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The Sources of Growth: Estimating Sectoral Productivity in Japan

Ken Miyajima

Ken Miyajima is a Ph.D. student in the Department of Economics, University of California, Los Angeles. He can be reached at kmiyajim@ucla.edu.

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The Sources of Growth: Estimating Sectoral Productivity in Japan *

Ken Miyajima[†]

University of California, Los Angeles

Abstract

This paper estimates industry-level productivity growth and contrasts it between the tradable and the nontradable sector in Japan. The tradable sector played a fundamental role in the extraordinary postwar growth of the Japanese economy. This finding supports the idea that the Japanese real exchange rate has appreciated through the Harrod-Balassa effect. This paper also emphasizes that both low productivity growth of the economy as a whole and the underperformance of the nontradable sector were already articulated in the 1970s, well before the Japanese economy entered "the lost decade" of the 1990s.

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[†]Department of Economics, P.O. Box 951477, Los Angeles, CA 90095-1477. E-mail: kmiyajim@ucla.edu.

1 Introduction

Since the Japanese economy started its reconstruction after World War II, its real exchange rate has appreciated significantly. In figure 1, the dark solid line with markers labled "SDR RER" shows the appreciating trend of the dollar-yen real exchange rate over the period of 1960-2000. We are not concerned about the two other series in figure 1 at this point.

Such trend of the real exchange rate is believed to reflect most clearly the fact that productivity in the tradable sector grew faster relatove to that in the nontradable sector in Japan. This mechanism is widely known as the Harrod-Balassa effect[1]. Motivated by this story, my analysis focuses on the estimation of productivity growth in order to document its industry-level differences in Japan, in particular between the tradable and nontradable sectors. I examine if productivity growth was much faster in the tradable sector than in the nontradable sector as the Harrod-Balassa theory assumes.

In his renowned paper, Balassa (1964) assumes that the tradable sector should be mainly responsible for a country's productivity growth, and real appreciation in exchange rates is a natural result of a country's growth. It should be noted that, however, the nontradable sector can assume an important role in a country's productivity growth, in which case one should expect real depreciation in exchange rates. Indeed, Harberger (2003) finds no systematic link between economic growth and the real exchange rate when he samples a large number of countries. Harberger's finding strongly suggests that the nontradable sector is mainly responsible for many countries' productivity growth[2].

Using the two-deflator method, a version of growth accounting, I estimate productivity growth and make comparisons among Japanese industries. I find that productivity growth in the tradable sector has been constantly higher than that in the nontradable sector in Japan. I also argue that the tradable sector has been largely responsible for productivity growth of the Japanese economy. The nontradable sector made little contribution in terms of productivity growth in good times, and made notably negative contribution during bad times.

I use industry-level time-series data covering the longest period possible, in order to document the historical growth of the Japanese economy. One notable limitation of my analysis comes from the fact that the data I use do not cover small firms. If small firms are less productive than large firms, my results should overestimate productivity, though not necessarily its rates of growth. This would be especially the case in industries such as trade or construction where small firms represent a large

[1] See Harrod (1933). This effect is conventionally called the Balassa-Samuelson effect. A renowned paper, Samuelson (1964), is largely oriented to the discussion of theory of international trade. The author states that the ratio of PPP to nominal exchange rate increases with higher productivity level, but there is no explicit reference to nontradable goods.

[2] This issue will be examined in my future research.

share of total output. Another point to note is that establishments in the Agriculture, Forestry and Fishery industry (AFF) in my data are all relatively large ones.

This paper consists of 6 sections. Section 2 explains the mechanism of the Harrod-Balassa effect. In section 3, I briefly review the Harberger two-deflator method that I use for productivity estimations. Section 4 provides an overview of the growth of the Japanese economy as a whole. In section 5, I conduct industry-level estimations and comparisons of TFP in Japan. In doing so, I contrast the tradable and the nontradable sectors. Section 6 concludes.

2 The Harrod-Balassa Effect

This section describes the channel through which productivity gaps between the tradable and nontradable sectors influence the real exchange rate. In doing so, I introduce the SDR real exchange rate, a version of the real exchange rate used throughout this paper.

