Productivity Growth of Chinese Economy by Industry[+]

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1 Introduction

It is well known that the "Reform and Open Door policy" of China started in 1978 gave extremely large effects on Chinese economy afterwards. It was such an about-face to adopt "Reform and Open" policy against its traditional "self re-construction" strategy that China had maintained since the foundation of communist China in 1949. However, circumstances around the reform policy were not always stable during 1980s because of the political discords in the communist party and such friction led to the tragedy of Tian-an-men Square as a result. After the Tian-an-men incident, though China temporarily fell in confusion that slowed the economy disputing which policy China should stand on socialism or capitalism. Deng Xiaoping, the leader of the reformists, never compromised with the conservative groups and in 1992 launched a campaign called "Southern Tour" in order to explain the concept of "socialism market economy" and persuaded the necessity of the reform policy. Since then, China's reform got along the expected lines and the GDP has been growing rapidly at the average annual rate of 11.0%.

However, the views of researchers are divided in forecasting the future of "socialism market economy" of China. Some of them forecast a rather optimistic scenario of China's economy presuming in a naïve way that the recent trend of China's economy will last. The World Bank's forecast represents such optimism. World Bank(1993,1997) highly evaluated the success of China's reform policy and expected its growth would last for a while. On the other hand, others say on China's economic performance that the economic growth would slowdown sooner or later. A typical example of the pessimistic views is Krugman's "The Myth of the Asia's Miracle". His view is that the increase of China's GDP growth is made by the *increase* of inputs or the *rise* of the education level of laborer as it was so in the Soviet Union, and that these cannot last for a long time.

Seeing in the light of the past experiences of Japan, the industrial structure has been upgraded mainly through the introduction of foreign technology from Western countries since the modern economic development had started in the beginning of 20th century. And it is generally recognized that Japanese economy had almost caught up with the western countries in the early 1970's as for technology, and now has shifted to the period of stable growth after the oil crisis. It is known that the effect of technological progress greatly contributes to the

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expansion of GDP during the high growth period, as to be mentioned later in this essay. If the high growth of China is to follow the same process, it is doubtful whether the high growth had not really been accompanied with improvement of production efficiency so far and will not be so in future as Krugman said.

Being a nation of planned economy, China has kept its economic data comparatively well among the developing countries. However, it is not sufficient enough to meet the international standard; for example, data on industrial base are not easily available. As for the research on the growth of productivity by industry in China, we cannot find except Izumi et al(1999), though there are some research at macro level such as World Bank (1997), Shen (1999), and Ezaki and Sun (1999), etc. Taking the opportunity that China State Statistical Bureau reported the third benchmark input-output table of 1997, we estimate the productivity growth by industry while reviewing the past discussions on the productivity of China in this essay. Then also we reconsider the driving force of the economic growth of China, and make a forecast of Chinese economy accordingly.

First the relation between economic growth and technological progress is discussed in the following section 2; then in the section 3 the concept of "productivity growth" is stated in detail. In section 4 and 5, the experiences of the U.S. and Japan are reviewed respectively, and the discussion of World Bank and that of Krugman is summarized. The productivity growth rate by industry in China is estimated in section 6.

2 Economic Growth and Technological Progress

The history of the theory of economic development is long and can be traced back to the dispute between philosophy of “laissez faire”, where the economic development is assumed to be a natural law, represented by Adam Smith in Britain, and that of the infant industry protection theory by List of Germany in the beginning of the 19th century. After the “Economics” experienced the Marginal Revolution in the latter half of the 19th century, the center of economics moved to the theoretical economics that stresses the adjustment function of markets, while the theory of economic development was losing its power.

However, when the Great Depression after the First World War attacked the world, classical market-oriented model of economics could not find a remedy to escape from the recession. Then Keynes developed a new theory, in which financial policy is important saying that unemployment could be decreased by governmental intervention to create demand for the goods market. Such Keynesian policy has become the prop of the economic policy afterwards.

When the age of colonial system had come to end in middle of the 20th century, economics had been imposed a new problem of economic development of the developing countries (former colonies) and the theory of economic development came to attract economists’ attention again. In the growth theory of Cambridge school (Harrod & Dormer theory) which follows the Keynesian, the balance between the natural rate of growth (equals

the rate of working population increase + the rate of technological progress) and the warranted rate of growth (full capacity growth rate of capital, savings rate/capital coefficient) is needed. Economy is to grow faster if technological progress rate and the savings rate are high: The natural rate of growth does not necessarily correspond to the warranted rate of growth, and it is recognized that economic growth is originally unstable. As such is the standpoint, the macro-control by government is approved in the Harrod & Dormer theory.

On the other hand, neo-classical school that follows the classical theory also completed the dynamic growth theory (Tobin & Solow theory, neo-classical theory). The neo-classical theory considered that the combination of capital, labor, and output changes according to the relative price and is not fixed as Cambridge school presumes. In a word, though the demand for capital goods increases in the state of capital scarcity, since in the course of capital accumulation the marginal productivity of capital decreases while the capital price increase, the increase of the demand for capital is to stop before long, relatively low-priced labor will be substituted. And, the state of labor shortage is opposite to that. Consequently the neo-classical growth theory concludes that the relative price changes in the market so that the natural rate of growth and warranted rate of growth may balance, and the balanced growth will be realize in the long run.

Though views differ on the point economic growth being stable or not, both schools put importance to the improvement of productive efficiency, that is, technological progress in the economic growth. Moreover they also seem to share the common recognition that importing an advanced technology through introducing the foreign capital or other means can promote the economic development of developing countries[1]. Then, the factor of growth had become a controversial issue where arguments included to which extent the contribution of labor, capital equipment and technological progress, which were the factors to bring economic growth, explained the economic growth respectively, and how the technological progress rate was presumed.

3 Definition of Productivity Growth Rate

Though there is common recognition that growth of productivity is important for economic growth as described in the foregoing section, it is not same for the definition and the measurement method. Some of the definition and method of measurement for productivity growth rate are shown here.

First of all, let's begin with a method called “residual method”. This method obtains at first the aggregated input of production factors whose weights are the corresponding production elasticities, and then measures the growth of productivity as a difference of the growth rate of the output and the aggregated input.

The research of Solow (1962) and Denison (1967) were conducted by this method. The production function used in the rest error method is presumed here as follows:

(1) $Y = A \cdot F(x_1, \cdots, x_n)$,

Where, the amount of the output is stated as Y, the amount of i[th] input as $X_i, (i = 1, \cdots, n)$, and the parameter of efficiency as A. The production function shown by Equation (1) differentiated by time can be shown in the form of the rate of change as follows:

(2) $$\frac{dY/dt}{Y} = \frac{dA/dt}{A} + \sum_i \left(\frac{\partial F / \partial X_i}{F / X_i} \cdot \frac{dX_i / dt}{X_i} \right).$$

In Equation (2), it is shown that the rate-of-change of output (left side) equals to the sum of rate-of-change of efficiency (right side the first term) and the weighted average of the rate-of-change of the each input whose weight is its production elasticity (right side the second term). Supposing that the rate-of-change to be stated as a variable with dot (.) and that production elasticity to be as $\alpha_i, (i = 1, \cdots, n)$, equation (2) can also be written as follows. In the following equation, productivity growth rate is expressed by $\dot{A}$.

