The capital-intensity reversal in the postwar Japanese economy: Why did Japan grow so fast during 1955-1975?

Takahashi, Harutaka

Department of Economics-Meiji Gakuin University

March 2004

The Capital-intensity Reversal in The Postwar Japanese Economy
-Why Did Japan Grow So Fast During 1955-1975?-

By Harutaka Takahashi, Kohichi Mashiya and Tomoya Sakagami*

Our main result is the following: during the high-speed growth era, from 1955 to 1973, the investment sector was more capital-intensive than the consumption sector. Just after the 1973 oil-shock, around 1975, the consumption sector turned out to be more capital-intensive than the investment sector. Since then, the consumption sector has been capital-intensive through the stable-growth era, from 1975 to 1984, and the Bubble era, from 1985 to 1995. In other words, we observe the appearance of a so-called "capital-intensity reversal" around 1975. Due to the 1973 oil shock, the economic structure of the Japanese economy has totally changed. Thus many researchers believe that this external shock brought the Japanese high-speed growth era to an end. On the contrary, as our empirical study has shown here, the capital-intensity reversal of the Japanese economy could have endogenously occurred as a result of the demand effect accruing from the high economic growth.

(JEL Classification: D24, E22, N10, O41)

Over the last 15 years, there has been an explosion of research interest centered on Endogenous Growth, under the title "New Economic Growth Theory", where the major research agenda is to understand the mechanisms of economic development. These research results have been documented in two famous textbooks, Barro and Sala-i-Martin (1991) and Aghion and Howitt (1989). Based on these theories, many empirical studies have also been conducted and are also documented in Durlauf and Quah (1999). The New Growth Theory has shed light on the mechanism of endogenous

* Takahashi: Department of Economics, Meiji Gakuin University, 1-2-37 Shirokanedai, Minato-ku, Tokyo 108-8636, Japan. The research was supported by a Grant-in-Aid for Scientific Research # 13630020. We also appreciate Professor Kuga for his detailed comments. The paper was presented at the International Conference on Trade, Growth and General Equilibrium held in February, 2004 in Kyoto. We also thank Kazuhiro Yuki at Kyoto University for his valuable comments at the conference.

technical progress as an engine of economic development, which was mostly neglected in the Old Growth Theory studied in the 60s and 70s. Although many empirical studies have been conducted so far, it is not sufficient to say that we understand the mechanism of economic development much better than before. For example, the Japanese economy showed high-speed growth in the 60s and the early 70s. Its average annual GDP growth rate was 9petcent during that time. It is often referred to as "A Miracle in East Asia." It is a good benchmark case to try to apply the endogenous growth theory to the postwar Japanese economy, which attracted many researchers. For example, Denison and Chung (1976) studied the Japanese high growth economy in detail. However, we are not confident yet that the New Growth Theory will give satisfactory explanations for this extraordinary phenomenon which occurred in postwar Japan. We think that those models have a serious drawback. Especially, because most of the endogenous growth models are based on a highly aggregated one-sector growth model, they neglect, from the outset, the inter-industry interactions through economic development.

In this paper, we have based discussions on the old growth theory, especially a two-sector growth model originally investigated by Uzawa (1965) and will try to measure the capital intensities of consumption and investment sectors in the postwar Japanese economy. The capital intensity is the ratio of capital stock to labor input used in each sector. In so doing, we will observe how each sector's capital intensity changed in the postwar Japanese economy. We will especially focus on the interactions of the capital intensities of both sectors. It is very surprising that no such a research has been done yet except by Kuga (1967). This fact implies that few people ever tried to perform any empirical research to study whether the old growth theory could explain properly the economic development based on the empirical data[1].

Following Kuga (1967), based on the I-O tables, we will aggregate the Japanese economy into two sectors, the consumption and investment sectors. In Japan, the I-O table has been published every 5 years since 1955 to 2000. So we have ten I-O tables for the Japanese economy so far.

---

[1] Some exceptions are Gilchrist and Williams (2001), and Dollar and Wolff (1994).

Our main result is the following: during the high-speed growth era, from 1955 to 1973, the investment sector was more capital-intensive than the consumption sector. Just after the 1973 oil-shock, around 1975, the consumption sector turned out to be more capital-intensive than the investment sector. Since then, the consumption sector has been capital-intensive through the stable-growth era, from 1975 to 1984, and the Bubble era, from 1985 to 1995. In other words, we observe the appearance of a so-called "capital-intensity reversal" around 1975. Due to the 1973 oil-shock, the economic structure of the Japanese economy has totally changed. Thus many researchers believe that this external shock brought the Japanese high-speed growth era to an end. On the contrary, as our empirical study has shown here, the capital-intensity reversal of the Japanese economy had endogenously occurred as a result of the demand effect accruing from the high economic growth. We also measured the two-sector capital intensities in other OECD countries, the U.S., Canada, West Germany and France. We never observed a similar capital-intensity reversal for those countries.

The structure of this paper is the following: In Section 2, we will explain how the Japanese economy can be integrated into two sectors, the consumption and investment sectors. Also, we explain how to measure the capital intensities of both sectors based on the I-O tables. The data needed for our estimation will also be explained. In Section 3, the main empirical results will be presented and discussed. We will also apply the same method as in Section 1 to the other OECD countries, and the results concerning only the US and West Germany will be reported. In Section 4, we will derive some empirical implications based on our observations. Section 5 will be assigned to the remarks and conclusions.