2.1 Sectoral Productivity Gaps and the Relative Price of Nontradable Goods

There are two sectors producing tradable and nontradable goods using capital and labor inputs:

$$Y_T = A_T L_T^{\alpha} K_T^{1-\alpha} \tag{1}$$

$$Y_N = A_N L_N^{\beta} K_N^{1-\beta} \tag{2}$$

where T and N denote the tradable and the nontradable sectors, respectively. Let p represent the relative price of nontradable goods in terms of that of tradable goods:

$$p = \frac{p_N}{p_T} \tag{3}$$

where p_T and p_N represent the price of tradable and nontradable goods, respectively. From profit maximization, one would find the following:

$$d \log p = \frac{\beta}{\alpha} d \log A_T - d \log A_N + (1 - \frac{\beta}{\alpha}) d \log r \tag{4}$$

Assuming a small open economy where r is fixed, equation (4) further simplifies to the following:

$$d \log p = \frac{\beta}{\alpha} d \log A_T - d \log A_N \tag{5}$$

Hence the relative price of nontradable goods in terms of that of tradable goods increases (falls) with higher (lower) A_T for a given level of A_N.

2.2 The Relative Price of Nontradable Goods and the Real Exchange Rate

Consider the SDR real exchange rate:

$$e_{SDR} = \frac{E \cdot p_{SDR}}{P} \tag{6}$$

where p_{SDR} is the SDR-WPI, an index representing the world price level of tradable goods, P is the GDP deflator of the country (in this specific case Japan), and E is nominal exchange rates. Proposed by Harberger (1989), the SDR-WPI combines the wholesale price index (WPI) in 5 major countries using the SDR weights constructed by the IMF[3]. WPI of the US, UK, France, Germany and Japan are weighted by the SDR weights and are converted in the dollar in order to be expressed in the same currency unit:

$$\begin{aligned} SDR\_WPI_{USD} = \; & 0.42 \cdot WPI_{US} \\ & +0.19 \cdot WPI_{DEU} \cdot USD/DM \\ & +0.13 \cdot WPI_{UK} \cdot USD/\$ \\ & +0.13 \cdot WPI_{FRA} \cdot USD/FF \\ & +0.13 \cdot WPI_{JPN} \cdot USD/\mathrm{U} \end{aligned} \tag{7}$$

Note that, unlike conventionally used symmetric real exchange rate[4], the SDR real exchange rate is not influenced by the relative price of nontradable goods in terms of tradable goods in foreign countries. The GDP deflator is assumed to be the geometric average of the price of tradable and nontradable goods:

$$P = (p_T)^{\omega}(p_N)^{1-\omega} \tag{8}$$

The SDR real exchange rate can be further disaggregated in terms of the log:

$$\log e_{SDR} = \log E + \log p_{SDR} - \omega \log p_T - (1-\omega)\log p_N \tag{9}$$

By gathering terms:

$$\log e_{SDR} = \log \left(\frac{E \cdot p_{SDR}}{p_T} \right) + (1-\omega)\log \left(\frac{p_T}{p_N} \right) \tag{10}$$

[3]A revision of the SDR valuation basket is undertaken every five years in accordance with the IMF's decision of September 17, 1980, unless the IMF's Executive Board decides otherwise. I applied the 1981-1984 weights for all years in constructing the SDR-WPI index, even though the weights are updated every five years in reality. This should not alter the main finding of this paper. The 1985-1989 (1991-1995, 1996-2000, 2001-) weights are 40 (40, 39, 45) percent for the U.S. dollar, 21 (21, 21, 29 for the euro) percent for the Deutsche mark, 17 (17, 18, 15) percent for the Japanese yen, 11 (11, 11, 29 for the euro) percent each for the French franc and 11 (11, 11, 11) percent for the Pound sterling.

[4]For instance, in the case of the dollar/yen real exchange rate, widely employed symmetric real exchange rate uses the US's GDP deflator for the numerator and Japan's GDP deflator for the denominator.

The SDR real exchange rate is separated in two components: 1) $\log\left(\frac{E \cdot p_{SDR}}{p_T}\right)$ and 2) $(1-\omega)\log\left(\frac{p_T}{p_N}\right)$. Figure 1 plots the two components of the dollar-yen SDR real exchange rate and shows that its long-term trend has been significantly influenced by the second component. On the other hand, the first component has been mostly responsible for the short-run fluctuations, and has not diverged mcuh from its initial level.

Real appreciation in the dollar-yen SDR real exchange rate in the long-run is mostly affected by the relative price of nontradable goods in terms of tradable goods in Japan. Thus, one can expect to find large productivity gaps between the tradable and nontradable sectors in Japan, and the following sections investigate if this conjecture is supported by the data.

