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JAPAN

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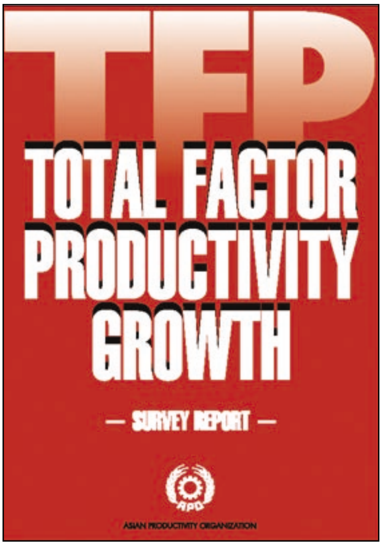

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JAPAN

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OVERVIEW OF THE JAPANESE ECONOMY DURING THE "LOST DECADE"

The Japanese economy has been experiencing the pain of serious recession for more than 10 years since the bursting of financial bubble in 1991. Things appear to be getting even worse. Macro statistics in 2001 show the evidence: −0.5% GDP growth rate (1.6% in 1995), 5.0% unemployment rate (3.0% in 1995), and 19,164 cases of firm bankruptcy (15,108 in 1995). Explanations could be made both from the supply and demand sides of the economy. While shrinking demand possibly lowers utilization of abundant resources accumulated during the bubble period, out-of-date economic and social structures might prevent resource reallocation from inefficient to efficient sectors.

Political instability seems to be a mirror of the economic turmoil in Japan. There have been eight prime ministers in the past 10 years. The Japanese political structure had been stable since 1957 under the "system of the year 1955" (when the two major conservative parties merged), which means a Gulliver-type of oligopolistic dominance in the Diet by the Liberal Democratic Party (LDP). A major change occurred in 1993, when a considerable number of politicians withdrew from the LDP and launched a new conservative party. The allied minority parties turned into a new majority and removed the leader of the LDP from the position of prime minister. Since then, the LDP has never recaptured an absolute majority in the Diet and has had to form a coalition government with at least one minority party.

Resource allocation appeared to be a minor issue during the high-growth period, because the total size of the economic pie was expanding and at least a small portion of the increase in output was attributable to everyone. The cessation of growth, however, would make some worse off if the government changed the rules of resource allocation, say, from a planned economy-oriented to a market economy-oriented system. LDP supporters mostly belong to traditional sectors of the Japanese economy such as agriculture, construction, and finance which have been highly protected by government regulations. In the face of globalization and marketization, these sectors will soon have to face severe competition in the global market. To receive stable votes from supporters, the government had to turn the economy away from a serious decline.

When the economic downturn occurred in 1991, however, the government at first considered it a temporary business shock that would be resolved shortly and tried to stand by its simple monetary policy. While the Bank of Japan made a 180-degree turn from a tight-money policy to calm the bubble economy to an easy-money policy to pull the economy up, the reduced budget principle was cited to maintain the soundness of national finance. (The official bank rate was continuously lowered from 4.5% in 1991 to 0.5% in 1995.) Just when the recovery process looked satisfactory, another blow came in 1997. The Hashimoto administration, criticized for passivity in its economic policy, was replaced by the Obuchi administration after the national election in 1998. Prime Minister Obuchi and his successor, Prime Minister Mori, drastically converted to a positive fiscal policy. Government bond issues increased by 46% in 1998, 32% in 1999, and 21% in 2000, and finally reached ¥90 trillion (US$0.75 trillion) in 2001. Both regional and central government loans soared to ¥666 trillion (US$5.5 trillion), which is ¥5.55 million per capita.

Considering the current situation of the Japanese economy, what can a survey of total factor productivity (TFP) contribute? TFP is one of the most convenient indicators to evaluate economic performance ex post facto. It is reasonable to view the Japanese economy during the period of drastic change in terms of TFP. Furthermore, TFP is expected to work as a buffer against economic fluctuations, especially during recession. If TFP gains during business booms are sufficient, companies accumulate them in the form of profits or capital gains and spend them during recession to maintain sound business conditions. In this sense, TFP can be interpreted as a shock absorber of business cycles. We should carefully watch TFP performance during bubble periods as well as after they burst.

REVISION FROM THE PREVIOUS SURVEY REPORT

A TFP study mainly involves the collection of data. The TFP derivation process itself is not very difficult once good data are obtained for sources of inputs and outputs. In other words, even with imprecise data we can calculate TFP indicators that could include both structural and stochastic errors, because the definition of TFP is a residual factor by subtracting input contributions from output growth.

Since TFP indices are convenient to evaluate the economic performance of nations, not only academic researchers but also government offices and commercial research institutes collect data and make their own calculations. There is usually insufficient information disclosure on how times series of input and output variables in those research papers were developed. Limited disclosure might cause duplication of work in collecting data, and as a result many types of TFP are reported for the Japanese economy.

A data processing procedure is laborious and time-consuming. Once an ideal database is constructed from the best sources, duplication of work may be inefficient unless the marginal productivity of an additional resource to upgrade the database is greater than the marginal cost. What we should do first is search for the best current TFP study in Japan and make full use of it. We can save resources by not doing the same work and allocate them to data extension or another analysis. The paper from Japan in the 2001 APO publication on TFP (*Measuring Total Factor Productivity: Survey Report*) is one candidate.

It is, unfortunately, difficult to say that the previous Japanese study (PJ study) was a good benchmark for us to extend the current TFP survey. It had serious problems concerning data sources, especially on capital stock. The capital stock data in the PJ study were basically from *The Gross Capital Stock of Private Enterprises 1955–1996 (GCSPE)* published by the Economic Planning Agency. Nomura (1998) pointed out four serious problems that the *GCSPE* has in the process of capital stock estimation. First, the *GCSPE* is based on the concept of gross capital stock, which ignores the depreciation of production capability in capital goods and assumes their sudden death at the end of life. Second, no classification of capital goods is considered in the *GCSPE*. (Nomura [1998] stated that an approximately 13% discrepancy exists between the simple summation of capital goods and the quality-adjusted aggregation of classified capital goods.) Third, the price (deflator) of capital stock is not available in the *GCSPE*. The fourth point is that information disclosure about the calculation process of capital stock is insufficient in the *GCSPE*, which would be an obstacle for outsiders to reproduce the *GCSPE* results.