(2') $\dot{Y} = \dot{A} + \sum_i \alpha_i \cdot \dot{X}_i$ or, $\dot{A} = \dot{Y} - \sum_i \alpha_i \cdot \dot{X}_i$

As for using this expression, the problem we should solve is how to estimate the value of the production elasticity. Take Cobb=Douglas production function as an example.

(3) $Y = A \prod_i X^{a_i}$, where $\sum_i a_i = 1$

There are two ways to estimate the function. If Equation (3) is expressed in a linear logarithm form, it is clear that the exponent on each input is its production elasticity in this form of the function. Then the first way to estimate the production elasticity of input is to estimate statistically the coefficient parameters of the production function by directly using time series data, and then to assume the estimated value obtained to be production elasticity. The second way is an application of the marginal theory[2]. Supposing that the quantity of input is determined by the marginal theory, marginal productivity of an input equals to its real reward as is shown in the following condition. The price of output is expressed by p, the price of i[th] input by $q_i (i = 1, \cdots, n)$.

(4) $$\frac{\partial Y}{\partial X_i} = \alpha_i \frac{Y}{X_i} = \frac{q_i}{p}$$

This condition can be rewritten in the condition that the exponent α_i of i[th] input in the production function is equal to the nominal share of the corresponding input.

$$(4') \quad \alpha_i = \frac{q_i X_i}{pY}, (i = 1, \cdots, n)$$

Since the nominal share of each input can be calculated from ordinary national income statistics, it can be of use to estimate the parameter.

As we mentioned in the foregoing explanation of the residual method, it is necessary to note that the residual method requires a production function in some. On the other hand, there is a method where a specific production function is not assumed. In that method, such two indices as the output index and the aggregated input index are calculated, and then the difference between them is defined as the productivity index.

The researches of Kendrick (1961), Abramovits (1962), and Solow (1957) have taken such approach of index theory. This method has benefit that it requires the indices of output and aggregated input only. And such a concept might be called "Total Factor Productivity Change" or TFP change, meaning that it shows the change in overall productive efficiency and not that of the productivity of the specific input, i.e. "labor productivity" or "capital equipment productivity". If the aggregate function of inputs is regarded as a production function, it can be seen as same as the residual method and not necessarily needs to be treated separately, and a variety of estimate methods are proposed from the standpoint of the index theory in a series of discussions.

Recently the following quadratic logarithm function ie., trans-log form is often used as an aggregation function in estimating TFP growth

$$(5) \quad \begin{aligned} \ln Y &= quadratic\ F(\ln X_i, \ln L, \ln K) \quad (i = 1, \cdots, n) \\ &= quadratic\ F(\ln X_i) \quad (i = 1, \cdots, n, n+1, n+2) \\ &= a_0 + a_1 \sum \ln X_i + a_2 \sum \ln X_i \times lnX_j \quad (i, j = 1, \cdots, n, n+1, n+2) \end{aligned},$$

where n+1 th and n+2 th inputs are respectively labor and capital. Since the trans-log production function is a quadratic function, we can use the quadratic lemma and the growth of output from the period 0 to 1 can be defined as follows.

$$(6) \quad \begin{aligned} \ln Y_1 - \ln Y_0 &= \frac{1}{2} \sum_i \left(\frac{\partial \ln Y_1}{\partial \ln X_{1i}} + \frac{\partial \ln Y_0}{\partial \ln X_{0i}} \right) (\ln X_{1i} - \ln X_{0i}) \\ &= \frac{1}{2} \sum_i \left(\frac{X_{1i}}{Y_1} \frac{\partial Y_1}{\partial X_{1i}} + \frac{X_{0i}}{Y_0} \frac{\partial Y_0}{\partial X_{0i}} \right) (\ln X_{1i} - \ln X_{0i}) \end{aligned}$$

If we can apply the marginal theory, real wage of each input is same as its marginal production, to China though china's economic system is not necessarily based on profit maximization, equation (6) is to be as follows:

$$(7)\quad \ln Y_1 - \ln Y_0 = \frac{1}{2}\sum_i \left(\frac{X_{1i}}{Y_1}\frac{q_{1i}}{p_1} + \frac{X_{0i}}{Y_0}\frac{q_{0i}}{p_0} \right)(\ln X_{1i} - \ln X_{0i}) \quad \text{or,}$$

$$= \frac{1}{2}\sum_i (w_{1i} + w_{0i})(\ln X_{1i} - \ln X_{0i})$$

$$(7')\quad \ln\left(\frac{Y_1}{Y_0}\right) = \frac{1}{2}\sum_i (w_{1i} + w_{0i}) \ln\left(\frac{X_{1i}}{X_{0i}}\right),$$

where symbol p and q are respectively an output and input prices, and w is a nominal input share of each input. Since $\ln(1+x) \approx x$, equation (7) can be expressed as follows:

$$(7'')\quad \frac{Y_1 - Y_0}{Y_0} = \frac{1}{2}\sum_i (w_{1i} + w_{0i})\frac{X_{1i} - X_{0i}}{X_{0i}}$$

This equation states that the growth rate of the output is the same as the weighted average of each input with the weight of corresponding nominal input share, as far as the shape of the production function is unchanged. However, the shape of production function usually changes overtime since it is natural that the production efficiency improves more or less overtime. Therefore the equality in Equation (7'') does not hold in the real data. We, therefore, define the difference between the left hand side and the right hand side is that caused by efficiency change. To say nothing of it, if the left hand side was lager, this is because of the efficiency improvement.

$$(8)\quad TFP = \frac{Y_1 - Y_0}{Y_0} - \frac{1}{2}\sum_i (w_{1i} + w_{0i})\frac{X_{1i} - X_{0i}}{X_{0i}}$$

4 Measurement of Productivity Growth Rate: Experiences of the United States and Japan

Though it is necessary to note that there are controversies over method of estimation of TFP and input aggregation of inputs, the comparison of the data obtained by the same method between different periods and between economies will make some standard when trying to capture the importance of the productivity growth. Some of the preceding research on time-series comparison in Japan, and United States-Japan comparison concerning the productivity growth rate are reviewed in this section.

In Japan, we can obtain comparatively long time series data during its industrialization since Japan was a developing country. It is well known that improvement of production efficiency played an important role for the rapid growth during 1955-70. The estimated result of Japan Economic Research Center (1995) is shown on table 1.