3 The Two-Deflator Method

The two-deflator method is the main tool of productivity measurement I use in this paper, and readers interested in detailed descriptions are directed to Miyajima (2003), the background paper of this work. This paper only goes over the key concepts such as the use of the GDP deflator, the standard wage and the return on capital.

The two-deflator method distinguishes itself from other methods of growth accounting in its use of two deflators, the GDP deflator and the standard wage. Also, the two-deflator method requires much less data compared to the contemporary version of the growth accounting, the Jorgenson method. However, estimated results using the two-deflator method are as reliable as those on the basis of the Jorgenson method[5].

The traditional growth accounting method uses factor- or product-specific deflators in order to express variables in real terms, based on the theory of production. On the other hand, because the two-deflator method is based on the theory of capital, it uses one single deflator, the GDP deflator, in order to deflate all variables as it is done in standard cost-benefit analysis. This is how all variables are brought to the same comparable basis. Another advantage of the use of the GDP deflator is that one does not need to construct detailed price data. Having said that, when the data for prices are available, it is preferred to price-adjust calculated real cost reduction (RCR) in order to account for the change in the relative price of final products[6].

[5] The Jorgenson method cross-classifies factor inputs in order to capture factor substitution among factors of different quality. See, for example, Jorgenson and Kuroda (1990). The fact that the two-deflator method is as reliable as the Jorgenson method in the estimation of TFP has been well documented. For instance, see Harberger(1998), Robles (1997) and Miyajima (2003).

[6] Ideally one should use the relative prices of value added if one is using value added as the relevant measure of output. However, the relative price of value added is difficult to obtain at a disaggregated level. One option to add price adjustments in practice is hence to use the relative price of output. Miyajima (2003) shows that one can obtain similar results by using either the relative price of value

A major issue in growth accounting has been how to separate the contribution of labor quality from calculated RCR. The two-deflator method solves this problem while maintaining the beauty of a light use of the data by introducing the standard wage, w^*. All kinds of workers are expressed in terms of the standard worker, L^*, which allows the two-deflator method to capture changes in labor quality[7]:

$$L_t^* = \frac{w_t L_t}{w_t^*} \tag{11}$$

For instance, one tenured professor might be worth 20 standard workers whereas one graduate student would be worth 5 standard workers. In this case, 1 professor is worth 20 units of L^* while 1 graduate student is worth 5 units of L^*.

Another feature that distinguishes the two-deflator method from other methods of growth accounting is that rates of return on capital are brought to the center of analysis. The return on capital is important because it predicts future growth[8]. The traditional method of growth accounting in most cases imposes a constant share of capital which does not make use of the return on capital. By recalculating return on capital every period[9], instead of imposing a constant share, estimated capital contributions in the two-deflator method should better reflect the actual contribution of capital[10].

Finally, real cost reduction is estimated by the following equation, where all variables are deflated by the GDP deflator:

$$RCR' = \frac{\Delta y}{y} + \frac{\Delta p}{p} - \frac{w^* \Delta L^*}{Y} - \frac{(\rho + \delta)\Delta K}{Y} \tag{12}$$

where y is quantity of value added, p is the relative price in terms of the GDP deflator, K is real value of capital, L and L^* are the number of workers and that of the standard labor, respectively, w and w^* are sectoral wages and the standard wage, respectively, ρ is rates of return on capital, and δ is rates of depreciation. When the economy as a whole is concerned, it is always true that $p = 1$ and $\Delta p = 0$. When industry-level

added or that of final output.

[7] This assumes workers are paid their marginal productivity while especially in Japan factors such as labor hoarding might make this assumption invalid. If effects of labor hoarding more or less equally distort wages across all industries and across the entire period under analysis, such as shifting wages up by the factor of 1.10, then growth rates of labor contribution will not be affected by the distortion.

[8] Cho (2000), Harberger (1998) and Hyongwon Kim (2001) document the positive relationship between rate of return on capital and future TFP growth.

[9] Estimated capital contributions using the two-deflator method is similar to those using a variable share of capital period by period. Yet, the explicit use of the return on capital is what distinguishes the two-deflator method from other alternative.