Another problem exists in labor input data. Although the PJ study did not describe the details of how the labor input time series was developed, it is assumed that simple total man-hours were utilized. It is well known that in the process of economic growth after the Second World War the number of high school and college graduates increased greatly in Japan. The simple summation of man-hours is insufficient to capture the drastic quality change in labor input. We need classified labor inputs and their wages to make a labor index consistent with the economic aggregation theory. The Ministry of Labor provides detailed statistics on the number of employees, working hours, and wages for classified labor input categories.

KEIO ECONOMIC OBSERVATORY DATABASE

Masahiro Kuroda and his research group at Keio University, Tokyo, have been constructing a database for a neoclassical economic model and subsequent productivity study since the early 1970s (Kuroda et al., 1996). This has been carried out in parallel with Dale Jorgenson's research group at Harvard University, USA, to maintain mutual comparability. Kuroda calls this database the KEO Database (KDB) after the Keio Economic Observatory (KEO) where he is employed.

The KDB contains capital stock, labor, energy, and material (KLEM) inputs and their prices, and a single gross output index and its deflator for 42 industrial sectors. To be consistent with macroeconomic statistics, the KDB treats numbers in the system of national accounts (SNA) as the control totals, which means the summation of nominal variables in the KDB. For example, value added equals GDP in the SNA. This constraint prevents KDB variables from becoming unrealistic numbers, although it could reflect errors and output definition problems in the SNA (the output of the real estate industry in the SNA includes attributed rents for self-owned housing).

The KDB fundamentally follows the Jorgenson-Griliches (1967) approach, which carefully monitors the effect of qualitative and structural change in input and output as well as quantitative change. For example, consider the case where labor input is captured simply by the number of workers. It would include many types of workers such as males, females, high school graduates, college graduates, young people, senior citizens, etc.

Their quality might be different in the sense of suitability to jobs. Suppose a firm substitutes one college graduate for a high school graduate, expecting more advanced technological skills from the former. In this case it is inappropriate to consider the labor input unchanged, because the quality of labor is improved even though the number of workers is still the same.

How can the quality be captured in data? We usually use proxy variables for the quality index with the help of economic theory. A product with higher quality should be priced higher than the one with lower quality at the equilibrium, because the latter would not be utilized at all if the two were priced equally. The quality differences are reflected in price differentials. The KDB and Jorgenson approaches make use of price information for classified inputs/outputs and calculate their aggregates that are consistent with economic theory. It can be shown that under perfectly competitive market conditions the application of appropriate aggregation function formulae yields a precise quality-adjusted quantity index. In the case of a trans-log aggregation function, for example, the Theil-Törnqvist formula creates exact index numbers. The KDB takes into account quality changes for KLEM inputs, as summarized below (for more details, see Kuroda et al., 1996).

Labor Input

The labor force is classified by gender (male and female), age (11 classes), educational career (four for males and three for females), and employment status (employed, self-employed, family worker) for industrial sectors. Working hours are also taken into account as the utilization rate of the labor force. Since in the SNA the income of self-employed and family workers is defined as a part of business surplus, the KDB reallocates it to a labor compensation item.

Capital Input

Making capital stock time series is one of the most laborious processes in constructing databases. The KDB applies the double benchmark methodology, which utilizes the *Census of National Wealth* (CNW) for 1955 and 1970. The two-point availability of the CNW is useful for determining the depreciation rates of capital goods on the basis of the Hulten-Wykoff (1981) dual approach, because the rates can be estimated so that the theoretical values are equal to the observed values. Applying the perpetual inventory method, capital stock is annually accumulated using investment data and estimates of depreciation rates. Capital goods are classified into 78 commodities for 42 sectors and aggregated into a single capital input index.

Intermediary Input

Rich information about intermediary input is available in input/output (I/O) tables. Unfortunately, the most precise commodity-by-commodity basic tables (X-tables) are published by the Ministry of General Affairs every five years, so the KDB estimates time series of X-tables through the KEO-RAS method, which allows estimation of input coefficients of X-tables by minimizing the summation of squared deviations between estimated coefficients and those of the X-tables on the restriction of control totals given by the annual SNA. After the estimation of X-tables, the KDB estimates commodity-by-sector input tables (U-tables) from sector-by-commodity output tables (V-tables) of the SNA and estimated X-tables under the commodity-technology assumption.

Output

The KDB assumes separation between input and output and aggregates multiple outputs into a single index for 42 industrial sectors. Basic information on output is from V-tables in the SNA. One characteristic of the KDB is that it does not use I/O commodity deflators for the conversion from nominal to real values, but applies the wholesale price index published by the Bank of Japan (BOJ). The reason is that the BOJ index considers quality change in commodities. Shimpo (1999) showed how the two different output deflators lead to large discrepancies in the TFP index. While in case of the I/O deflator, the US automobile industry had an advantage in the level of TFP over the Japanese industry in the 1980s, the BOJ price index yields higher TFP of the Japanese auto industry than that in the USA (Urata et al., 1995). Considering the recent rapid technical change in high-tech commodities, a quality-adjusted price index is preferable.

INDUSTRY-LEVEL TFP GROWTH, 1960–95

Industry-level TFP growth rates from 1960 to 1995 were calculated using the Nomura-Kuroda (1999) method based on the KDB. The observation period covered by the KDB is divided into four subperiods: 1961–73 (high-growth period); 1974–85 (stable-growth period); 1986–91 (bubble economy period); and 1992–95 (post-bubble economy period).

