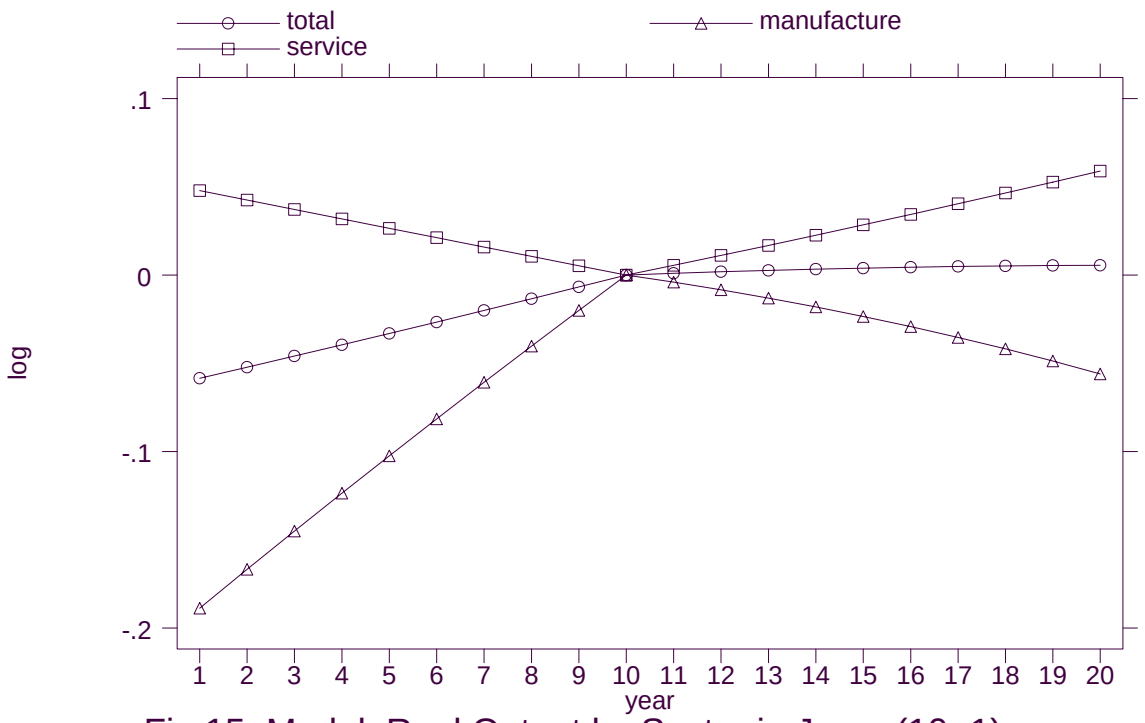

Fig 15: Model: Real Output by Sector in Japan(10=1)

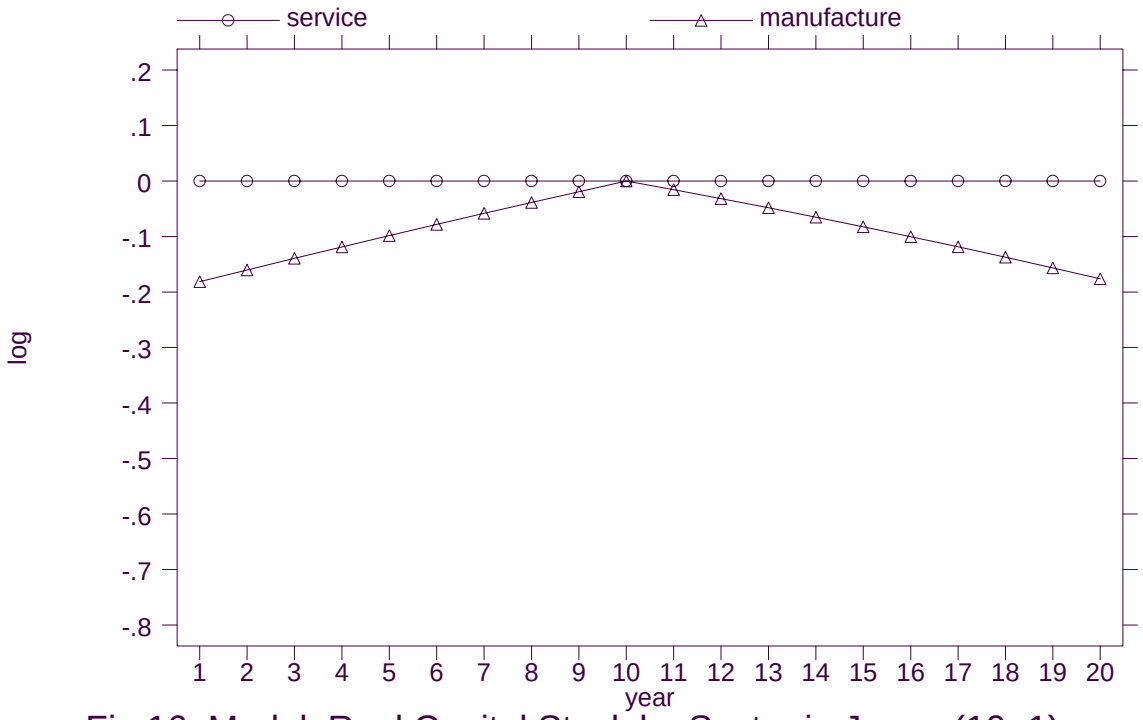

Fig 16. Model: Real Capital Stock by Sector in Japan (10=1)