I. Method and data

We will apply the method adopted by Kuga (1967), which was originally invented by Leontief (1954), where he reported the famous "Leontief Paradox." Since then, the Japanese I-O tables have been well developed. No such research, however, has been conducted again after Kuga (1967).

Suppose that the equilibrium conditions based on the n-sector I-O table measured by

producers' prices are given as follows:

$$(\mathbf{I}-\mathbf{A})Y=\mathbf{C}+\mathbf{F}$$

where

$\mathbf{I}$: *unit matrix*,

$\mathbf{A}$: *input – output matrix*,

Y : *output vector*,

$\mathbf{C}$: *private final consumption vector*,

$\mathbf{F}$: *private investment vector*.

Based on this relation, we may define the outputs of the consumption and investment sectors as follows:

$$Y_I=(1,\cdots,1)(\mathbf{I}-\mathbf{A})^{-1}\mathbf{F}$$

$$Y_c=(1,\cdots,1)(\mathbf{I}-\mathbf{A})^{-1}\mathbf{C}$$

, where $Y_i\ (i=I,C)$ is the aggregated output of each sector.

Furthermore, each sector's capital coefficient vector could be defined as follows:

$$\kappa=(K_1/Y_1,\cdots,K_n/Y_n)$$

$$\tau=(\ell_1/Y_1,\cdots,\ell_n/Y_n)$$

where K_i is the *i-th* industry's capital stock and ℓ_i is the *i-th* industry's labor input.

Combining both relations yields:

$$\mathbf{K}_c=\kappa(\mathbf{I}-\mathbf{A})^{-1}\mathbf{C},$$

$$\mathbf{L}_c=\tau(\mathbf{I}-\mathbf{A})^{-1}\mathbf{C}$$

, and for the investment sector

$$\mathbf{K}_I=\kappa(\mathbf{I}-\mathbf{A})^{-1}\mathbf{F},$$

$$\mathbf{L}_I=\tau(\mathbf{I}-\mathbf{A})^{-1}\mathbf{F}.$$

From the above definitions, each sector's capital stock and labor input are the total capital stocks and the total labor inputs directly and indirectly used to produce the private final consumptions and the private investments. We think that this aggregation method is intuitively justified. Furthermore, capital-output and labor–output ratios of both sectors will be defined as follows:

$$\frac{K_C}{Y_C}, \frac{L_C}{Y_C}, \frac{K_I}{Y_I} \text{ and } \frac{L_I}{Y_I}.$$

Finally, the capital intensity of both sectors will be defined as follows:

$$k_C = \frac{\kappa(\mathbf{I}-\mathbf{A})^{-1}\mathbf{C}}{\tau(\mathbf{I}-\mathbf{A})^{-1}\mathbf{C}}$$

, and

$$k_I = \frac{\kappa(\mathbf{I}-\mathbf{A})^{-1}\mathbf{F}}{\tau(\mathbf{I}-\mathbf{A})^{-1}\mathbf{F}}.$$

If the capital intensity increases without increasing the labor input, we may then call it "capital-deepening." On the other hand, if it increases with an increasing labor input, we will call it "capital widening."

We will apply the method explained above to the ten tables published every five years from 1955 to 2000 by the Statistic Bureau of the Ministry of Public Management, Home Affairs, Posts and Telecommunications. We use the 46-sector tables based on producers' nominal prices[2]. The sectors will then be aggregated into the following 24 sectors[3] to maintain consistency with the sector classification by the kind of economic activity

---

2 The 1960 I-O Table did not separate the public investment from the private investment. So we estimated the 1960 capital intensity for such an aggregated capital stock.

3 1) Agriculture and forestry and fishery, 2) Mining, 3) Food and beverages, 4) Textiles, 5) Pulp, paper and wooden products, 6) Chemicals, 7) Petroleum and coal products, 8) Non-metallic mineral products, 9) Basic metals, 10) Fabricated metal products, 11) Machinery, 12) Electrical machinery, equipment and supplies, 13) Transport equipment, 14) Precision instruments, 15) Other manufactures, 16)Construction, 17) Electricity, gas and water supplies, 18) Wholesale and retail trade, 19) Finance and insurance, 20) Real estate, 21) Transportation and communication, 22) Services, 23) Unclassified, 24) Government services.

(industry) of the Private Capital Stock and the Employed Persons data for the National Accounts.