Table 1 summarizes the results. (For the theoretical background of the TFP calculations, see the Appendix.) First the good performance of machinery-related industries in general can be noted. They maintained positive TFP growth except for general machinery during the final period, although the rates gradually declined. The communications industry made constant productivity progress against the background of an expanding telecommunications market. On the other hand, some traditional sectors such as agriculture, food, wood, publishing, leather products, water supply, and education had almost constant productivity declines throughout the observation period.

Examining the average annual growth rates from 1961 to 1995 in Tables 1 and 2, the differences in TFP performance among industries become more obvious. The ranking supports the understanding that TFP measured in the long term reflects the characteristics of industries. (See Nakajima [2001] for a more detailed explanation of the relationship between industrial characteristics and TFP growth.) Although air, railway, and water supply services are categorized as a network-based transportation industry, their TFP performance differs. The differences in their market conditions are obviously an influence. Water supply is still widely provided by local governments in Japan. However, we should also pay more attention to production and technological characteristics. The big difference exists in the burden of cost for building infrastructure. While railway and water supply services need huge amounts of investment to construct rails and lay pipes throughout the country, an air transportation service needs only an airport.

Table 1. TFP growth rate by industry (%).

	1961-1973	1974-1985	1986-1991	1992-1995	1961-1995		1961-1973	1974-1985	1986-1991	1992-1995	1961-1995
Agriculture	-2.24%	-1.97%	-0.35%	1.21%	-1.43%	Vehicle	2.47%	1.44%	0.66%	0.07%	1.53%
Coal mining	5.11%	-3.12%	0.46%	2.98%	1.25%	Other transportation machinery	1.06%	0.40%	0.60%	0.05%	0.64%
Other mining	5.45%	-1.24%	2.07%	-1.98%	1.73%	Precision machinery	3.39%	2.43%	0.44%	0.21%	2.19%
Building & construction	-0.94%	-0.03%	0.69%	-0.87%	-0.34%	Miscellaneous manufacturing products	2.28%	-0.08%	0.59%	-0.14%	0.90%
Foods	-0.08%	-0.09%	-1.11%	-0.33%	-0.29%	Railway transportation	0.67%	-2.57%	-1.40%	2.47%	-0.59%
Textile	-0.07%	1.81%	1.26%	2.24%	1.07%	Road transportation	0.98%	-0.22%	0.92%	-1.69%	0.25%
Apparel	1.29%	0.07%	-0.88%	-0.60%	0.28%	Water transportation	0.96%	3.16%	-2.36%	3.21%	1.40%
Woods	-0.31%	2.75%	-0.75%	-0.94%	0.59%	Air transportation	6.95%	1.42%	0.90%	-1.01%	3.11%
Furniture	0.82%	0.11%	0.87%	-3.00%	0.15%	Storage	-2.11%	4.79%	-2.32%	1.96%	0.69%
Paper & pulp	1.80%	-0.07%	1.68%	0.33%	0.97%	Communications	1.79%	2.97%	0.88%	1.56%	2.01%
Publishing	-2.32%	-1.63%	0.60%	-1.49%	-1.49%	Electricity	4.01%	-2.25%	3.10%	-2.96%	0.91%
Chemical	2.91%	0.44%	0.77%	2.56%	1.65%	Gas	2.86%	1.79%	3.18%	1.18%	2.36%
Petroleum	-2.13%	0.61%	2.70%	1.69%	0.08%	Water	-3.92%	-0.86%	-1.56%	-0.90%	-2.12%
Coal	-0.63%	-2.45%	0.07%	4.73%	-0.52%	Trade	4.54%	0.24%	2.79%	0.63%	2.32%
Rubber	2.11%	-0.14%	1.92%	-1.62%	0.88%	Finance	2.80%	0.82%	0.22%	-0.77%	1.27%
Leather	1.70%	-0.07%	-0.16%	-1.69%	0.39%	Real estate	1.75%	-0.79%	-0.07%	0.43%	0.42%
Stone & clay	1.65%	-0.56%	0.85%	-0.37%	0.52%	Education	2.32%	-3.76%	-0.55%	-0.92%	-0.63%
Iron & steel	0.95%	-0.11%	0.20%	1.22%	0.49%	Research	2.12%	1.61%	1.05%	-0.59%	1.45%
Non- ferrous products	0.93%	0.79%	0.40%	2.24%	0.94%	Medical service	0.25%	1.13%	-2.21%	-2.82%	-0.22%
Metal products	2.85%	-0.18%	1.32%	0.71%	1.31%	Other industries	-2.85%	-1.87%	-2.58%	0.77%	-2.05%
General machinery	0.54%	1.64%	0.65%	-0.72%	0.79%	Public services	3.91%	-1.05%	0.87%	1.89%	1.46%
Electric machinery	4.18%	2.23%	2.90%	1.05%	2.93%						

Table 2. Top 10 and worst 10 TFP performers.

	Top 10	Worst 10
1	Air transportation	Water supply
2	Electric machinery	Other industries
3	Gas	Publishing
4	Trade	Agriculture
5	Precision machinery	Education
6	Communications	Railway transportation
7	Other mining	Coal
8	Chemicals	Building & construction
9	Vehicles	Food
10	Public services	Medical services

In the short term, changes in market conditions as well as other features of the external environment could affect industry-level TFP performance. A good example is the financial sector, in which TFP growth rates decreased throughout the period. Even during the bubble economy period, which everyone believes caused unprecedented prosperity for financial institutes, the TFP growth rate was only 0.22%. This appears mysterious unless we consider the change in the market conditions of Japan's financial sector. The following interpretation may be true: the long-term regulations and protection provided by the Japanese government to financial institutes might have prevented them from making efforts to raise productivity, and the globalization and liberalization in financial markets with the bursting of the bubble economy finally led to negative TFP growth in the post-bubble period.