[10] In this framework, industry specific wages mainly reflect labor quality, among other factors that I assume are not major determinants such as the impact of unionization or minimum wages. On the other hand, rates of return should mainly reflect risks associated to the use of capital in each industry rather than capital quality.

data are concerned, however, generally $\Delta p \neq 0$ and $\frac{\Delta p}{p}$ needs to be subtracted from both sides:

$$RCR^* = RCR' - \frac{\Delta p}{p} \qquad (13)$$

RCR^* is considered to represent estimated real cost reduction with higher precision.

4 Growth of the Japanese Economy

Before moving on to the industry-level estimation of RCR, I examine the growth process of the Japanese economy as a whole as far back from 1905. The data I used for the period of 1905-1940 is taken from Estimates of Long-Term Economic Statistics of Japan Since 1868 (LTES). This includes only the Non-Agriculture private sector. The data for the period of 1954-1998 are taken from Financial Statements of Corporation by Industry (FSC), which covers all sectors except for the Finance, Insurance and Government sectors and does not include small firms. The priority was given to the choice of a dataset with long time series including many industries. The major limitation of my analysis hence comes from the fact that the FSC dataset does not include small firms, which will most likely work to overestimate the estimated level of productivity, though not necessarily its rates of growth. One should keep this in mind throughout this paper.

Figure 2 shows the trend of productivity for the Japanese economy based on these data sets. The estimated values are expressed in per worker units[11]. The trend of RCR first rose significantly in 1914. The economy actually boomed on the back of large demand caused by World War I. Japan was hit by the Kanto Earthquake in 1923, the devastating effect of which is reflected in the plot by the sluggish growth of RCR. In the 1930s, the trend of RCR accelerated significantly until World War II broke out, reflecting robust economic growth. The post-war period experienced tremendous growth until early 1970s when the economy was hit by the first oil shock. Perhaps due to energy saving innovations, the trend of RCR recovered its pre-oil crisis level by 1980, and the Bubble economy accelerated the trend of RCR. During the post-Bubble recession, the level of RCR seems to have picked up in the middle of 1990s, but it started falling again in the late 1990s .

5 Industry-Level Estimation of Productivity

This section investigates the growth process of the Japanese economy at the industry-level. The Sunrise-Sunset (SS) Diagram proposed by Harberger is used in order to

[11] This is the only place where I estimate real cost reduction in per worker terms. I chose to use per worker units here simply because estimates by Ohkawa and Rosovsky based on LTES dataset are also expressed in per worker units.

illustrate the extent of RCR in each industry[12].

First, industries are classified into the tradable and nontradable sectors. Second, the Sunrise-Sunset diagrams are drawn for industries level RCR. Table 1 shows detailed industry classifications.

5.1 Industry Classifications

The distinction between the tradable and the nontradable sector is usually made by looking at the extent to which prices are determined in international markets. There are international markets for products of the Manufacturing, Agriculture and Mining industries where prices are more or less equalized internationally. Products of other industries are likely to be nontradable due to characteristics attached to each product, such as prohibitively high transportation costs. In practice, the tradable sector is considered to consists of the Manufacturing, Agriculture and Mining industries. Note that the amount of products actually traded may be a good indicator for industry classifications. If the domestic supply of personal computers exactly matched the demand for them in Japan, personal computers would not be imported nor exported. Yet, the production of personal computers should be categorized in the tradable sector. Hence some products can be tradable but not traded.

In the case of Japan, I categorize both the Agriculture and Mining industries in the nontradable sector. The main agricultural product, rice, is protected with high levels of tariffs, rendering the product nontradable. Regarding the Mining industry, Japan imports mining products in order to meet domestic demand, while domestic producers receive subsidies aimed at covering the gap between the costs and market prices.

5.2 Characterizing the Growth Process of Japan

In what follows, I use the Sunrise-Sunset diagram to depict the distribution of industry-level RCR in Japan. Figure 3 shows productivity growth of the Japanese economy since World War II to the end of the 20th century, 1954-1998. Besides the Mining and the AFF industries making small positive contribution to total RCR, the Manufacturing industry was the dominant source of positive growth. With about 50% share of initial value added, the Manufacturing industry alone realized almost 100% of the maximum of the cumulative sum of RCR. The remaining industries made only negative contributions.