Note that we could use the 13-sector I-O tables instead of the 46-sector ones, where all the sectors from Sector 3) to Sector 15) will be integrated as the "Manufacturing" sector. However, the 13-sector tables are so "coarse" that the manufacturing sector's capital coefficient is seriously overestimated, and it follows that the capital stocks used in the consumption sector will also be seriously overestimated. To avoid this bias, we need reasonably "fine" I-O tables[4]. We will calculate the capital intensities of consumption and investment sectors with the following steps:

i) Based on the integrated 24-sector I-O tables, calculate the 24 by 24 input-coefficient matrix denoted by matrix $\mathbf{A}$.

ii) Calculate the Leontief matrix $(\mathbf{I}-\mathbf{A})$. Omitting Sectors 23) and 24) from the results and obtain its inverse matrix $(\mathbf{I}-\mathbf{A})^{-1}$, which is a 22 by 22 matrix.

iii) Multiplying the private consumption ($\mathbf{C}$) and the private investment ($\mathbf{F}$) column vectors constructed by eliminating Sectors 23) and 24) of the 24-sector I-O table to $(\mathbf{I}-\mathbf{A})^{-1}$ and calculate the induced vectors $(\mathbf{I}-\mathbf{A})^{-1}\mathbf{C}$ and $(\mathbf{I}-\mathbf{A})^{-1}\mathbf{F}$.

iv) With the Output Deflators of the National Accounts Database, re-evaluate those values at 1985 constant prices.

v) Multiplying the capital and coefficient vectors, which are calculated based on the Japanese national accounts database.

vi) As the total sum of the element of vectors calculated in Step v), $\mathbf{K_C}, \mathbf{K_I}, \mathbf{L_C}$ *and* $\mathbf{L_I}$ will be obtained.

vii) From the results in Step vi), each sector's capital intensity will be calculated.

The same procedures will be applied to the US and West German data. All the data sets are explained in the Data Appendix.

---

[4] Also note that because the construction sector, which is extremely labor-intensive, is classified into the investment sector, the overestimation of the consumption sector will provide a serious bias for estimating capital intensities.

II. Empirical results

A. Postwar Japan

The detailed calculation results are reported in Appendix A. All the tables and figures are constructed based on this table. It is convenient to divide postwar Japan into the following three periods:

- High-speed Growth Era (1955-1975) : Average GDP growth rate
  = 9 percent per annum
- Stable Growth Era (1975-1985) : Average GDP growth rate
  = 4 percent per annum
- Bubble Era (1985-1995) :Average GDP growth rate
  =1-4 percent per annum
- After (1995-) : Average GDP growth rate
  = 0.1 percent per annum

First of all, let us see how each sector's capital intensity changed in postwar Japan.

-Figure 1-

In Fig.1, C-sector and I-sector means the consumption and the investment sectors, respectively. We may find the following facts from the graph:

Fact 1: *Through the observation period (1955-1995), both sectors' capital intensities grew in an exponential manner. The consumption sector also increased capital-intensity much faster than the investment sector.*

Fact 2: *During the High-speed Growth Era, the investment-sector was more capital-intensive than the consumption sector. After the 1973 oil-shock, through the Stable Growth and Bubble Era, the consumption-sector turned out to be more capital-intensive than the investment sector.*

The last finding of Fact 2 is very important, because it implies that in postwar Japan, just after the 1973 oil-shock, the "capital-intensity-reversal" occurred. To confirm this fact, let us define the two-sector capital intensity ratio as follows:

$$the\ two-sector\ capital\ intensity\ ratio = \frac{capital\ intensity\ of\ the\ consumption\ sector}{capital\ intensity\ of\ the\ investment\ sector}.$$

Figure 2 shows the graphs of the two-sector capital intensity ratio and the average annual growth rate of the real GDP.

-Figure 2-

Because the graph of the capital intensity ratio crosses the horizontal-line indicating 1.00 from below in Figure 2, the capital intensity was reversed just after 1975. However, note that, from Fact 1, the capital intensity of the consumption sector grew faster than that of the investment sector. Thus sooner or later, the capital intensity of the investment sector could be overwhelmed by that of the consumption sector without the occurrence of the 1973 oil-shock. To see what actually happened, we need to observe each sector's labor and capital inputs in detail. Fig 3 and Fig.4 below show the graphs for labor and capital inputs, respectively. To observe this in more detail, we also list the average annual change in each input in Appendix B.

-Figure 3 and Figure 4-

Based on the above figures and the tables in Appendix B, from 1970 to 1975, the consumption sector accumulated capital stock at an average annual rate of more than 12 percent but increased labor input by less than 1.3 percent. On the other hand, the investment sector accumulated its stock at an average annual rate of 6 percent but reduced labor input by 2 percent. We may conclude the followings:

Fact 3: *The consumption sector extremely increased the capital intensity to avoid the effects of the 1973 oil-shock compared with the investment sector. Because of this, the 1973 oil-shock actually accelerated the capital-intensity reversal.*

Fact 4: *In the earlier period of the Bubble Era, the investment sector increased capital stock at an average annual rate of 9 percent, which was comparable to that in the High-speed Growth Era. On the other hand, the consumption-sector's expansion was moderate in this period. On the other hand, the consumption sector extremely expanded capital and labor inputs in the latter period of the Bubble Era.*

Finally from Appendix B, we may also read the following fact:

Fact 5: *The consumption sector mainly increases its capital intensities through the*

capital widening processes. On the other hand, the investment sector mainly did so through the capital-deepening processes.