Next, we apply TFP (fixed-effect panel) regression analysis to industry-level TFP indices and attempted to determine the influential factors. Although various combinations of independent variables were tested, it was difficult to obtain satisfactory results. One result is shown in Table 3. The coefficients of public finance ratio and R&D-related variables are positive and significant. The effect of public subsidy is negative and significant at the 5% level only in the first column. To some extent, R&D activities and the public finance system might be effective in increasing TFP growth. Concerning other industrial policies, the results are too ambiguous to derive robust implications.

Table 3. Estimation results of TFP regression model (fixed-effect model).

	Eq. 1	Eq. 2	Eq. 3	Eq. 4
Dependent	ln TFP	ln	TFP ln	TFP
number of observations	154	168	105	105
PF			0.461 [2.264]**	0.434 [2.164]**
R&D0	1.591 [4.754]**			
R&D1		0.153 [10.577]**	0.114 [7.662]**	
R&D2				0.768 [2.585]**
R&D3				0.052 [0.626]
R&D4				0.105 [4.885]**
subsidy	-5.062 [-1.960]*	-1.322 [-0.595]	2.756 [0.953]	3.165 [1.118]
tariff	-1.207 [-0.736]	0.839 [0.611]	1.499 [0.821]	2.010 [1.117]
const	0.973 [80.892]**	0.782 [39.429]**	0.771 [23.269]**	0.759 [22.837]**
sigma_u	0.093	0.209	0.144	0.156
sigma_e	0.114	0.102	0.070	0.069
rho	0.397	0.809	0.807	0.837

All independent variables are measured by logarithmic values
*,**: significant on 5% and 1% level respectively
PF: The ratio of public finance over total debt.
(source: *Basic Survey on Commercial and Manufacturing Structure and Activities*)
R&D0 : R&D expenditure based on I-O table over total production
R&D1 : R&D sales ratio (source: *Survey of Research and Development*)
R&D2 : R&D (basic reserch)/sales (source: *Survey of Research and Development*)
R&D3 : R&D (applied reserch)/sales (source: *Survey of Research and Development*)
R&D4 : R&D (development)/sales (source: Survey of Research and Development)
subsidy : subsidy production ratio (quoted from Urata et al.(1995))
tariff : tariff production ratio (quoted from Urata et al.(1995))
Eq.1 : 1965-1995
Eq.2 : 1960-1995
Eq.3, Eq.4 : 1970-1990

Finally, we tried to extract factors common to some industries by applying cluster analysis to industry-level TFP growth rates. The results are shown in Table 4. It appears difficult to specify the four factors based only on the industry types listed. One interesting interpretation, however, may be derived from group 2 in Table 4. This group is composed of Japan's typical traditional sectors, some of which have been or still are protected by government regulations. It is ironic as well as persuasive that the public sector is also classified in this group.

Table 4. Results of cluster analysis based on TFP growth rate by industry.

< 1 >	< 2 >	< 3 >	< 4 >
Other mining	Agriculture	Publishing	Petroleum products
Building & construction	Coal mining	Rubber products	Coal products
Apparel	Food	General machinery	Leather products
Wood	Textile	Electric machinery	Non-ferrous products
Furniture	Chemical	Water transportation	Other transportation
Paper & pulp	Stone & clay	Air transportation	
Vehicles	Iron & steel	Electricity	
Precision machinery	Metal products	Trade	
Railway transportation	Miscellaneous manufacturing products	Research	
Road transportation	Finance		
Storage	Medical services		
Communications	Public services		
Gas			
Water			
Real estate			
Education			
Other industries			

MACRO TFP GROWTH OF THE JAPANESE ECONOMY, 1960−2000

There are basically two ways to derive TFP growth for an entire country. One is to perform growth accounting by utilizing macro statistics on labor, capital, and value added. The other is to aggregate the industry-level input/output to the national level and calculate macro TFP. The differences in input, output, and TFP between the above two are defined as allocation bias by Nomura and Kuroda (1999). According to the definition, the bias is estimated as positive if a resource is reallocated from a lower-priced sector to higher-priced one and vice versa.

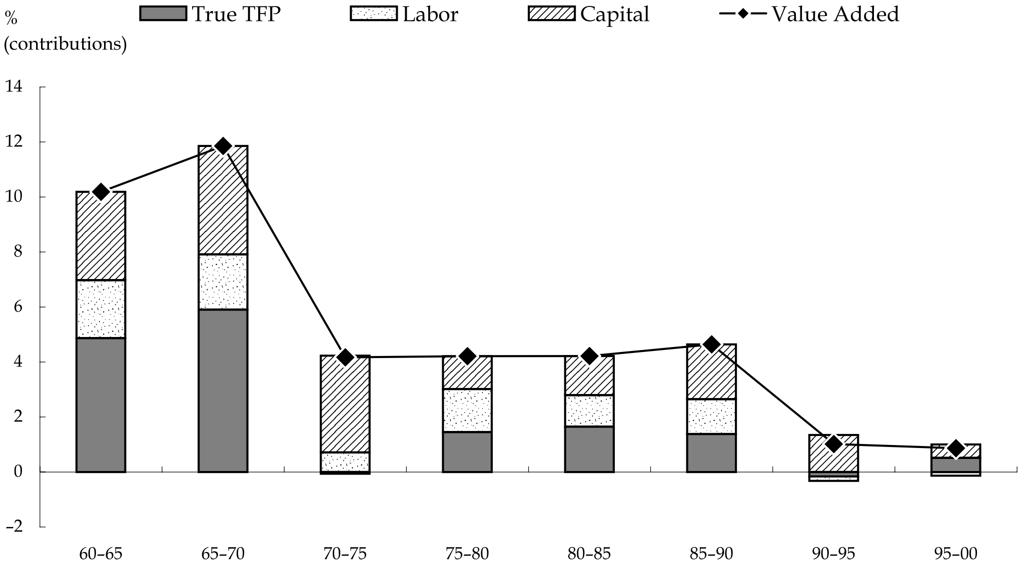
Table 5 shows the basic results. Column A explains the final nationwide growth accounting that reflects the quality change in input factors and allocation bias effects among industries. Columns B, C, and D illustrate factor decompositions of growth rates for output, input, and TFP, respectively, and correspond to the four panels in Figures 1 and 2. The row of "other bias" stands for the value of the cross-term that inevitably appears in the process of aggregation from industry level to macro level.