Table 1 Growth factor analysis of Japanese economy by Nihon Keizai Kenkyu Center

(Annual Growth Rate (%))

	1885-1940	1955-1970	1970-1990
Growth rate of NNP	3.30	9.5	4.3
Contribution of capital	1.55	3.3	2.4
Contribution of labor	0.39	1.4	0.7
Contribution of technological progress	1.36	4.8	1.2

Source: Nihon Keizai Kenkyu Center (1995)

The capital accumulation accounted for 1.55%, which was about a half of the macro-economical growth rate of 3.30% during the prewar period, and then the contribution of productive efficiency came next holding 1.36%, which also accounted for considerable part though somewhat less in number. In the period of rapid growth during postwar days, the growth of technological progress accounted for 4.8%, which was more than the half of the GDP growth rate of 9.5%, while the effect of growth of productive factor input came up less than half. And during 1970 to 1990 after Japan has technologically to a certain extend caught up to the USA, the technological progress rate had decreased to 1.2% while the growth rate of GDP also had decreased to 4.3%.

Results from Kuroda(1992), the growth factor analysis of Japanese economy during the rapid growth, is shown on table 2. According to Kuroda, the GDP growth rate from 1965 to 1970 was the highest 11.798%; Technological progress contributed to the half, which was 5.482%, and then fixed capital contributed to rather high of 5.237%, somewhat less than technological progress. Though the previous period of 1960-65 was also at a high growth, the primary factor of the growth at this period was an accumulation of capital stock, and the technological progress did not give an important contribution to GDP growth.

Table 2:TFP growth rate of Japan by Kuroda (Annual Average (%))

	60-65	65-70	70-75	75-80	80-85
Growth rate of GDP	9.725	11.798	4.733	3.784	3.896
Contribution of labor	1.397	1.079	-0.075	1.154	0.953
Contribution of the capital	5.349	5.237	3.792	1.925	2.047
Contribution of technological progress	2.979	5.482	1.016	0.704	0.895

Source: Kuroda (1992)

Table 3 Comparative Growth Performances of the USA, UK, and Japan, 1820-1992

		1820-1870	1870-1913	1913-1950	1950-1973	1973-1992	1820-1992
GDP	USA	4.22	3.94	2.84	3.92	2.39	3.61
	UK	2.04	1.90	1.19	3.00	1.59	1.89
	Japan	0.31	2.34	2.24	9.25	3.76	2.77
TFP	USA	-0.15	0.33	1.59	1.72	0.18	0.63
	UK	0.15	0.31	0.81	1.48	0.69	0.57
	Japan	n.a.	-0.31	0.36	5.08	1.04	1.38

Source Maddison (1995)

The results from above-mentioned two studies have interesting findings in common. The first point is that the factor of technological progress was important as a growth factor in the period of high growth, and the second point is that the factor of capital accumulation played an important role during the time before the factor of technological progress rose. These two findings can be read that the preceding period of capital accumulation is needed for a certain duration in order that the technological progress may work as the growth engine.

Actually, we can see the similar phenomenon in Maddison's historical comparative research as the figures in Table 3 showing the result of his study (Maddison(1995)). The lower part of the table shows TFP annual growth rate of each country during the corresponding period. The most interesting is that we can find a negative TFP growth in the USA during 1829 to 1870 and in Japan during 1870 to 1930. And it seems that the TFP the growth in the UK before 1820 would be negative if we follow the UK TFP growth trend backward. This result suggests that the TFP growth in even so-called developed countries was negative or very low at least in the beginning of economic growth.

5 Two Views on the Economic Growth of East Asia

5-1 The East Asian Miracle (World Bank Report)

The World Bank published a report on the analysis of factors for the economic growth of East Asian nations, utilizing its database covering wide range of nations and regions including more than 110 countries. This report involves eight Asian countries (Japan, South Korea, Taiwan, Hong Kong, Malaysia, Singapore, Thailand, and Indonesia). In the report, the World Bank especially notes them as High Performance Asian Economies (HPAE), and the success of HPAE was explained with comparison to the countries of South America and Africa.

The World Bank presented the following five points as factors of HPAE's success:

(1) The high growth of Total Factor Productivity: The growth of productive efficiency was faster than South American and Sub-Saharan nations.

(2) Appropriateness of the public policies: The policy authorities had enough pliability to continue good policies and to abolish bad ones.

(3) The ingenuity of the export support policies: The macro stability policy and the micro incentive policy were well combined.

(4) The expansion of economic system: The redistribution of wealth was done effectively, economic bureaucracy as a professional group was established, and the government-private cooperation system worked well for economic management.
(5) The rapid growth of human capital: Owing to the expansion of income and the decrease in population growth rate, the enhancement of human capital (education) was achieved. The policy emphasizing on education backed it up.

Here let us introduce the empirical analysis on TFP growth done by the World Bank. The World Bank presumes an interesting macro production function whose inputs consist of the capital equipment, the labor force, and human capital (education level, concretely and estimate production elasticity of each input by regression analysis. However, the next problem here is how to estimate the production elasticity of each input. Since the TFP growth is obtained by subtracting an increase in the aggregated input from an increase in the output, the figure of production elasticity, which is used as a weight in the aggregation of input, is critically important to estimate TFP growth. The World Bank estimated two kinds of production elasticity for the calculation in the report, i.e. those sampled from (i)all countries or (ii)high income countries[3]. As is shown in Table 6a, the production elasticity of high-income countries is bigger in the capital input and smaller in the labor input[4].

Table 4b shows the productivity growth rate of each country calculated on the basis of production elasticity shown in Table 4a. When the production elasticity estimated with a sample of all countries, the TFP growth in all Asian HPAE nations was much larger than those in South Africa and Sub-Saharan countries. On the other hand, when the high income nations were used as weight[5], though the TFP growth turned into a big minus in Singapore(to be mentioned later) and TFP growth was rarely found in Indonesia and Malaysia, as for Hong Kong, Japan and Taiwan, the TFP growth marked considerable large figures in a absolute value standard as well as in comparison with South Africa and Sub- Saharan Africa.

Table 4a Estimate of production elasticity by World Bank (1960-90)

Samples	Fixed capital	Labor force	Human capital
All samples (2,093)	0.178	0.669	0.154
High income nations (460)	0.399	0.332	0.269

Table 4b Estimate of TFP Growth by World Bank ((%) 1960-90)

Industry	All samples weight	High income nation weight
Hong Kong	3.6470	2.4113
Indonesia	1.2543	-0.7953
Japan	3.4776	1.4274
South Korea	3.1020	0.2335
Malaysia	1.0755	-1.3369
Singapore	1.1911	-3.0112
Taiwan	3.7604	1.2829
Thailand	2.4960	0.5466
South America	0.1274	-0.9819
Sub Sahara	-0.9978	-3.0140

Source: World Bank (1993);'Human capital' refers to the education standard index.

