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THE SECTORAL PRODUCTIVITY PERFORMANCE OF JAPAN AND THE U.S., 1885–1990

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This paper provides a disaggregated productivity comparison between Japan and the U.S. for the period 1885–1990. It combines two detailed productivity comparisons for 1939 and 1975 with time series to provide a long-term sectoral perspective. There is much diversity in the Japanese experience. The agricultural sector has shown relative stagnation since 1885. The service sector showed considerable growth before the Second World War and reached high productivity levels in the post-war period. Within services there is great diversity in productivity levels. Japan's manufacturing sector has shown the fastest catch-up and its productivity level is currently close to that of the U.S.

1. INTRODUCTION

International comparisons of economic performance have become an important topic in studies dealing with income and wealth. There is much interest in the measurement of real income and price levels between countries, and a growing interest in long term analysis of economic growth. Recently, Summers and Heston (1991) and Maddison (1991, 1994) have integrated international comparisons and long-term analysis. Apart from giving valuable insights in long-term processes of growth and stagnation, these long-term series have become important building blocks for the development of the "new growth theory" (Romer, 1986; Barro, 1991). Presently, most of the studies on comparative performance in the long run concern themselves with the economy as a whole (Maddison, 1991), with a number of expenditure categories (Summers and Heston, 1991) or with only one specific sector (Broadberry, 1992). Few studies have attempted a disaggregated sectoral approach to international comparisons.

The purpose of this paper is to measure and analyse comparative productivity by industry of origin for the two largest industrialised economies in the world, Japan and the United States, for the period 1885–1990. More disaggregated comparisons can help in the development of a sectoral approach to long run growth. They can also contribute to the improvement of the comparability of national statistics by pointing to inconsistencies. In addition they can help in finding answers to some important questions, such as: Are processes of catch up and convergence important for all sectors of the economy? Which sectors have been most important in the Japanese catch up with U.S. productivity levels? What is presently the gap between Japan and the U.S. in productivity levels and can Japan take over the lead in productivity from the U.S.?

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Long-term international productivity comparisons are faced with considerable problems. First, detailed sectoral comparisons for benchmarks have to be derived, preferably for more than one year. Second, comparable time series by industry must be available to derive a long-term perspective. Apart from these data problems, there are a number of methodological problems. It is quite likely that multiple benchmarks will not be consistent with each other (Heston and Summers, 1993). In addition, the international comparison of service output from the production side of the national accounts is quite difficult, especially between developing and developed countries.

Japan and the U.S. are two countries with a wide range of available statistics of high quality. In Japan, a great effort has been made to produce detailed long-term economic statistics from 1885 onwards (Ohkawa, *et al.*, 1974–88). In addition detailed information on quantities and prices of important products is available for benchmark comparisons. In the U.S., work on long-term economic statistics has an even longer tradition, and official estimates of national income go back as far as 1929. Before that, work by Kendrick (1961) traces most of the series back to the 19th century. The availability of high quality statistics makes both countries suitable candidates for a detailed analysis of productivity levels.

An aggregated comparison of income and productivity between Japan and the U.S. is shown in Figure 1. According to these estimates, GDP per capita in Japan was some 29 percent of that in the U.S. in 1870. Although this represents a considerable gap, it is much smaller than that between low income developing countries and the U.S. presently. In the World Bank's classification of countries, Japan in 1870 would be classified among the upper middle income countries. According to Maddison's (1994) recent estimates the range between the lowest per capita income in 1870 (in African countries) and the highest (Australia) was almost 1 to 8. Among the countries in Maddison's sample this ratio had increased to almost 1 (Tanzania) to 40 (U.S.) in 1989. Obviously the spread of income levels in the world has increased substantially since 1870.