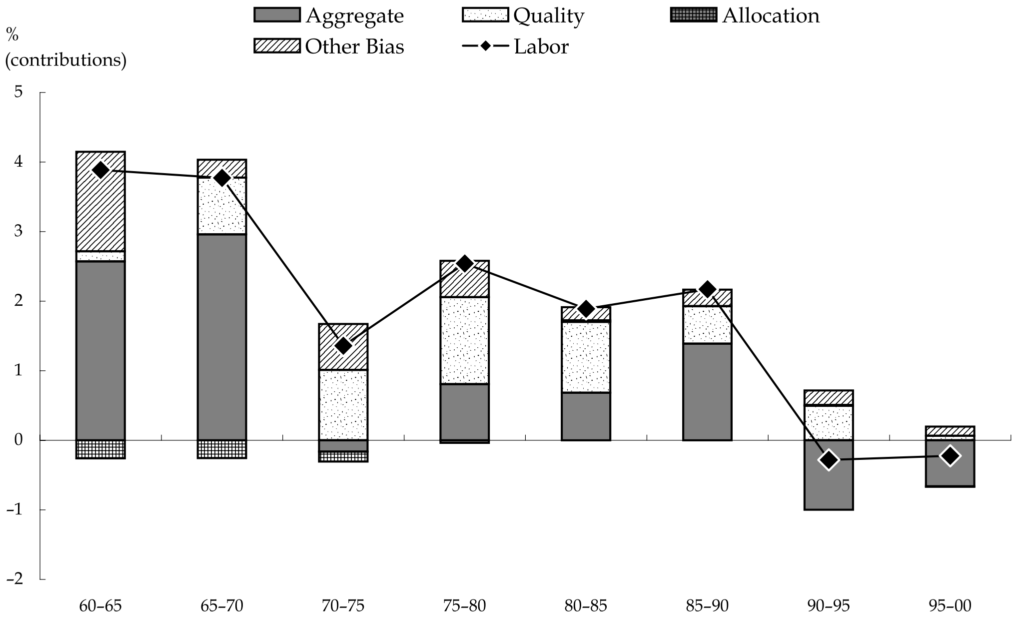
Table 5. Decomposition of sources of economic growth during 1960−2000 in Japan.

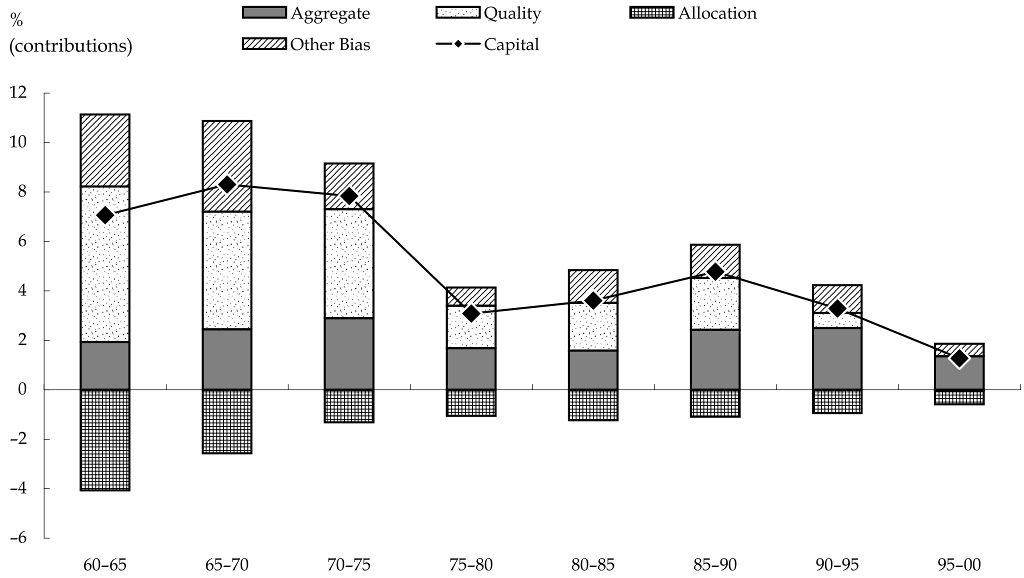
	A. Divisia aggregation														
a1	True TFP		4.867	5.903	−0.063	1.452	1.647	1.380	−0.160	0.514	4.542	0.832	1.259	0.124	1.942
a2	Output	Value added	10.187	11.857	4.167	4.211	4.218	4.639	1.018	0.866	10.095	3.704	4.463	0.649	5.146
a3	Input	Labor	3.885	3.772	1.359	2.541	1.890	2.170	−0.282	−0.223	3.417	1.655	1.900	−0.342	1.889
a4		Capital	7.061	8.306	7.836	3.085	3.610	4.778	3.289	1.275	7.980	4.393	5.024	1.841	4.905
a5	Contribution	Labor	2.105	2.008	0.712	1.565	1.145	1.265	−0.166	−0.137	1.832	0.991	1.107	−0.204	1.062
a6		Capital	3.214	3.946	3.519	1.195	1.427	1.994	1.344	0.490	3.721	1.795	2.097	0.729	2.141
	B. Output Decomposition														
b1	Value added	Aggregate	4.798	10.014	4.093	3.067	3.724	4.302	0.999	1.031	7.179	3.024	4.193	0.723	4.004
b2		Allocation	5.386	1.829	0.085	1.149	0.493	0.336	0.019	−0.165	2.921	0.682	0.269	−0.074	1.141
	C. Input decomposition														
c1		Aggregate	2.571	2.960	−0.162	0.807	0.684	1.388	−0.998	−0.660	2.310	0.437	1.168	−0.929	0.824
c2		Quality	0.146	0.816	1.012	1.250	1.018	0.537	0.495	0.065	0.560	0.882	0.512	0.269	0.667
c3		Allocation	−0.261	−0.259	−0.145	−0.038	0.022	0.002	0.011	−0.010	−0.265	−0.007	0.000	0.001	−0.085
c4		Other Bias	1.431	0.258	0.660	0.523	0.190	0.238	0.210	0.132	0.814	0.349	0.216	0.178	0.455
c5		Aggregate	1.931	2.447	2.895	1.684	1.585	2.421	2.497	1.354	2.398	2.188	2.677	1.700	2.102
c6	Capital	Quality	6.287	4.758	4.408	1.716	1.928	2.101	0.610	−0.037	5.460	2.117	2.174	0.037	2.722
c7		Allocation	−4.071	−2.571	−1.321	−1.058	−1.235	−1.095	−0.945	−0.551	−2.956	−1.144	−1.125	−0.690	−1.606
c8		Other Bias	2.917	3.669	1.848	0.740	1.325	1.346	1.124	0.509	3.076	1.226	1.290	0.795	1.685
	D. TFP decomposition														
d1	Aggregate TFP		2.538	7.255	2.952	1.917	2.682	2.482	0.578	0.918	4.818	1.873	2.394	0.614	2.665
d2	Aggregation	Bias in value added	5.386	1.829	0.085	1.149	0.493	0.336	0.019	−0.165	2.921	0.682	0.269	−0.074	1.141
d3		Bias in labor	−0.725	−0.416	−0.862	−1.066	−0.738	−0.453	−0.430	−0.113	−0.592	−0.736	−0.425	−0.270	−0.600
d4	bias	Bias in capital	−2.335	−2.784	−2.227	−0.543	−0.797	−0.980	−0.327	0.030	−2.601	−0.901	−0.976	−0.059	−1.245