5-2 The Myth of the Asia's Miracle (Krugman)

While there is such an optimistic view as the World Bank's report, there are reverse ones, the most well-known of which is Krugman's "The Myth of the Asia's Miracle" meaning the Asian growth is no threat.

Krugman's discussion can be summarized as follows: After the World War II, the economic growth of Soviet Union was greater compared with the United States, and it came to be seen that a socialism system could be more efficient than the capitalism system if focused on the aspect of growth. It seemed that the United States feared under the pressure that the Soviet Union might defeat in even economic power as they had preceded in the technological development of satellite and missile. As it went on, however, it has became clear that remarkable economic growth of the Soviet Union was possible for a certain period just because they concentrated on capital accumulation for expansion for the manufacturing sector by mobilizing all the economic resources and labor force including women and planning of consumption and saving. In short, it turned out that the threat of Soviet Union was not a threat in fact but which has already been known as a commonsense in economics. Krugman explained that this strategy would not work for a long term since the supply of labor force is limited and qualitative improvement of the labor (increase in human resources) happened for one time only. "There is not a miracle", he says as conclusion.

According to Krugman, the economic development of Asian nations was basically the same as that of the Soviet Union, which in a word was all resource mobilization type, and the improvement of productivity (improvement of technological standard or the accumulation of knowledge) was not seen so much. Then, as for the secret that the growth of the Asian economy had continued for considerably a long term though it was just a all resource mobilization, Krugman ascribed it to "the mind that can put off satisfaction = the mind to save and invest" as conclusion. As his discussion is based on the research by Young (1992,1994) and by Kim and Lau(1994), let us review them here.

Table 5 Comparison of Hong Kong and Singapore by Young

Hong Kong	GDP growth	Labor share	Capital share	Tech. progress share
1971-76	0.406	27%	36%	36%
1976-81	0.512	30%	40%	30%
1981-86	0.294	19%	55%	26%
1986-90	0.260	8%	38%	54%
Singapore	GDP Growth	Labor share	Capital share	Tech. progress share
1970-75	0.454	24%	122%	-47%
1975-80	0.408	28%	68%	4%
1980-85	0.300	12%	101%	-13%
1985-90	0.383	35%	33%	31%

Source: Young (1992); the GDP growth shows the average annual growth.

First, take a look at the research by Young. Young (1992) covered Hong Kong and Singapore, with the conclusion that the capital accumulation was a primal factor in the economic development of Singapore and the improvement of efficiency was not seen. His conclusion is shown on Table 5. As to the case of Hong Kong, the technological progress accounted for large part in the economic growth and it contributed to economic growth for more than half especially for the period of the year 1986 to 90. On the other hand seen in Singapore, the improvement of productive efficiency was hardly seen before 1985. It is worth taking note that improvement of productive efficiency was seen after 1985, though.

Now let us see the other research by Young: Young(1994) is titled "The Tyranny of Numbers", which means "You can't make objection since the figure itself is the proof". Its results are shown on Table 6. This paper focuses on the so-called Four Tigers of Asia, namely Hong Kong, Singapore, South Korea, and Taiwan, and estimates the average annual TFP growth rate during 1966-90, where the estimation of Elias(1990) as to South American countries and Christensen (1980) as to the advanced countries were quoted for the comparison. Though there is the problem that the paper does not clarify how the referenced results were estimated, Young valued them on the whole saying "the TFP growth of NIEs is not higher than that of South African nations and does not surpass what the advanced countries had experienced, either".

Table 6 Comparison of TFP growths among Asia, advanced countries, and Latin

Developing countries	Period	Annual rate	Advanced countries	Period	Annual rate
Hong Kong	1966-91	2.3%	Canada	1947-73	1.8%
Singapore	1966-90	- 0.3%	France	1950-73	3.0%
South Korea	1966-90	1.6%	West Germany	1950-70	3.7%
Taiwan	1966-90	1.9%	Italy	1952-73	3.4%
Argentina	1940-80	1.0%	Japan	1952-73	4.1%
Brazil	1950-80	2.0%	Netherlands	1951-73	2.5%
Chile	1940-80	1.2%	Britain	1955-73	1.9%
Colombia	1940-80	0.9%	The USA	1947-73	1.4%
Mexico	1940-80	1.7%			

Source: Young (1992) As for the advanced countries quoted from Christensen et al (1980) and as for South America quoted from Elias(1990).

Table 7 Technological progress rate in each country by Kim and Lau

Country	Period	Technological progress
Hong Kong	1966-90	2.4%
Singapore	1964-90	1.9%
South Korea	1960-90	1.2%
Taiwan	1953-90	1.2%
France	1957-90	2.6%
West Germany	1960-90	2.2%
Japan	1957-90	2.9%
Britain	1957-90	1.5%
The USA	1948-90	1.5%

Source: Kim and Lau(1993)

Then the research by Kim and Lau(1994) is shown on Table 7. Their research was a comparative study of TFP growth by estimating the production function of Asian NIEs and the advanced nations. They concluded that Korean and Taiwanese productivity has decreased slightly in a relative ratio to the United States even though they themselves admit the problems in their research that they had presumed the capital stock as a simple summation of gross investment (where depreciation was not correctly measured) and that they had not considered the human capital stock which was said to be accumulated remarkably in Asian NIEs.

Krugman also pointed out regarding the current day Japan that it was impossible for Japan to have caught up with Europe and America without a large-scale investment almost twice the United States in the ratio against GDP. That means not TFP growth but the capital accumulation worked greatly to push up the GDP. Considering the current Japan where there was not much improvement of efficiency, he concludes the Japanese GDP per-capita might hardly exceed that of the United States.

As for China, Krugman also insists as follows without a data to back up his discussion: If the period after 1978 only was used as a sample, since the productivity was surely decreased considerably in the period of Cultural Revolution, the TFP growth would be observed as well as the input increase. if the former year of 1964 was used as a starting point, however, improvement of productivity efficiency would be as much as that of NIEs (i.e. insignificant), Krugman says.

5-3 Why opinions differ?

It is necessary to keep in mind that the results differ depending on the selection of weights used (in other words, estimated value of the production elasticity), as represented in the estimate by World Bank. If we put a light weight on capital equipment or human capital as the "all country weight" in World Bank's estimation, TFP growth in NIEs tends to be

estimated marginal.

And the fact is that one cannot place excessive trust in economic data. To declare "The Tyranny of Numbers" (The figure will not tell a lie) might be problematic. And the other problem lies in a method of estimating the capital stock. We must admit that to measure a capital stock is the most difficult step in empirical studies. For instance, it might be considerably difficult to reflect in the amount of the capital stock accurately that the computers are improving in the performance as the prices are becoming cheaper.