Before the Second World War, Japan did not catch up with U.S. income levels, but neither did it fall behind. In the early 1930s there was a spurt ahead, partly caused by the Great Depression in the U.S., which had only limited effects on the Japanese economy. The war caused an enormous drop in Japanese income levels to less than 10 percent of the U.S. level. Almost 25 percent of the Japanese capital stock was destroyed, important colonies had to be abandoned, Japan was cut off from important suppliers and it also had to assimilate more than 6 million soldiers and ex-patriates. After the war, income rose fast. Into the 1950s this was largely due to a large backlog with potential. Since then, there has been an almost continuous upward trend in Japanese income levels. Figure 1 also shows the trend in labour productivity. In 1870 relative productivity was considerably below relative income, due to much higher participation levels in Japan. Since 1870, these have fallen to levels comparable to the U.S.

2. Comparing Price and Productivity Levels

International comparisons of levels of performance between countries are difficult because exchange rates do not accurately reflect real price differences

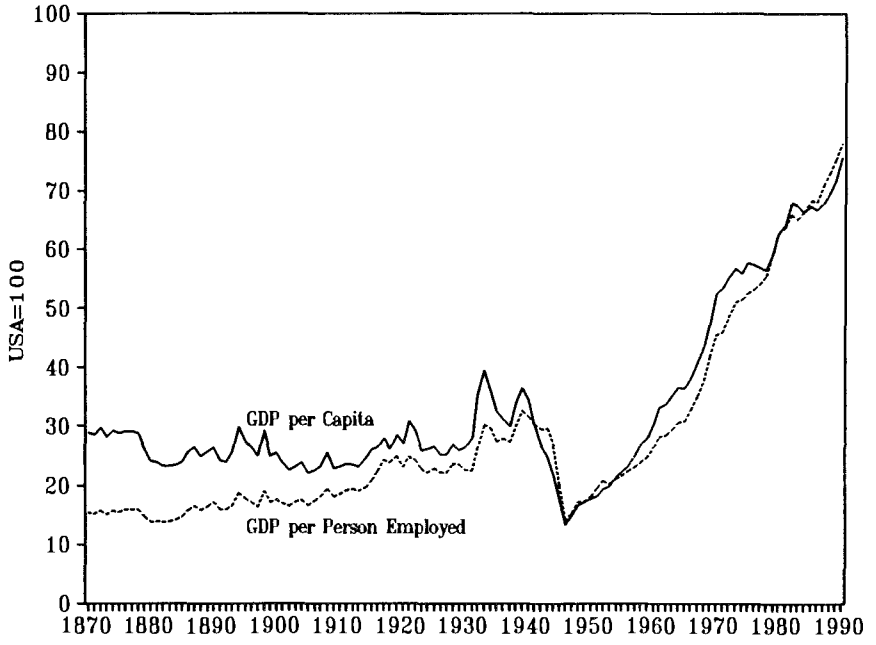

Figure 1. Income and Productivity Levels Japan/U.S., 1870–1990, in percent.

Source: Based on estimate for 1975 from Table 3, GDP series and population from Maddison (1991), employment from Ohkawa *et al.* (Vol. 2) and EPA (1991; 1993) for Japan, and from Kendrick (1961) and BEA (1986; 1992; various issues) for the U.S.

between countries. Both the expenditure (Kravis *et al.*, 1982) and the production approach to international comparisons are aimed at the development of purchasing power parities (PPPs), which can be used as an alternative to exchange rates. The basic approach to industry of origin comparisons has been spelled out in previous studies (Maddison and Van Ark, 1988; Szirmai and Pilat, 1990; Van Ark and Pilat, 1993). For commodity sectors, such as agriculture, mining and manufacturing, industry of origin comparisons can be implemented by weighting the price ratios of individual products with the corresponding quantity in either of the two countries:

$$(1) \qquad PPP_j^{XU(X)} = \frac{\sum_{i=1}^{s} P_{ij}^X * Q_{ij}^X}{\sum_{i=1}^{s} P_{ij}^U * Q_{ij}^X} \qquad PPP_j^{XU(U)} = \frac{\sum_{i=1}^{s} P_{ij}^X * Q_{ij}^U}{\sum_{i=1}^{s} P_{ij}^U * Q_{ij}^U}$$

at quantity weights of country X and U respectively, where P represent prices and Q quantities, and where i = 1 . . . s is the sample of matched products in industry j. These purchasing power parities correspond to Laspeyres and Paasche price indices in intertemporal comparisons. In most binary comparisons a geometric (or Fisher) average of the two ratios is taken as the final index.