Calculation is based on the Keio Economic Observatory Database.
Note : a1=a2−a5−a6
a2=b1+b2
a3=c1+c2+c3+c4
a4=c5+c6+c7+c8
a1=d1+d2+d3+d4

Figure 1. Macro Growth Accounting of Japan Labor Input Growth Accounting of Japan Capital Input Growth Accounting of Japan TFP Growth Accounting of Japan






%
(contributions)
Aggregate
Quality
Allocation
Other Bias
Capital
12
10
8
6
4
2
0
-2
-4
-6
60–65
65–70
70–75
75–80
80–85
85–90
90–95
95–00

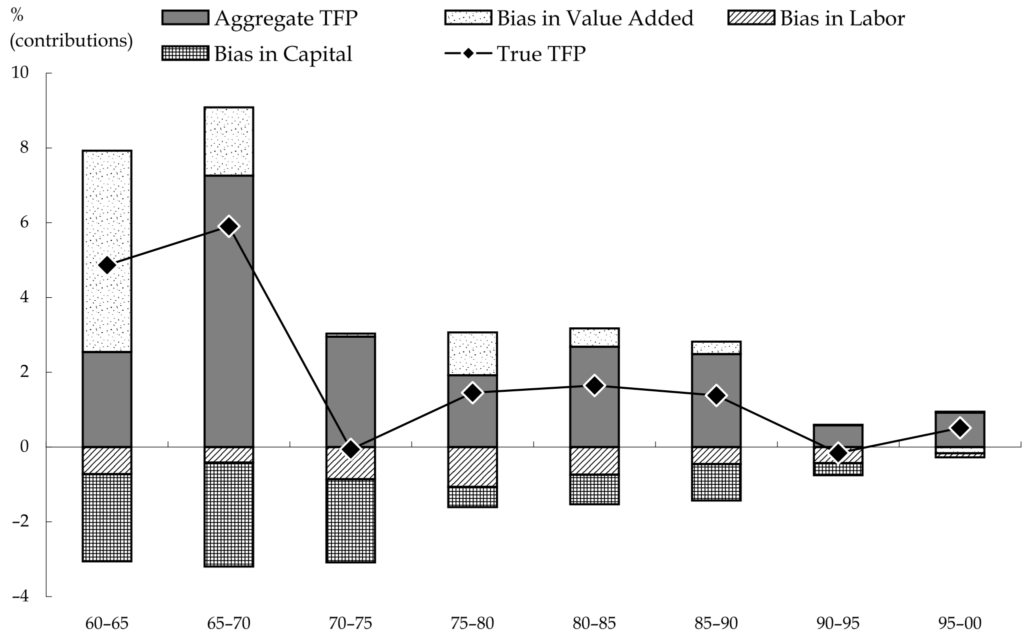
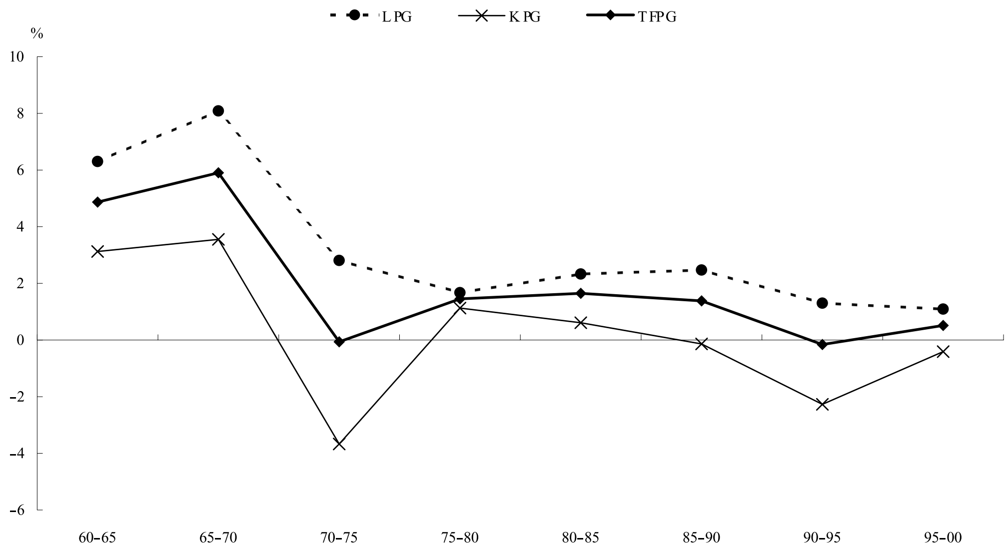