Now, does Krugman's view really differ so much from the World Bank's? It seems to me that the titles of their report, one of which reads "The East Asian Miracles" by the World Bank and the other "The Myth of the Asia's Miracle" by Krugman, attracted our attention and gave us the impression that their contents were opposed. The discussion of Krugman can be summarized as follows: "Though it is said that the growth of Asia is a miracle, however, the truth is that it is just as same as what the advanced countries have experienced (in the sense that they will follow the same process, i.e. take off period - high growth period - stable growth period), and that it is not necessary to be afraid that Asia will conquer the world". As we saw in Table 3 TFP growth in 1800's in the United States was negative and the main source of economic growth of those days was increase of inputs. Japan in Meiji and Taisho era seems to be in the similar situation while such situation is considerably common in the early stage of economic development.

On the other hand, the report of the World Bank seems to be made with the intention "to find a reason why some of the East Asian nations are in the period of high growth and that it lasts so long". Needless to say, it is also shown in their report that the capital accumulation with the high savings rate is important as to the high growth of East Asian nations. However, the interpretations concerning the productivity growth differ. The productivity growth rate in the East Asian nations is estimated based on a certain level higher than standard leaving aside Singapore[6]. It seems that the difference is just that World Bank gave positive evaluation, and Krugman referred to it as just same as the experience of advanced countries.

6 The Productivity Growth in China

6-1 Preceding Studies

Productivity growth in China at macro base was estimated by Ezaki (1999), the World Bank (1997) and Shen(1999).

First of all, let's take the estimated result of the World Bank shown on Table 10. In the World Bank's research, three factors, which are capital equipment, labor, and human capital stock are used as the inputs as we have already mentioned before. As for the factor of economic growth, the share of the effect of an increase of the inputs and of technological progress is about at a ratio of 7:3 as shown in the right side on Table 8, and the result had not significant difference compared with Japan, the U.S.A and South Korea.

Table 8 Comparison of TFP growths among China, US and South Korea

Country	Period	Average annual growth rate (%)				Factor share (%)	
		GDP	Capital equipment	Human capital	Labor force	Input	Tech. change
China	1978-95	9.4	8.8	1.6	2.4	71	29
The USA	1950-92	3.2	3.2	1.1	1.6	65	35
Japan	1960-93	5.5	8.7	0.3	1.0	70	30
South Korea	1960-93	8.6	12.5	3.5	2.4	79	21

Source: World Bank (1997)

Table 9: Estimate of TFP rate of increase in China by Shen

	Growth rate of GDP	Labor share	Capital share	Technological progress share
1953-78	6.1%	23.7%	73.8%	2.5%
1979-90	9.0%	19.4%	44.4%	37.2%
1991-97	11.2%	10.3%	46.4%	43.3%

Source: Shen (1999)

And next, in the study of Shen, he first estimates some types of production functions explained by capital and labor and the productivity growth and assumes that the production elasticity of both capital and labor were about 0.5 each. Shen evaluates this result as China's production elasticity is large in capital equipment and small in labor compared with estimate of advanced countries. This relates that the marginal productivity of capital in China is large since the level of the capital accumulation is still small in China. As we see in Table9, according to his study, the contribution of technological progress to the China's economic growth has become larger every year, and has exceeded 40% is in 1990's, while the contribution of increase in labor force and capital equipment has decreased on the contrary.

The research result by Ezaki is shown on Table 10. In his research, Ezaki adopted his original method to estimate capital stock data[7] since it is impossible to get official data regarding the capital equipment stock. Though there might be an estimate error, the result turned out roughly as same as that of Chin.

Table 10: Estimate of TFP Growth in China by Ezaki and Sun

	GDP Growth	Labor share	Capital share	Technological progress share
1981-8	10.8%	16%	44%	40%
1986-9	7.9%	17%	72%	11%
1991-9	12.0%	8%	41%	50%

Source: Ezaki abs Sun(1999)

Table 11 Growth Rate of Non-agricultural Sector, 1978-98

	Official Statistics	Adjusted
Output per worker	6.1	3.6
Output per effective worker	5.0	2.6
Output per unit of capital	1.4	0.4
Total factor productivity	3.0	1.4

These results evaluate a role of technological progress in the economic growth of China positively, suggesting that China is promoting the improvement of productive efficiency by using technological import from foreign countries as a lever just as Japan used did. However, these estimates were done at macro level (GDP level), and the other effects that were not directly related to the productivity improvement of each enterprise, such as changes in industrial structure, were included. In the next section, we will look into the issue which industry has mainly brought such a result, and reinforce the above-mentioned hypothesis.

However, there is a research assuming that there exists doubt in the credibility of official statistics of China. Young (2000) readjusts production statistics as for the amount of production, deflator, and labor force and a capital stock, etc on his standpoint. He says that TFP growth of manufacturing sector decreases from 3.0% to 1.4% as shown in Table 11 as a result. Young concludes TFP growth of 1.4% is a considerably large figure but not that surprisingly so. Though there is such skeptical view to official statistics that there is a possibility that TFP would be estimated with a upper bias, we decided to use official statistics in our research. The reason is that since the aim of this research is the comparison of the TFP growths between two periods, those of 1987-92 and 1992-97, we think it is fairly meaningful to compare TFPs on the basis of official statistics, even if they would have bias included similarly in the both periods.

6-2 Estimation by Authors

In this section, using three input-output tables of 1987, 1992 and 1997[8], we report the estimation results of China's productivity[9] by industry in 19 industrial classification; that is, agriculture, mining, manufacturing(12 industries), construction, electricity, gas & water, transportation & communication, trading & catering, and service industries. As already mentioned in the foregoing section, there are various methods to estimate TFP. The productivity growth in this essay assumes trans-log productivity function as shown in the equation (8), and TFP is defined as the difference between "the growth rate of the amount of production and that of the aggregated amount of input. Divisia index is used for the aggregation of the amount of input in this definition.