Figure 4 shows that this striking fact equally holds for period by period observations. The diagrams demonstrate that RCR of the whole economy was already low in the 1970s. Productivity growth in the tradable sector decelerated significantly,

[12] The Sunrise-Sunset diagram was proposed by Harberger (1998) in order to visually illustrate productivity improvements at disaggregated levels. The slope represents rates of productivity improvements and the distance on the X axis represents the industry's share of value added.

yet remained positive. The nontradable sector never performed well in terms of RCR and its underperformance was articulated in the 1970s. Such evidence may shed some light on the potential causes of economic difficulties that Japan is currently undergoing. Given that macroeconomic policy measures could not revive its growth after the economy had collapsed in the 1990s, one would suspect that structural factors might have been the impediments to the Japan's potential growth.

This is, for instance, the view that McKinsey Global Institute takes in its micro-level research of the service industry. A macro-level analysis with similar conclusions is done by Hayashi and Prescott (2002), who show that growth theory treating TFP as exogenous accounts well for Japan's lost decade of growth. Hayashi and Prescott assert that the Japanese economy stagnated in the 1990s due to low TFP and argue against the credit crunch hypothesis. They suggest that the focus should be on what policy changes are needed in order to allow productivity to again grow rapidly. My findings also point in the same direction.

6 Final Remarks

Japan grew spectacularly for two decades up to the beginning of the 1970s followed by a deceleration during the 1970s and 1980s, except for the period of the Bubble. The decade of the 1990s is characterized by the long-lasting post-Bubble recession. The industry-level analysis demonstrated that throughout the periods under investigation the Manufacturing industry was responsible for positive rates of RCR. The nontradable sector made at best slightly positive contributions in good times, and significantly underperformed by making large negative contributions during bad times.

This paper provided evidence that growth rates of productivity in the tradable sector were higher than those in the nontradable sector in Japan, supporting the conjecture that the steady appreciation in the dollar-yen real exchange rate is the evidence of the Harrod-Balassa effect.

I also pointed out that, given that macroeconomic policies have not been able to revive the economy, low productivity growth might be a cause of the recession that Japan is currently experiencing. Given that productivity growth already slowed down in the 1970s, the recession was inevitable and was simply delayed by the Bubble economy of the late 1980s.

The episode of the Japanese economic growth seems to support the Harrod-Balassa theory. Next question to be asked is if the same patterns are observable in other countries, i.e. the tradable sector has always been mainly responsible for a country's productivity growth. The literature seems to suggest that it is not obvious. My next project is hence to extend the coverage of countries and examine the role of the nontradable sector in the context of economic growth.

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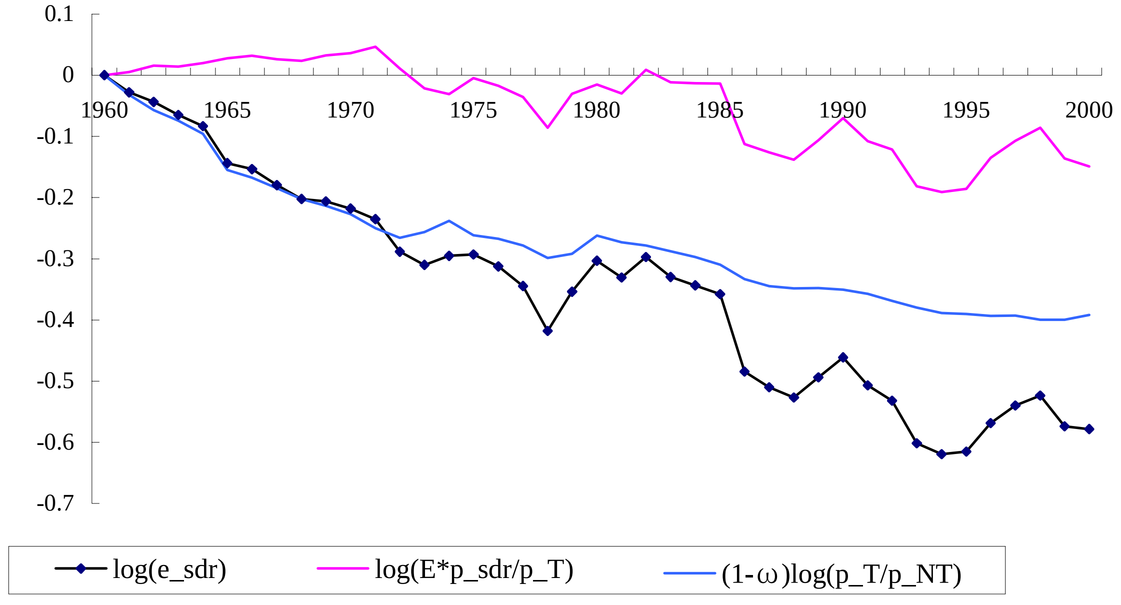


Figure 1. Trend of the Dollar-Yen Real Exchange Rate
Period: 1960-2000.