%
(contributions)
Aggregate TFP
Bias in Value Added
Bias in Labor
Bias in Capital
True TFP
10
8
6
4
2
0
-2
-4
60–65
65–70
70–75
75–80
80–85
85–90
90–95
95–00

Figure 2. TFP, LP and KP growth rates



Column A

1) The contribution of TFP to value-added growth was strongly significant (mostly 50%) during the high-growth period.
2) The supply-side shock of the first oil crisis was perfectly absorbed by TFP growth from 1970 to 1975.
3) The bubble economy, which was praised as the second advent of high growth, had substantially different characteristics in terms of growth accounting from the high economic growth in the 1960s. While the latter was mostly attained by TFP growth, the former relied on a more than 70% contribution from input growth.

Column B

1) Allocation bias had a substantially large positive value during the high-growth period, which reflected rapid structural change in Japanese industries.
2) Only the post-bubble recession period (1995-2000) showed a negative value of bias, which indicates that some inefficiency might have occurred in output allocation among industries at that time.

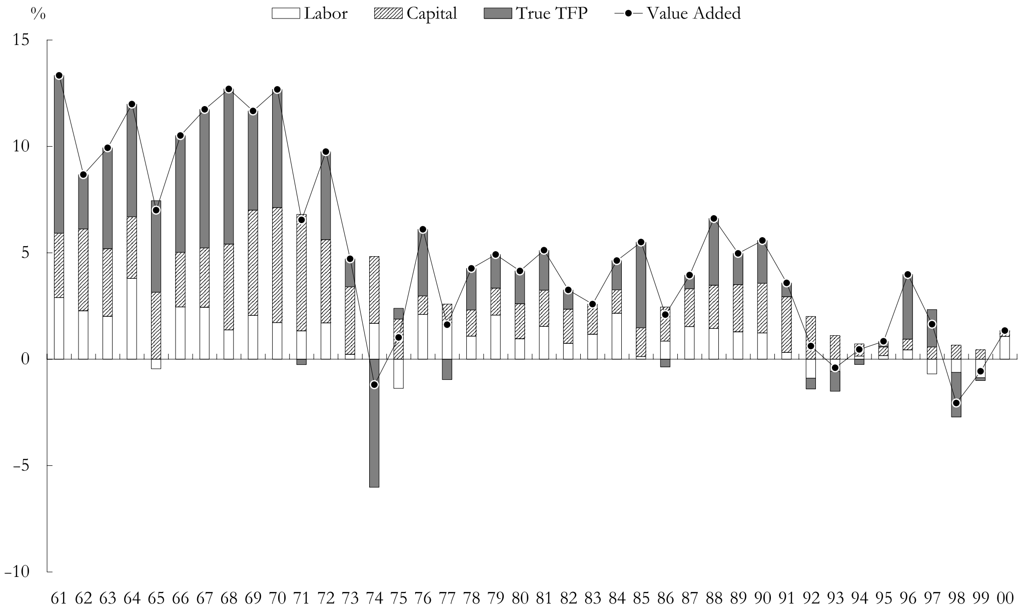
Column C

1) The positive and significant contribution of labor quality change was constant.
2) The contribution of capital stock to Japan's economic growth was constantly substantial.
3) The allocation bias of capital was constantly negative, which shows that capital goods were allocated to industries that have relatively small capital stock shares in the Japanese economy.

Figure 3 summarizes the macro growth accounting results and partial productivity indicators for the Japanese economy. The LP growth was stably larger than KP growth.

The KP growth rate was small and occasionally negative a result of a higher rate of capital accumulation than economic growth. The difference between LP and KP narrowed after the first oil crisis, but expanded again until the bubble economy period. This shows that capital accumulation-driven growth experiences setbacks at economic downturns.

Figure 3. Macro Growth Accounting of the Japanese Economy



CONCLUSIONS AND POLICY IMPLICATIONS

In TFP studies there is always a trade-off between data precision and availability of resources. The KDB is one of the finest data sources for TFP calculations but needs a huge amount of work to construct. We must accept a three-year-lag to obtain the complete version. The previous APO TFP publication sacrificed precision for the latest growth accounting numbers. In this paper, we chose the KDB in exchange for a three-year-lag. The reason for our choice is that a TFP indicator becomes meaningless if it contains measurement errors.

Figure 3 and Table 4 show that TFP growth has made a considerable contribution to the economic growth of Japan. Especially during the high-growth period, the contribution of TFP was nearly 50%, which must have worked as a shock absorber at the time of the economic recession after the first oil crisis in 1973. The bubble economy after the late 1980s raised TFP growth rates, but the gains at that time might not have been enough to absorb the downward shock of the sudden bursting of the bubble in 1992.

In a sophisticated economy like Japan, it is not easy to interpret macro TFP fluctuations because it has a complicated industrial structure and many other factors that jointly affect TFP measurement. Relatively longer time series of industry-level TFP indicators could present more interpretable results reflecting industrial characteristics. Table 1 shows that manufacturing industries, especially machinery-related ones, had better TFP performance throughout the observation period. Tertiary industries, on the other hand, had either positive or negative TFP growth rates depending on their production technologies and market structures. Although the TFP regression analysis results only show a significant effect of R&D expenditure on TFP growth, the cluster analysis based on industry-level TFP growth rates (group 2) pointed out industries that have been under government protection and regulations.