Table 12a TFP growth by Industry in China (1987-92 average)

	Growth rate of output	Growth rate of inputs			TFP growth
		Int. inputs	Labor	Capital	
1 Agriculture	6.84	3.01	1.18	0.13	3.10
2 Mining	8.53	11.90	0.45	1.89	-8.81
3 Food	8.36	7.80	0.47	0.86	-0.60
4 Textile	8.40	9.42	0.91	0.63	-3.19
5 Wooden Prod.	10.16	7.44	0.79	0.47	2.41
6 Paper Prod.	10.60	10.57	1.30	0.93	-2.34
7 Coal & Oil Prod.	6.03	9.75	0.63	1.19	-8.13
8 Chemicals	11.73	10.79	0.99	0.97	-0.57
9 Mineral Prod.	14.00	13.06	1.07	1.17	-0.73
10 Metals	7.84	10.24	0.84	0.76	-5.61
11 Machinery	12.15	10.22	1.04	0.41	1.44
12 Trans. Equipment	20.28	17.64	0.91	0.73	3.37
13 Elec. Appliances	11.37	9.30	0.95	0.61	1.43
14 Other Manu	22.51	20.04	1.11	1.16	2.87
15 Construction	5.97	3.04	2.24	0.25	0.88
16 Elec, Gas &Wa	15.39	11.92	0.26	6.04	-1.32
17 Transportation	6.06	9.83	0.71	2.77	-10.92
18 Trade	22.88	19.80	3.94	1.21	1.15
19 Services	11.91	11.36	2.29	2.69	-4.82
Total	10.35	9.07	1.13	1.00	-0.34

Other Manu = Other Manufacturing
Elec, Gas &Wa = Electricity, Gas and Water

Table 12b TFP growth by Industry in China (1992-97 average)

	Growth rate of output	Growth rate of inputs			TFP growth
		Int. inputs	Labor	Capital	
1 Agriculture	7.49	5.62	-0.56	0.28	2.55
2 Mining	5.80	7.58	-0.16	1.31	-3.76
3 Food	13.61	11.58	0.12	0.94	2.08
4 Textile	13.50	9.08	-0.22	1.02	5.35
5 Wooden Prod.	15.54	9.49	-0.02	0.03	8.23
6 Paper Prod.	6.36	5.87	0.18	0.30	0.14
7 Coal & Oil Prod.	6.47	10.37	-0.02	0.20	-6.32
8 Chemicals	15.00	12.25	0.18	0.47	3.64
9 Mineral Prod.	11.74	9.28	0.27	0.67	2.59
10 Metals	12.59	12.05	0.06	0.49	0.29
11 Machinery	9.35	4.71	-0.44	0.21	5.64
12 Trans. Equipment	22.10	18.86	0.59	0.65	5.03
13 Elec. Appliances	22.74	19.57	0.21	0.87	5.17
14 Other Manu	19.99	9.50	0.60	0.42	13.23
15 Construction	10.54	12.68	0.94	0.13	-4.86
16 Elec, Gas &Wa	4.28	10.36	-0.03	1.52	-12.29
17 Transportation	14.81	5.20	1.08	2.45	8.77
18 Trade	5.22	3.68	1.98	0.84	-1.10
19 Services	11.31	8.22	2.35	1.36	0.61
Total	11.68	9.37	0.27	0.72	2.33

Table 12a shows the estimation results for the period of 1987-1992. The figures in the table show the average annual growth rate[10].

Summary from the estimation results is as follows:

(1)The growth rate of the amount of production at the average of all industries racked up annual rate of 11.06%. It is especially high in the industries such as trading & catering, other manufacturing, transportation equipment, electricity, gas & water, and ceramics, stone & clay. It reflects the rapid motorization and construction rush in the coast area that occurred along with the preeminence of the market in the whole economy.

(2)As for the factors that contributed to the growth of the amount of productivity, the growth rate of intermediate input at the average of all industries marks high number of 9.90%, which made the biggest contribution for the growth of the amount of production.

(3)The productivity improvement shows negative at the average of all industries and also there are few industries where positive TFP growth is observed. Moreover, in the industries such as textile or metal, which are supposed to be the strong point of Chinese economy, the growth of TFP is marked big minus figures showing –3.22% and –7.04% respectively. Krugman's view that "expansion of production in Asia depends mostly on the expansion of input" seems to hold true for this period to some degree. As for the industries such as general machinery, electric machinery, transportation machinery, which made active introduction of foreign capital, however, plus TFP growth is observed.

Table 12a shows the estimation results for the period of 1992-1997. As we mentioned in the introduction of this essay, it is this period when the enforcement of reform and open policy speeded up, and the growth rate of GDP at this period marked extremely high rate of 11.0%. The characteristics of the estimation results of TFP growth for this period can be summarized as follows:

(1)The annual average growth rate of the amount of production was 9.96%, still keeping very high growth rate, though it decreased about 1% point compared with the preceding 5 years.

(2)The average growth rate of the intermediate input of all industries was 7.79%: It was also still high, however, it decreased about 2% point compared with the preceding 5 years.

(3)As for the input of labor force, an interesting trend is found. In the industrial classification used in this essay, the growth in the input of labor force was seen in all industries for the period of 1987-1992, however, as for the period of 1992-1997, the input of labor force was decreased in the light industrial sector such as textile or wood products, and also in the oil & coal products industries and machine industries. It can be considered that the decrease of employment in light industrial sector represents the shift toward capital-intensive method of production occurring also in this sector. On the other hand, oil & coal products and machine industry sectors include large-scale state-owned enterprises.

It can be considered that the effect of labor adjustment in such state-owned enterprises is reflected in the decrease in the input of labor force in these sectors.

(4)The growth rate of TFP was larger compared with the preceding period in most of all industries. It is remarkable that the TFP growth was on the rise especially in the industries such as general machinery, electric machinery, transportation machinery and other manufacturing. We can see the picture that the introduction of technology from foreign countries boosts the development of Chinese economy.

7 Conclusion

In this short essay, the significance of the improvement of productivity (in other words, technological progress) in economic growth was confirmed through reviewing the preceding empirical researches. And also we tried to estimate the productivity growth by industry in Chinese economy of recent ten-odd years.

Though it is necessary to take note that there might be errors between the data and realities or difference in estimated figures by methodology in empirical researches, we think the following are confirmed:

(1) In the estimation of the TFP growth, the results differ depending on which estimation method was taken; it also matters how the estimation results is valued. Moreover, TFP growth is small in the beginning of development process and then its contribution become big in the high growth period, just as it can be seen in the experiences of many economies. Therefore it would not be so constructive to argue which of the optimistic theory such as World Bank's or the pessimistic one such as Krugman's is realistic.

(2)In fact, when we examine some studies concerning the productivity improvement of China by macro base, its contribution of productivity growth to the economic growth can stand comparison with the advanced countries and is showing a tendency to grow in recent years. The growth rate of TFP is high compared with the advanced countries at present.