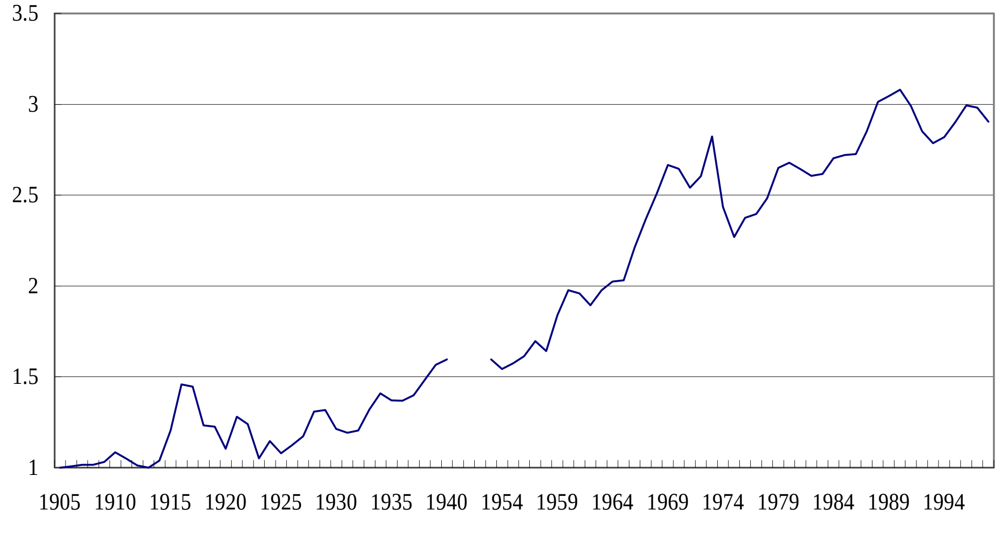


Figure 2. Trend of RCR per Worker

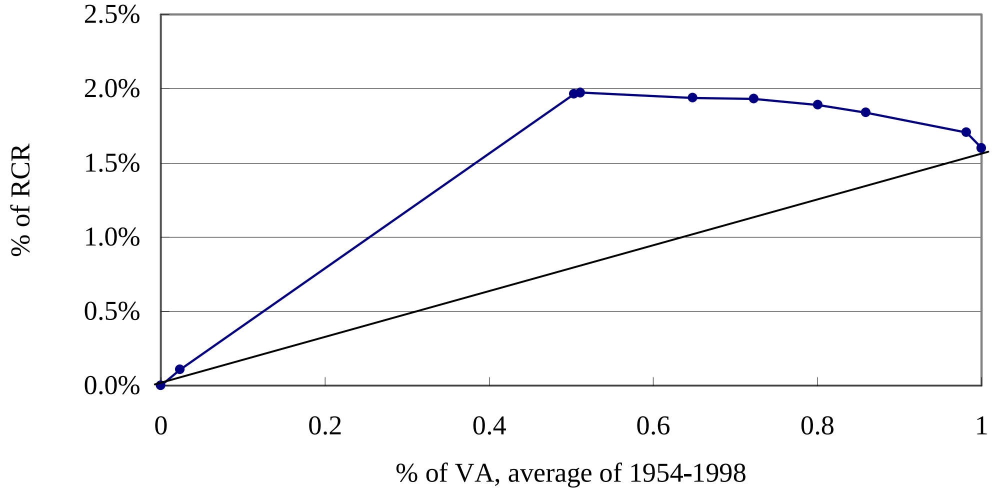
Sources: 1905-1940: LTSD, non agricultural private sector.
1954-1998: FSC, all industries.