B. Demand and technology effects

The capital intensities will be affected by changes in the demand structure as well as technology changes. For example, if the demand for television sets and electric refrigerators increases, then it will surely affect the capital intensity of the consumption sector. Indeed in the latter half of 1960s, we had observed explosive development of the consumer durable industries, producing automobiles, color television sets, and air conditioners. So we need to distinguish both effects. We will apply the following method to do so: Consider the two consecutive periods (10 years), say 1960, 1965 and 1970. Let us denote the 1965 technology by the 1965 input-output matrix $\mathbf{A}_{65}$ and the final demand vectors of those years as $\mathbf{C}_{60}, \mathbf{C}_{65}, \mathbf{C}_{70}, \mathbf{I}_{60}, \mathbf{I}_{65}$ *and* $\mathbf{I}_{70}$. We can compute the capital intensities $\kappa_C^{65-60}, \kappa_I^{65-60}, \kappa_C^{65-70}$, *and* κ_I^{65-70}, where the superscript "65-60" means that the intensity is calculated using the 1960 final demand vectors based on the 1965 input-output matrix, and so forth. We compute these intensities for any two consecutive periods from 1955 to 2000. Appendix C reports the results. The demand effects can be identified by reading the table in the vertical direction. The horizontal direction shows the technology effects. For both sectors, the technology effects are clearly identified, but the demand effects are hardly observed in both sectors. So we confirm that, in postwar Japan, technical progress played an important role in economic growth as many economists claimed.

On the other hand, the demand effects took important roles in the capital intensity reversal observed around 1975. This is clearly observed in the last table of Appendix C. The intensity ratio raised along the vertical direction from 1995 to 1970. But such a phenomenon cannot be observed after 1975. Thus the driving force of the capital intensity reversal is changes in the demand structure.

C. Comparison with other countries

Let us compare the results concerning the postwar Japanese economy with that of other OECD countries. We use the OECD Input-Output Tables (1995) and the OECD Industrial Structure Statistics (1995) as the data set. Of course, we cannot cover all years. The results for the US and West Germany are summarized in Table 1 and Table 2[5]:

-Table 1 and Table 2-

We may conclude the followings from the above:

Fact 6: *Compared with the Japanese case, the capital intensity ratios of both countries, especially of West Germany, are much greater than that of the Japanese economy.*

Fact 7: *Both countries' capital intensities are very stable and slightly fluctuating. On the other hand, in the Postwar Japanese economy, they grew exponentially until 1995.*

-Table 3-

Table 3 shows a comparison of the capital intensities of those three countries in 1990. For an actual comparison, the Geary-Smith Dollar is used for evaluation.

Fact 8: *In 1990, the Japanese capital intensities of both sectors turned out to be almost equivalent to those of West Germany, but they were less than the half of those of the US.*

Finally, we have to be careful with our results, because all our results crucially depend on the National Accounts Database used here. Especially, the private capital stock data are critical for our estimations[6]. Because of this, we need to compare our empirical results with those derived from a database different from ours to confirm the robustness of the results. Fortunately, we have the Keio Database (KDB), which is constructed based on completely different I-O tables from those used here. Our method was applied to the KDB, and results almost identical to ours were obtained[7]. So we may conclude that our results are robust.

III. Empirical implications

Based on our empirical study, we have documented eight facts from Fact 1 to Fact 8

---

[5] We studied France and Canada other than these two countries.

[6] Some researchers point out that the capital stock data estimated by the Economic and Social Research Institute is overestimated due to its estimation method. So to confirm our results, we need to apply our method to the other database.

[7] Kohji Nomura at Keio University kindly re-estimated the capital intensities with the KDB from 1960 to 1998.

that characterize the postwar Japanese economy. We need to inquire whether or not the standard growth theories can explain these findings. Among others, the theories should explain the following two important questions:

i) The Japanese capital intensities of both sectors grew exponentially. Do they follow transition paths to steady states? Or, will they keep growing in future too?

ii) Why did Japan grow so fast during 1955-1975 and the high-speed growth end after the oil-shock?

To these two important questions, first of all, it seems that the New Growth Theory may give better answers compared with the Old Growth Theory, because the exponential growth of capital intensity in both sectors implies that consecutive technical progress has occurred during the observation period. However, this theory cannot explain the reasons why the high-speed growth ended after the oil-shock, because, although the capital intensities of both sectors grew exponentially even after the 1973 oil-shock, the average GDP growth rate plummeted. This means that only the technical progress induced endogenously or exogenously cannot explain the Japanese economic growth process. Instead of that, we need to introduce the aspect of inter-industry interactions.

The core theory to answer question i) is the "Rybczynski Theorem" which is often used in trade theory[8]. Under an elastic labor supply, if the investment sector is more capital–intensive than the consumption sector and expands, the investment sector's expansion will then be magnified. We observed that "investment called forth more investment"[9] in this era. Let us refer to this phenomenon as the "magnification effect." Actually, during the early period from 1955 to 1965 in the high-speed growth era, the labor supply was very elastic and many young people migrated from rural areas to urban areas as the labor force. Indeed, the Active Job-opening Rate exceeded one in 1967 for the first time, and this situation then lasted until 1973. From Figures 3 and 4, the capital

[8] Under the two-sector optimal growth setting, Benhabib and Nishimura (1985) have demonstrated the followings: when the investment sector is more capital-intensive, then the equilibrium capital stock will then expand (Theorem 2'). On the other hand, when the consumption sector is more capital intensive, the equilibrium capital stock will then converges to a stationary point or a cycle of period two (Theorem 3).