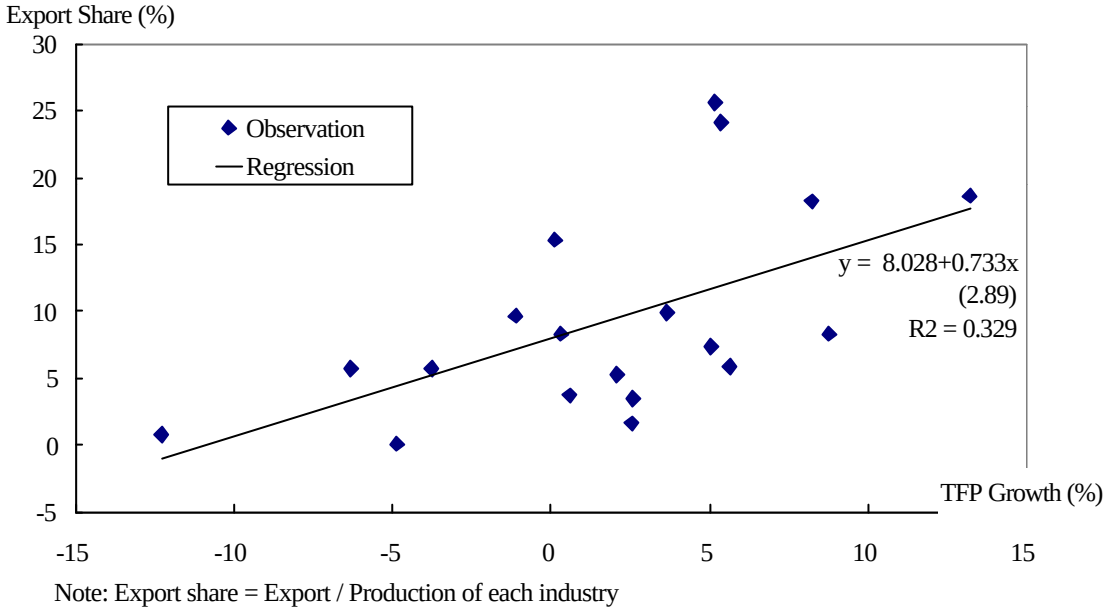
(3)The growth of amount of production by industry and the improvement of the production efficiency was estimated for two periods, 1987-1992 and 1992-1997 in this essay. The growth rate of amount of production was very high for the both periods, which marked about 10%. As for the growth rate of productivity, however, difference was remarkable between two periods. There was not so much improvement of productivity in the period of 1987-1992; therefore Krugman's "Myth of Asia's miracle" would not always be off the point for China in this sense.

(4)However, the situation is quite different in the period of 1992-1997. Remarkable growth is found in the industries such as transportation machinery or electric machinery, where foreign capitals were introduced positively. Though there are some exceptions such as oil & coal products or electricity industries, where there are many state-owned enterprises, it is seen as a common trend in each industry that the effect of TFP improvement as the

contributing factor for the growth of the amount of production is expanded compared with the period of 1987-1992.

Figure 1 and table 13 show the relation between the share of the export value in the production value by industry and TFP(1992-1997), using Chinese input-output table of 1997[11].

Figure1 Export share and TFP growth



Note: Export share = Export / Production of each industry

Table 13 Relation between TFP growth (1992-97) and Export share in 1997

	TFP	Export Share
1 Agriculture	2.55	1.65
2 Mining	-3.76	5.71
3 Food	2.08	5.32
4 Textile	5.35	24.09
5 Wooden Prod.	8.23	18.24
6 Paper Prod.	0.14	15.37
7 Coal & Oil Prod.	-6.32	5.74
8 Chemicals	3.64	9.95
9 Mineral Prod.	2.59	3.52
10 Metals	0.29	8.32
11 Machinery	5.64	5.87
12 Trans. Equipment	5.03	7.36
13 Elec. Appliances	5.17	25.63
14 Other Manu	13.23	18.65
15 Construction	-4.86	0.14
16 Elec, Gas &Wa	-12.29	0.86
17 Transportation	8.77	8.33
18 Trade	-1.10	9.69
19 Services	0.61	3.73

We can see from these figure and table that the industries with large ratio of export to the real productive value such as electric machinery, textile products & leather, other manufacturing and wood products, have also high TFP growth rate. It is also shown that the industries such as chemical products, transportation, transportation machinery and general machinery have also this relation of high export share and high TFP. On the other hand, as for the industries with small shares of export value such as construction, electricity, gas & water, oil & coal products and mining, low growth of TFP is seen.

Thus when we take the relation between the share of export value and TFP growth rate, it can be said that the industries with large share of export value have high growth of TFP, in other words, high improvement of productive efficiency.

Next take a look at the relation between foreign capital companies in Chinese economy and TFP. Figure 2 shows the ratio of foreign-funded enterprises(FFE) to Chinese companies at the point of 1999, as to the gross-production, value added and capital value[12]. It can be found from the figure that industries where FFE have large shares are electric machinery, other manufacturing, textile products & leather, wood products and textile products. As for the production value in particular, the share of FFE accounts for more than 50% in electric machinery and other manufacturing.