1 **AFF**		Agriculture, Forestry and Fishery
2 **Mining**		Mining
3 **Const.**		Construction
4 **Manu.**		Manufacturing
	5 **Food**	Food Products
	6 **Textile**	Textile Mill Prodcuts
	7 **Paper**	Pulp, Paper and Paper Worked Products
	8 **Ceramics**	Ceramic, Stone and Clay Products
	9 **Chemical**	Chemicals and Allied Products
	10 **Prim.**	Primary Metal Products
		Iron and Steel
		Non-Ferrous Metal Products
	11 **Fabric.**	Fabricated Metal Products
	12 **Machine.**	General Machinery
	13 **Electric.**	Electrical Machinery, Equipment and Supplies
	14 **Trans.**	Transportation Equipment
	15 **Other**	Apparel and Other Textile Products
		Lumber and Wood Products
		Publishing, Printing and Allied Products
		Petroleum and Coal Products
		Precision Machinery
		Other Manufacturing
16 **Wholesale**		Wholesale Trade
17 **Retail**		Retail Trade
18 **Real Est.**		Real Estate
19 **UTT**		Utilities, Telecommunication and Transportation
20 **Services**		Services

Table 1. Classification of Japanese Industries.

* FIRE stands for Finance, Insurance and Real Estate. In the following tables RCR of FIRE is actually that of real estate, since the dataset I used to estimate the RCR only includes real estate industry.

Japanese Economy: 1954-1998



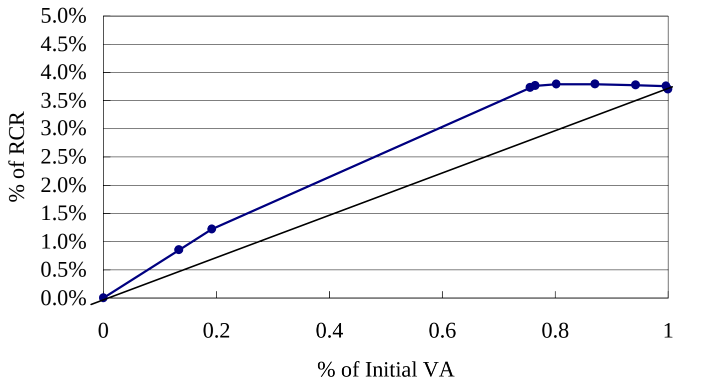
	Mining	Manu.	AFF	UTT	Retail	Const.
% of RCR	0.11%	1.86%	0.01%	-0.04%	-0.01%	-0.04%
Cum-sum	0.11%	1.96%	1.97%	1.94%	1.93%	1.89%

Services	Wholesale	Real Est.
-0.05%	-0.13%	-0.10%
1.84%	1.71%	1.60%

Average	1.60%
Max	1.97%

Figure 3. Sunrise-Sunset Diagram for the Japanese Economy, 1954-1998

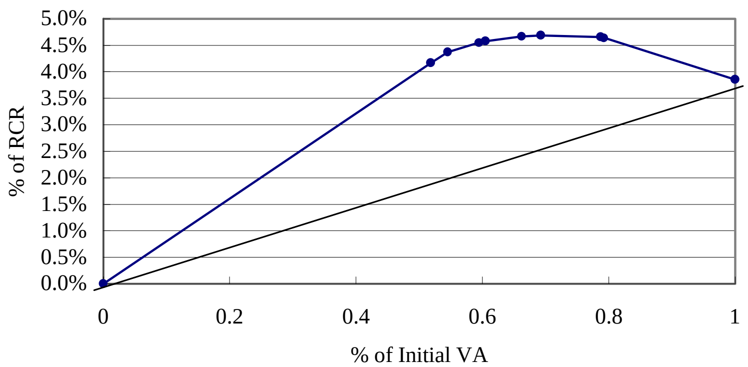
Japanese Economy: 1954-1959



	UTT	**Mining**	**Manu.**	**AFF**	**Services**	**Retail**
% of RCR	0.86%	0.36%	2.51%	0.03%	0.03%	0.00%
Cum-sum	0.86%	1.22%	3.73%	3.76%	**3.79%**	3.79%

Wholesale	**Const.**	**Real Eest.**
-0.02%	-0.01%	-0.06%
3.77%	3.76%	**3.70%**

Japanese Economy: 1960-1969

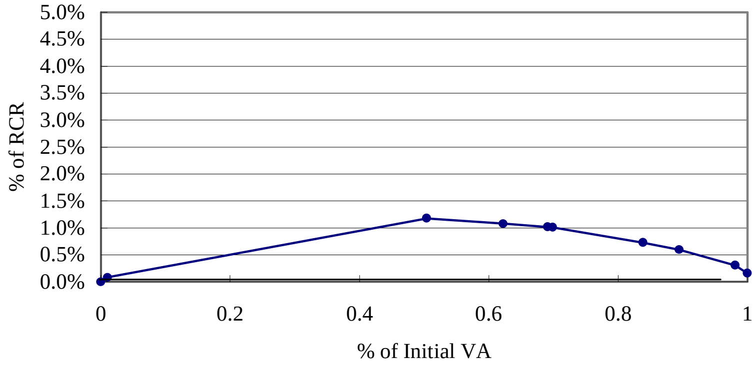


	Manu.	**Mining**	**Const.**	**AFF**	**Retail**	**Services**
% of RCR	4.17%	0.20%	0.18%	0.02%	0.10%	0.02%
Cum-sum	4.17%	4.37%	4.55%	4.57%	4.67%	**4.69%**