[9] See Chapter 7 of Kosai (1991).

widening process occurred in the Japanese high-growth era. In the latter periods of the high-speed growth era, we may easily speculate that the wage-rental rate soared, and both sectors substituted their inputs from labor to capital. Further, this accelerated the increase in capital intensities of both sectors. Again, Figures 3 and 4 show that the capital deepening process occurred from 1970 to 1985, especially in the investment sector. The consumption sector lowered its labor input growth from 3 percent to 1 percent at an annual average percent-change. The consumption-sector's capital intensity then overwhelmed that of the investment sector around 1975. As I argued before, the changes in demand structure also accelerated this process.

The entire story above reminds us of the famous phase diagram drawn in Uzawa's 1965 two-sector optimal growth model paper, where the initial stocks are given in an unstable region where the investment sector is more capital-intensive than the consumption sector. The optimal path then grows and moves into the stable region where the consumption sector is more capital-intensive because of the soaring wage-rental ratio. At the end, the optimal path will converge to an optimal steady state, where the capital intensities of both sectors are constant.

The last statement is closely related to the question ii). If we follow Uzawa's theory, it clearly means that the postwar Japanese economy follows the transition path and may converge to a steady state. Our finding Fact 7 implies that we are allowed to regard the US and West Germany as being in a near steady state in the 1980s. On the other hand, the capital intensities in Japan still grew exponentially until 1995. However, after the Bubble, the growth rate of the capital intensity of the consumption sector declined. Based on Fact 8, the Japanese capital intensities have already reached the same level as that of West Germany. It is hard to imagine that the Japanese capital intensities will still grow and reach the level of the US, because the potential economic scale of the US is much greater than that of the Japanese economy from the point of economic resources. Thus the level of the Japanese capital intensities is on a scale similar to that of West Germany. Thus, sooner or later, the Japanese capital intensities will hit the ceiling. Some other characteristic fact in the Japanese economy is that the two-sector capital intensity ratio is much lower than those of the US and West Germany. Through the

Bubble Era, it decreased. We could think that this trend made the Japanese economy unstable.

IV. Concluding comments

We have measured the two-sector capital intensities in the Postwar Japanese Economy and found several characteristic facts. One of the striking facts is that a capital-intensity reversal had occurred around 1975, and simultaneously the Japanese high-speed growth era had ended. After 1975 until 1990, the Japanese GDP growth rate had been stable at around 4 percent. It follows that, in the early stage of the post-war Japanese economic development, the investment sector accumulated its capital stock much faster than that of the consumption sector. One-sector models of endogenous growth failed to explain this phenomenon. To provide a satisfactory explanation, we need to introduce inter-industry interactions. One such model is the two-sector optimal growth model studied by Uzawa (1965) which belongs to the Old Growth Theory, and it provides a better explanation for the postwar Japanese economy growth than does the New Growth Theory.

The remaining interesting problem is to measure the two-sector capital intensity ratios for other East Asian countries, say Taiwan, Korea and China. We applied the same method to the postwar Korean economy and found empirical evidence such that, by 1995, the two-sector capital intensity ratio had reached 0.96[10]. This may imply that, sooner or later, we could observe the appearance of a capital-intensity reversal in Korea, too. Unfortunately, we don't have enough data to estimate after 1995. Because the capital stock data of Taiwan and China were not obtained at this time, we gave up estimating the capital intensities of both countries.

Finally, we would like to emphasize again that the inter-industry interactions assume an important role in understanding the economic growth and development as well as technical progress. Therefore, to build economic development models, we need to

[10] Yoshihisa Godo at Meiji Gakuin University kindly provided us the Korean fixed capital data estimated by H. K. Pyo.

introduce several industrial sectors instead of the extremely aggregated one-sector.[11]

References

Aghion, Phillipe and Howitt, Peter *Endogenous Growth Theory,* Boston: MIT Press, 1998.

Barro, Robert J. and Sala-i-Martin, Xavier *Economic Growth*, New York: McGraw-Hill 1995.

Benhabib, Jess and Nishimura, Kazuo "Competitive Equilibrium cycles," J*ournal of Economic Theory 35*,1985, pp. 284-306.

Burmeister, Edwin and Dobell, Rodney A. *Mathematical Theory of Economic Growth*, New York: Macmillan 1972.

Denison, Edward F. and Chung, William K. *How Japan's Economy Grew So Fast: The Sources of Postwar Expansion,* Oxford: Oxford University Press 1976.

Dollar, David and Wolff, Edward N. "Capital Intensity and TFP Convergence by Industry in Manufacturing, 1963-1985," in *Convergence of Productivity* eds. By W. Baumol, R. Nelson, and E. Wolff eds. New York: Oxford University Press, 1994.

Durlauf, Steven N. and Quah Danny T. "The New Empirics of Economic Growth," in *Handbook of Macroeconomics Vol. 1A,* eds. by J. Taylor and M. Woodford, New York: North-Holland, 1999.