Our results based on the KDB unfortunately still seem to have uncorrected errors. We cannot say that the effect of the business cycle has been completely eliminated from our TFP fluctuations in Figures 1, 2, and 3. Since Griliches-Jorgenson (1967), great efforts have been made to select data sources to obtain "pure" TFP indicators. However, those efforts mainly focused on the input side of growth accounting. Less attention has been paid to the definition of output, that is, GDP, although a 1% error in output growth leads directly to the same amount of error in TFP growth.

The problem of output definition is more serious for a developed economy like Japan. In the early stage of economic development, the main actor is manufacturing that produces a visible and measurable output. As the economy becomes more mature, a structural change may occur from econdary to tertiary industry such as finance, retail, real estate, and many other service industries. How can we correctly define output for those industries? What should be their deflators? Consider the retail industry. The service output is defined as the trade margin, and traditionally the double deflation approach has been utilized to obtain the "real" output. When the trade margin decreases and the quality of a retail service increases as a result of more competition, "real output" will decrease under the traditional definition. The TFP number for trade is 92 to 95 in Table 1 and could reflect this situation. Considering the more than 40% contribution of the service industry to nominal GDP, we should pay more attention to the output definition issue in TFP analysis.

ACKNOWLEDGMENTS

We thank Noriyoshi Oguchi and other participants in the APO meeting in Kuala Lumpur for useful comments and suggestions. We are also grateful to Masahiro Kuroda and Kazushige Shimpo for allowing us to utilize the Keio Economic Observatory Database and to quote some of their results.

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APPENDIX. THEORETICAL BACKGROUND OF TFP

Choice of Index Formula

TFP is defined as the ratio of output to input. It is simple to calculate TFP in the case of a single-input/output technology such as a simple transportation service in which a worker carries baggage from one place to another. In more general cases of multiple-input/output technologies, we need to aggregate them into single input and output indices to calculate TFP. Although the choice of an appropriate aggregate function is basically left to a researcher according to the purpose of the study, economic theory gives guidelines on making the choice, especially when a TFP indicator with a specific calculation formula holds.

Diewert (1976) made a considerable contribution to the consistency of an index formula with a production technology (a form of production function). He proved that an input/output index based on the Theil-Törnqvist (T-T) formula is consistent with a trans-log production function. This implication is useful, because once a producer's rational choice of an input combination is assumed, it is not necessary to estimate the production function itself to obtain aggregated numbers. It is only needed to calculate an index using an exact (corresponding) formula. Since the trans-log production function satisfies the requirement for technological flexibility, Diewert called the T-T (trans-log) index the superlative index.

The TFP numbers referred in this paper were basically calculated using the T-T index to maintain the flexibility of production technologies. If we assume a constant cost share for an input factor, the production function is specified as a Cobb-Douglas type.

Adjustment of Capital Utilization

One of the most difficult tasks for TFP researchers is how to solve the problem of fixed-factor utilization. Because in the KDB the rate of return on capital stock is endogenously derived based on the neoclassical economic theory, it is impossible to show the difference in TFP results before and after the utilization adjustment. As Yoshioka (1987) explained, TFP occasionally has a procyclical movement with the business cycle. For the sake of the original definition of TFP, that is, a purely external technological shift factor of production technology, the mixture of business cycle effects might be an obstacle to be eliminated. There are actually a variety of methods to remove the effect of fixed-factor utilization from TFP. Oguchi (2001) presented a useful and appropriate method that could be applied to most APO member countries. In this paper, however, we apply another method to adjust capital utilization.

One of the most famous theories of microeconomics explains that a perfect allocation of nominal output to the compensation of input factors is guaranteed under the following conditions: perfect competition, linear-homogeneous production technology, perfect flexibility of input factors, and producer's rational behavior (profit maximization). In this ideal case, no capital utilization problem occurs because the optimal input level is obtained rapidly. One simple method for the utilization adjustment is to make use of this theorem.

Suppose the short-run production cost can be expressed using a variable cost function G as follows:

$$C = G(p, Y, K) + p_K K \tag{Eq. 1}$$

where p stands for the price vector of variable inputs, Y for output, K for fixed input (capital stock), and pK for the user cost of capital. Taking a partial derivative in terms of Y, we obtain the following two different results depending on whether capital stock is adjustable (in the long term) or not (in the short term):

$$\frac{\partial G}{\partial Y} + \frac{\partial G}{\partial K}\frac{\partial K}{\partial Y} + p_K \frac{\partial K}{\partial Y} \rightarrow \text{Change in variable cost in the long term} \tag{Eq. 2}$$

$$\frac{\partial G}{\partial Y} \rightarrow \text{Change in variable cost in the short term} \tag{Eq. 3}$$

We define the optimal input level of K (unity capital stock utilization rate) as one that equalizes the long-run derivative and short-run derivative in terms of Y, that is,

$$p_K = -\frac{\partial G}{\partial K} \,. \tag{Eq. 4}$$

Since it can be shown that the left-hand side corresponds to marginal productivity of capital, replacement of the user cost of capital with LHS in Eq. 4 gives utilization-adjusted growth accounting.

The marginal productivity of capital can be easily calculated if we assume that the four conditions mentioned above hold true. Applying Euler's theorem for a linear-homogeneous function to production function $Y = F(L, K)$, the following relation holds:

$$Y = \frac{\partial F}{\partial L} L + \frac{\partial F}{\partial K} K$$

$$= wL - \frac{\partial G}{\partial K} K \,, \tag{Eq. 5}$$

where w means wage rate and it is assumed that the product price equals unity. Using Eq. 5, the marginal productivity can be calculated as:

$$-\frac{\partial G}{\partial K} = \frac{Y - wL}{K} \,. \tag{Eq. 6}$$

Considering the discussion above, it is theoretically confirmed that utilization adjustment can be achieved using the estimated marginal productivity of capital instead of user cost.