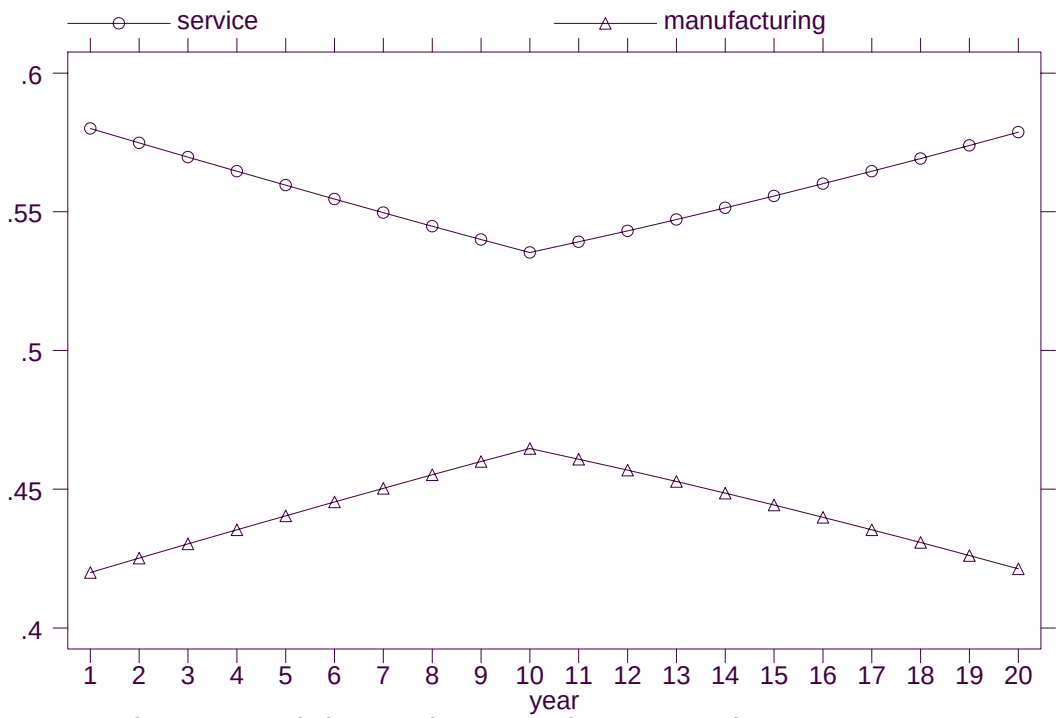

Fig 17. Model: Employment by Sector in Japan

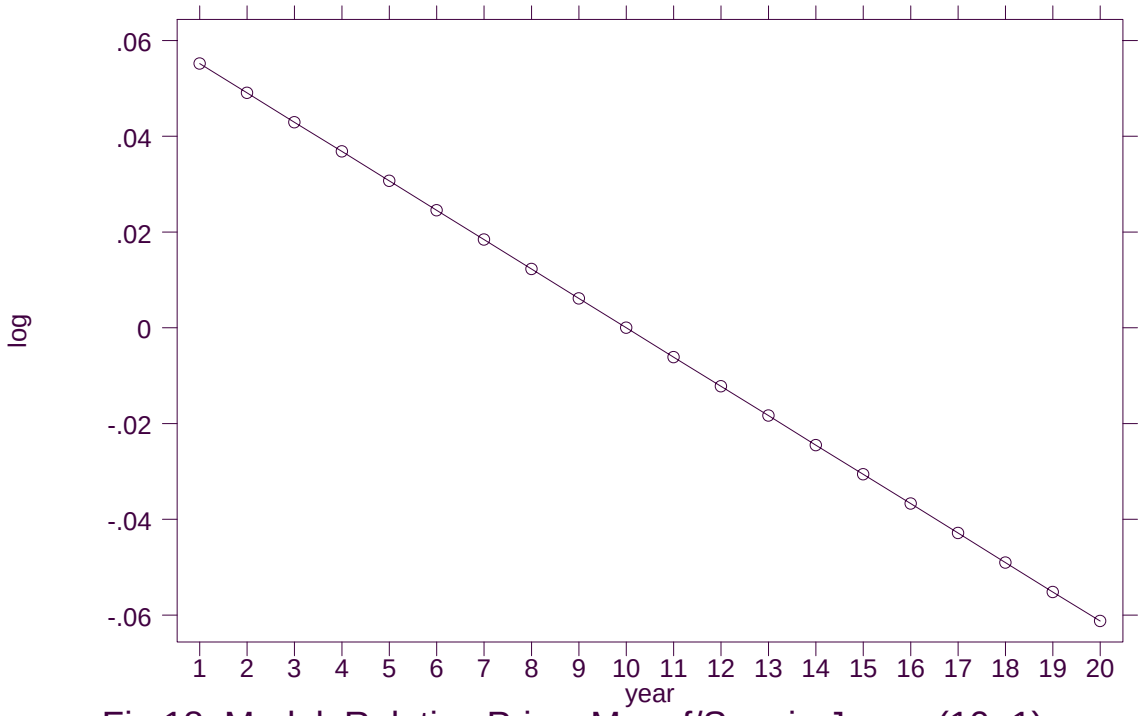

Fig 18. Model: Relative Price, Manuf/Serv in Japan (10=1)