Gilchrist, Simon and Williams John C. "Transition Dynamics in Vintage Capital Models:Explaining the Postwar catch-Up of Germany and Japan," *Finance and Economics Discussion paper 2001/07*, Board of Governors of the Federal Reserve System 2001.

Kuga, Kiyoshi "On the Capital Intensity Hypothesis," *Economic Studies Quarterly 18*, 1976, pp.1 51-59.

Kosai, Yutaka *The Era of High-Speed Growth*, Tokyo: Tokyo University Press 1986.

Leontief, Wassily W. "Domestic Production and Foreign Trade: The American

[11] For example, multi-sector growth models were studied in the 1970s, and those results are documented in Burmeister and Dobell (1972).

Capital Position Reexamined," *Economia Internazional Volume 7,* 1954.

Uzawa, Hirofumi "Optimal Growth in a Two-Sector Model of Capital Accumulation," *Review of Economic Studies 31*, 1964, pp.1-24.

DATA APPENDIX

Data for the Japanese Economy

- The Input-Output Tables:

The 46 Sector 1955-1990 I-O Table published by the Research Institute of Economy, Trade and Industry in CD-ROM format. The 1995 and 2000 I-O Tables are downloaded from the following site:

http://www.stat.go.jp/english/data/io/index.htm

- Private Capital Stock Data:

The Gross Capital Stock of Private Enterprises (installation base) Data in *Annual Report on national Accounts* published by the Economic and Social Research Institute.

- Labor Input Data:

The Employed Persons by the Kind of Economic Activity Data in *Annual Report on national Accounts* published by the Economic and Social Research Institute.

- 1985 Deflator:

The Output Deflator by the Kind of Economic Activity Data in *Annual Report on national Accounts* published by the Economic and Social Research Institute.

Data for the OECD Countries

- The Input-Output Tables:

The OECD Input-Output Database published by OECD in1995

- Private Capital Stock, Labor Input and 1985 Deflator Dataset

The Industrial Structure Statistics published by OECD, 1998

APPENDIX A

Consumption Sector

	1955	1960	1965	1970	1975
Capital Input (Billion Yen in1985 price)	19732.92	24823.91	47107.83	91178.69	154270.66
Labor Input (1000 persons)	23551.99	22230.77	26142.67	30683.50	32277.97
Capital Intensity (Million Yen in1985 price)	0.84	1.12	1.80	2.97	4.78
	1980	1985	1990	1995	2000
Capital Input (Billion Yen in1985 price)	220403.23	316086.95	411046.11	701321.94	724951.59
Labor Input (1000 persons)	33701.45	35649.11	32681.32	42026.21	39969.08
Capital Intensity (Million Yen in1985 price)	6.54	8.87	12.58	16.69	18.14

Investment Sector

	1955	1960	1965	1970	1975
Capital Input (Billion Yen in 1985 price)	3610.79	11657.92	17758.82	43865.16	56466.72
Labor Input (1000 persons)	3484.99	9578.82	8797.01	12619.60	11644.58
Capital Intensity (Million Yen in1985 price)	1.04	1.22	2.02	3.48	4.85
	1980	1985	1990	1995	2000
Capital Input (Billion Yen in 1985 price)	69743.63	97331.59	171596.23	231181.20	286398.57
Labor Input (1000 persons)	11186.34	11351.28	15291.91	15532.81	15599.26
Capital Intensity (Million Yen in1985 price)	6.23	8.57	11.22	14.88	18.36

APPENDIX B

Annual Average % Change of Inputs and Intensities

Annual Average %-change

C-sector	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-00
Capital Input	4.70	13.67	14.12	11.09	7.40	7.48	5.39	11.28	0.66
Labor Input	-1.15	3.29	3.25	1.02	0.87	1.13	-1.72	5.16	-1.00
Capita Intensity	5.91	10.04	10.52	9.97	6.47	6.28	7.24	5.82	1.68
Type	D	W	W	W	W	W	D	W	D

Annual Average %-change

I-sector	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-00
Capital Input	26.42	8.78	19.82	5.18	4.31	6.89	12.01	6.14	4.38
Labor Input	22.41	-1.69	7.48	-1.60	-0.80	0.29	6.14	0.31	0.09
Capita Intensity	3.27	10.65	11.48	6.89	5.15	6.58	5.53	5.81	4.29
Type	W	D	W	D	D	D	W	D	D

D: capital deepning process

W: capital widening process

APPENDIX C

Demand and Technology Effects

C-sector

	Technology Effect								
Demand Effect	1955	1960	1965	1970	1975	1980	1985	1990	1995
1955	0.8	1.1							
1960	0.9	1.1	1.7						
1965	0.9	1.1	1.8	2.9					
1970			2.0	3.0	5.1				
1975				2.8	4.8	6.7			
1980					4.6	6.5	8.3		
1985						4.8	8.9	11.9	
1990							9.3	12.6	16.3
1995								12.6	16.7
2000									14.9

I-sector

	Technology Effect								
Demand Effect	1955	1960	1965	1970	1975	1980	1985	1990	1995
1955	1.0	1.3							
1960	1.0	1.2	2.0						
1965	1.0	1.2	2.0	3.4					
1970			2.1	3.5	5.2				
1975				3.2	4.8	7.0			
1980					4.7	6.2	8.3		
1985						6.4	8.6	10.8	
1990							8.9	11.2	14.4
1995								11.5	14.9
2000									14.0