Wholesale	**Real Est.**	**UTT**
-0.03%	-0.01%	-0.79%
4.66%	4.64%	**3.85%**

Figure 4. Sunrise-Sunset Diagram for the Japanese Economy, 5 sub-periods.

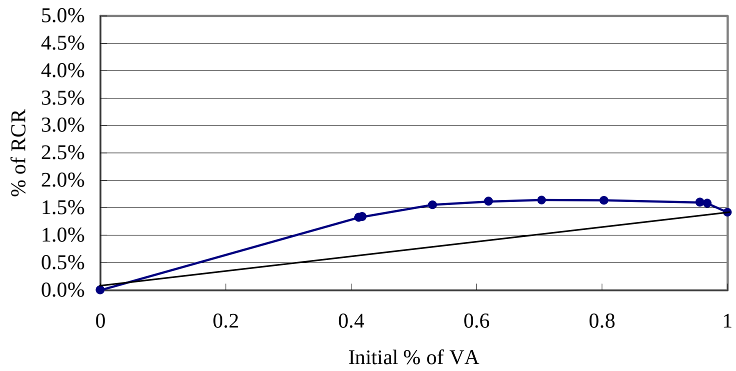
Japanese Economy: 1970-1979



	Mining	Manu.	UTT	Retail	AFF	Wholesale
% of RCR	0.09%	1.09%	-0.09%	-0.06%	-0.01%	-0.29%
Cum-sum	0.09%	**1.17%**	1.08%	1.02%	1.01%	0.72%

Services	Const.	Real Est.
-0.13%	-0.29%	-0.15%
0.60%	0.30%	**0.16%**

Japanese Economy: 1980-1989

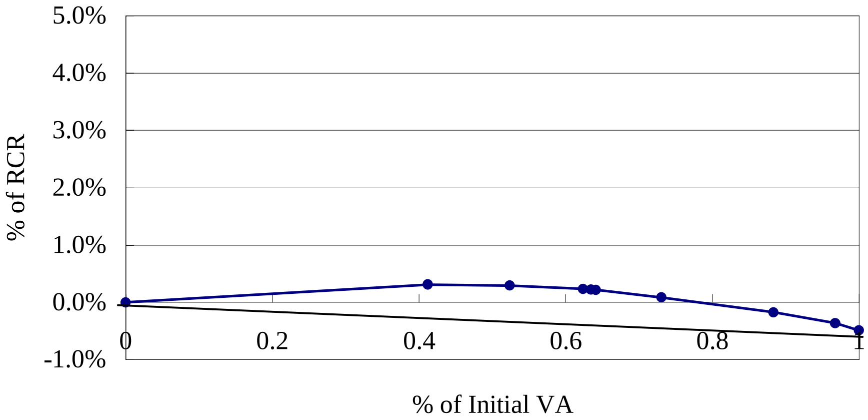


	Manu.	AFF	UTT	Retail	Services	Const.
% of RCR	1.32%	0.01%	0.22%	0.06%	0.03%	-0.01%
Cum-sum	1.32%	1.34%	1.56%	1.61%	**1.64%**	1.64%

Wholesale	Mining	Real Est.
-0.04%	-0.02%	-0.16%
1.60%	1.58%	**1.42%**

Figure 4. Continued.

Japanese Economy: 1990-1998



	Manu.	**UTT**	**Const.**	**Mining**	**AFF**	**Retail**
% of RCR	0.31%	-0.01%	-0.06%	-0.01%	-0.01%	-0.13%
Cum-sum	**0.31%**	0.29%	0.23%	0.22%	0.22%	0.09%

Wholesale	**Services**	**Real Est.**
-0.26%	-0.19%	-0.13%
-0.17%	-0.36%	**-0.49%**

Figure 4. Continue