Figure 2 Share of FFEs in Manufacturing

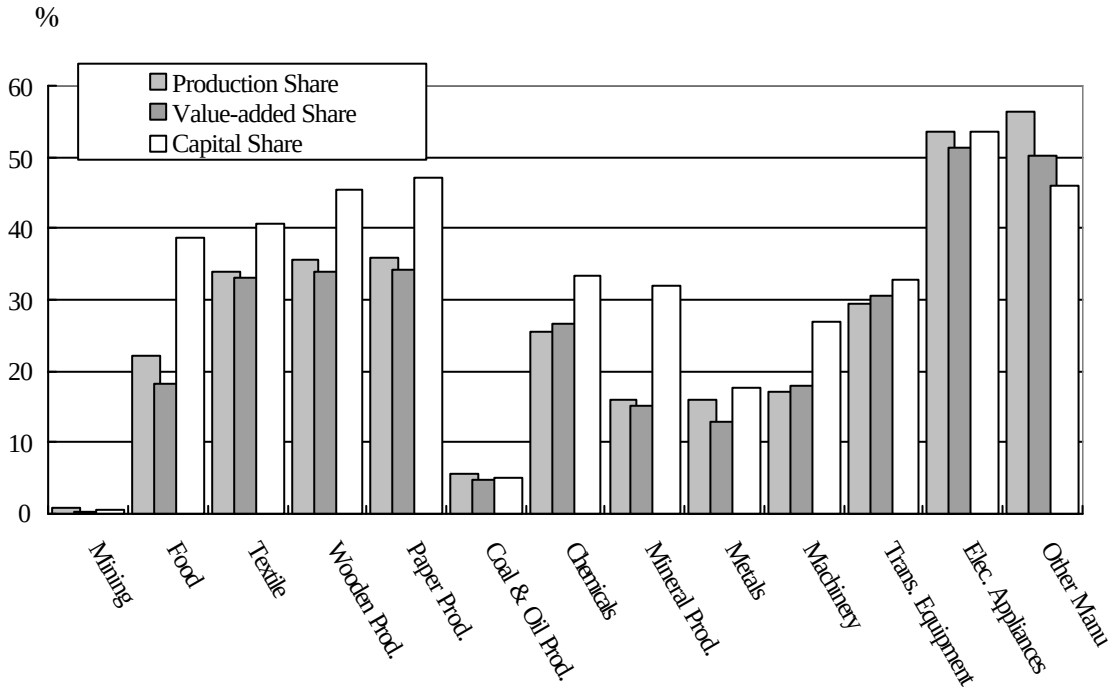
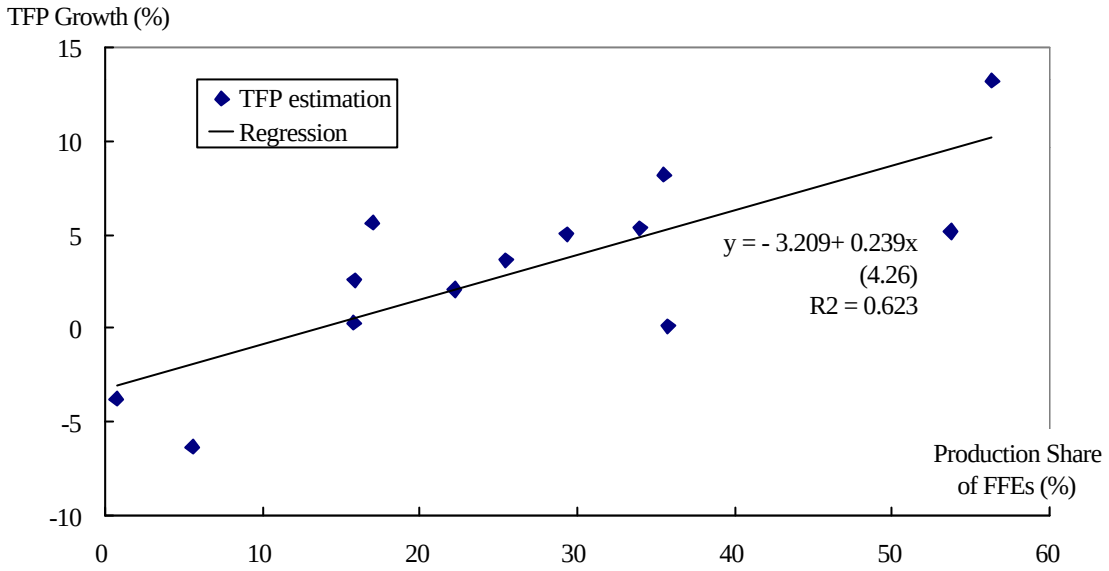


Figure3　Production Share of FFEs and TFP Growth



Here we examine the relation between the production share of FFE (the ratio of FFE to the production value of Chinese companies) shown in figure 2 and the growth rate of TFP estimated in this essay. Figure 3 shows the production share of FFE in 1999 in the horizontal axis and the TFP growth rate of 1992-1997 in the vertical axis. According to this, TFP growth rate is high in the industries where FFE have large shares, e.g. electric machinery and other manufacturing. And TFP growth rate is low in the industries where FFE have small shares, e.g. mining and oil & coal products. Consequently it can be said that FFE plays an important role to the improvement of productive efficiency in Chinese industries. Moreover, considering the tendency that the share of export in the production of each industry is to go up in the industries where productivity is highly improved, we can see that the Chinese economy owes much to foreign capital companies for its success today.

The results can be summarized as above as for the growth factors of Chinese economy seen from the supply side,. However, we would like to add that the economic growth is decided not only by the supply capacity but also the connection with the demand side is also important.

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Data Appendix

1. Input Output Tables

State Statistical Bureau(1991), *Input-Output Tables of China 1987*, China Statistical Publishing House.

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————(2000), *Input-Output Tables of China 1997*, China Statistical Publishing House.

As for constant price depreciation of fixed capital by industry, we estimated them by deflating the nominal depreciations in current price tables. We assumed the deflators of depreciation to be the weighted average of deflators by sector with weight of nominal share in the fixed capital formation, or investment, though we know this method is not necessarily suitable to obtain real capital consumptions.

2. Prices and Labor Force

State Statistical Bureau (2001), *China Statistical Yearbook 2000*, China Statistics Press.

As for prices by sector, we used "Factory Price Indices of Industrial Products by Sector" in *China Statistical Yearbook*. As for employed persons by sector, we used "Number of Employed Persons by Sector" in *China Statistical Yearbook*.

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1 The theory of economic development has been restored to modern ideas by Rostow(1960) and others in the cold war period of postwar days. According to Rostow, the economic development will go through the process that can be put as traditional society → take-off period → mature stage → mass consumption age. He regarded the take-off period especially important and assumed that it required as necessary condition that the rapid expansion of the productive capacity by fluidizing the capital in order for economy to take off. So it was considered that the factors such as change of income policy, the capital concentration by tax increase, increase of the export of

primary commodity, introduction of foreign capital, and the establishment of monetary systems were required in order for the rapid expansion to be achieved. And, it was considered that these were often caused by exogenous factors such as a political revolution and help from foreign countries, etc.

2 In the marginal theory, when an enterprise wishes to get the maximum profit in a given price structure (where the perfect competition is assumed), it has to make an input's marginal productivity and its real reward even.

3 According to the definition of World Bank which evaluated by the gross domestic product per person in 1991, low-income nations refer to the countries with less than 635 dollars and the middle-income countries refers to the one with between 635 and 7911 dollars and the high-income nations refers to the one with more than 7911 dollars.

4 However, on the other hand, we may feel this result is not parallel with our economic common sense that the production elasticity of capital might be large in a country like developing countries where the capital stock is relatively scare.

5 Again, it is meant that the weight of capital equipment to be increased, and the weight of the input of labor to be decreased.

6 In the estimate of all of their researches, it is doubtful that there was a significant improvement of productivity in Singapore.

7 In his research, strangely enough, the technological progress rate has been given tentatively beforehand and the stock of capital equipment was then estimated as solution of the reverse function. It seems paradoxical to use the capital equipment in order to estimate the technological progress rate again.

8 Therefore periods for the estimation are 1987-92 and the 1992-97.

9 In the estimation of this essay, the production means all of the production where the value-added and the intermediate input are included, and the concept of productivity corresponds to it.

10 As for the calculation of TFP growth rate(annual basis), we calculated the 5-year growth rate of TFP for the former period(1987-92) and also for the latter period and then converted them to annual rate. It differs from the TFP growth as residual that is got after converting the growth rate of the amount of production and each factor (intermediate input, labor input and capital input) to annual basis. The TFP growth rate (annual basis) in this essay, therefore, does not equal to the difference between the growth rate of the amount of production and the sum of each factor.

11 We calculated the share of export value as follows using Chinese input-output table of 1997: (export/the value of production) $\times 100$

12 Foreign-funded enterprises (FFE) are the enterprises that Chinese companies established with the foreign capital companies: it includes contractual joint venture, equity joint venture and foreign-owned enterprise.