Fig.1 Capital Intensities in Two sectors

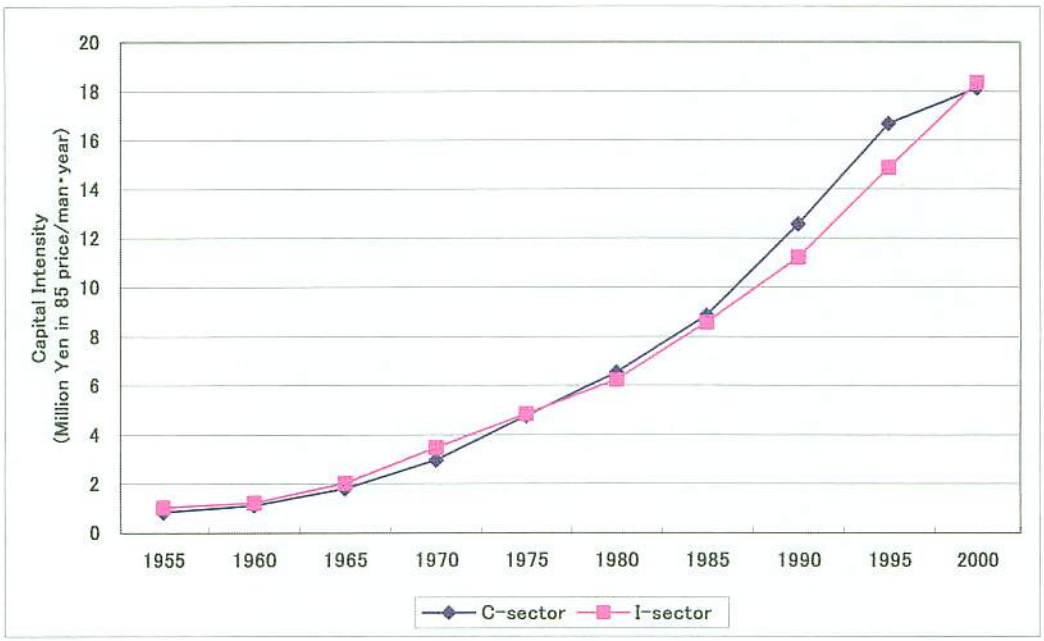

Fig.2: Capital Intensity Ratio in the Postwar Japanese Economy

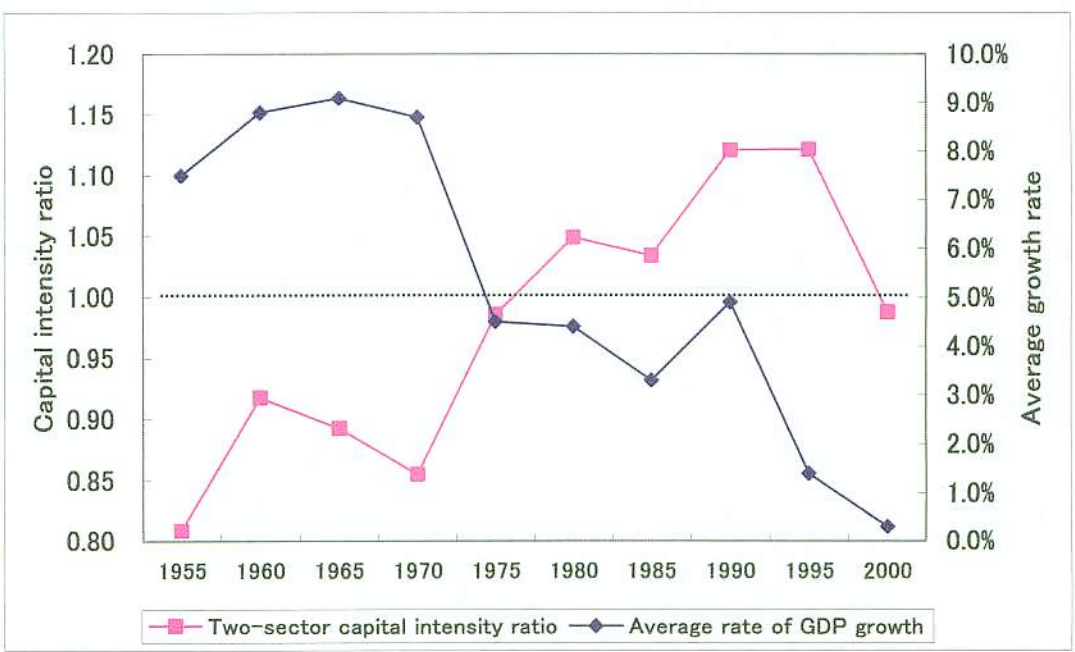

Fig.3: Labor Input

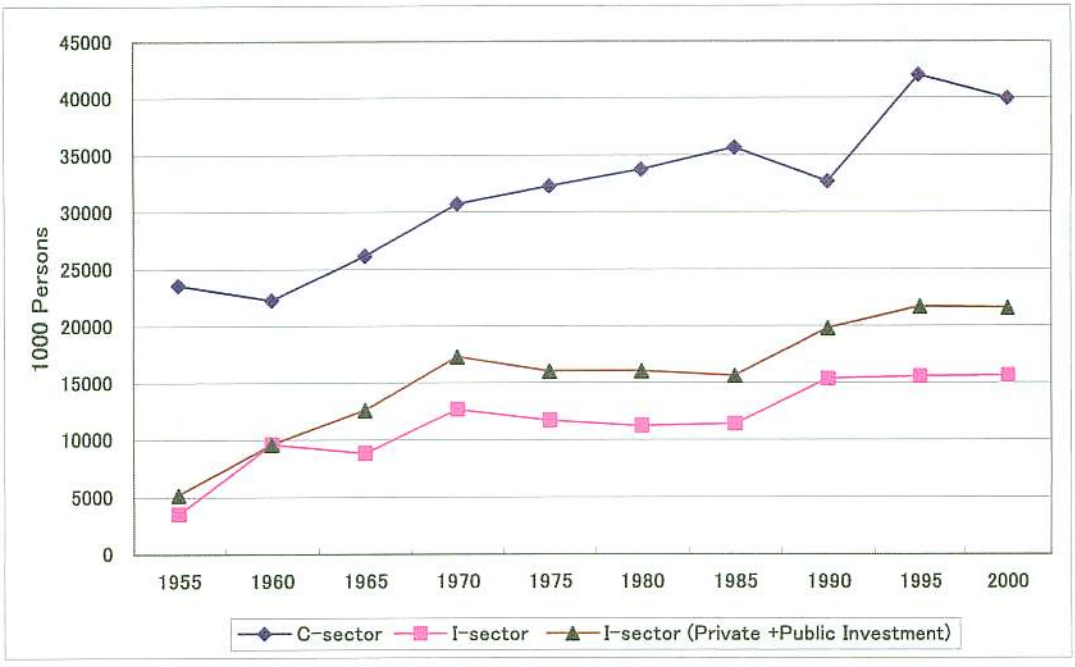

Fig.4: Capital Input

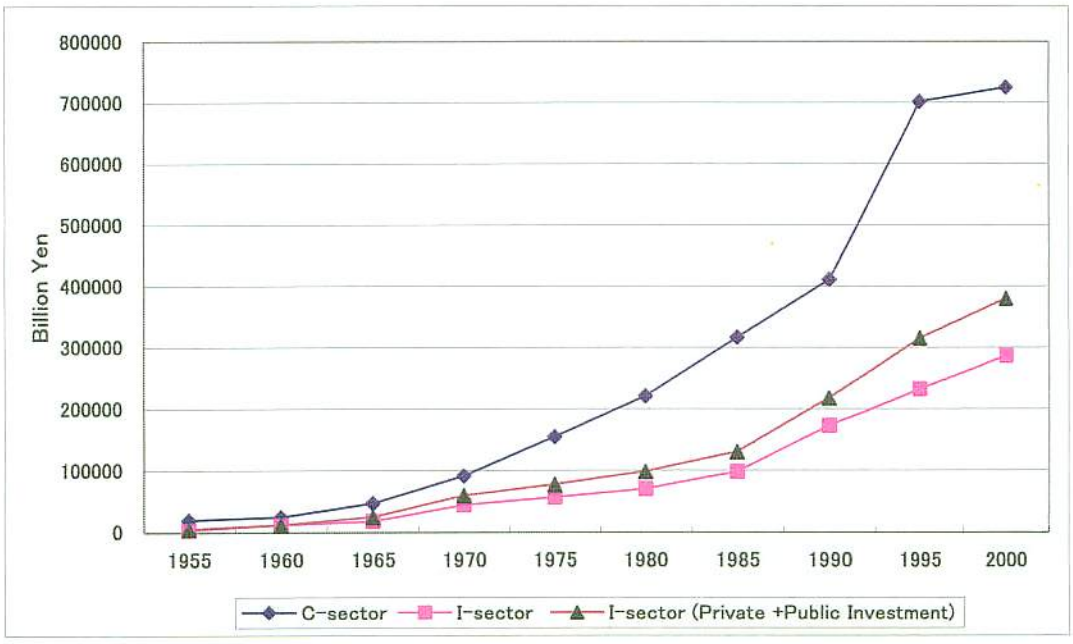

Table 1: Capital Intensities in U.S.

Million $/man・year (1990 prices)					
	1972	1977	1982	1985	1990
C-sector	18	19.3	20.2	22.6	20
I-sector	12.4	14	15.7	16	16.2
Ratio	1.5	1.4	1.3	1.4	1.2

Table 2: Capital Intensities in West Germany (before the economic integration)

MillionDM/man・year (1990 prices)				
	1978	1986	1988	1990
C-sector	14.40	17.85	18.40	18.28
I-sector	8.00	9.81	10.33	10.74
Ratio	1.8	1.8	1.8	1.7

Table 3: Capital Intensities in Three Countries

Million Geary-Smith $/man・year (1990 prices)			
	U S	W. Germany	Japan
C-sector	20	8.92	6.99
I-sector	16.2	5.24	6.23
Ratio	1.2	1.7	1.12