A similar approach can be applied to some service sectors, in particular electricity, gas and water, transport and communication. In these industries, information on the quantity and value of output produced is often available. For other services, especially for non-market services, it is more difficult to find reliable price

or volume indicators. For the later benchmark, 1975, it is possible to utilise some of the price indicators of the ICP project, but for the prewar benchmark this is not possible. As the share of services in GDP is increasing in high income countries, more effort (Smith, 1989; Kendrick, 1990; Dean and Kunze, 1992) is being made to derive reliable indicators. Since a large number of services are traded in the market, prices for certain types of services are available in the marketplace, and improved measurement is possible.

If PPPs by industry have been derived, they are applied and weighted by value added or gross domestic product by industry. This approach is known as the "adjusted single indicator approach" (Paige and Bombach, 1959). Unfortunately, the available information by industry is usually insufficient to derive input PPPs as well.[1] In addition, inaccurate input PPPs may lead to large measurement errors at the GDP level, especially if the ratio of value added to total output is small.

3. Benchmark Price and Productivity Comparisons

3.1. *Prewar Productivity Levels*

Most Japanese time series show a break for the period 1940–53. Even the few series which are available are influenced by the great disturbances in price and output levels during the war and its aftermath. Therefore, it is important to derive a prewar benchmark which represents prewar output levels and is based on prewar weights. Here, 1939 was selected for a detailed comparison, due to the relative abundancy of statistics for that year.[2]

Basic price and quantity information for Japan is available from the *Historical Statistics of Japan* (Japan Statistical Association, 1986) and from *Estimates of Long-Term Economic Statistics of Japan since* 1868 (Ohkawa *et al.*, 14 Vols). NDP and employment information for Japan are also available from Ohkawa *et al.* (Vol. 1 & 2).[3] For the United States the basic price and quantity information was derived from the *Statistical Abstract of the United States* (Bureau of the Census, various issues). NDP and employment for the United States are available from the *National Income and Product Accounts of the United States*, 1929–1982 (Bureau of Economic Analysis, 1986).

For agriculture, 20 product matches could be made covering 65 percent of Japanese output and 42 percent of U.S. output. In addition, a match for fisheries was made, based on the total tonnage caught, and a match for forestry, based on the total amount of logs felled. Weighting each price ratio by its corresponding quantity gives a rather high final PPP for total agriculture, forestry and fisheries, of 5.08 Yen to the US$, compared to the exchange rate of 3.85 Yen to the US$.

[1]Van der Meer and Yamada (1990) is one of the few studies which uses double deflation in an international comparison. However, their study covered only the agricultural sector, which is a sector with a limited range of inputs and outputs, and relatively high quality data.

[2]More detail on the 1939 comparison is available in Pilat (1993).

[3]The prewar benchmark comparison uses NDP as the output concept, since this was available in a comparable form for most sectors of the economy. The postwar benchmark comparison uses the preferred GDP concept.

For mining, six product matches could be made, representing more than 50 percent of total mining production in both countries. The product structure of mining differs much more than that of agriculture or manufacturing, since it is much more related to the national resource base. The price ratios vary between a low 1.46 Yen to the US$ for manganese ore, in which Japan was a large producer in 1939, to a very high 11.44 Yen to the US$ for crude oil, where Japan was only a small producer. Weighted by product quantity, the PPP for mining is 6.03 Yen to the US$, again indicating a relatively high price level.

For manufacturing, 48 products were matched, representing approximately 15 percent of Japanese manufacturing output and 16.5 percent of U.S. manufacturing output. Although this is slightly less than could be matched in some postwar manufacturing comparisons between Japan and the U.S. (Szirmai and Pilat, 1990; Van Ark and Pilat, 1993) it represents a substantial part of total output. Again, the variation in price ratios by product is considerable, from very low PPPs in textiles, clothing, leather and non-metallic minerals, to quite high in food products, paper products, chemicals and machinery. The final result, weighted by major branch, gives a PPP of 3.64 Yen to the US$, which is quite close to the exchange rate.

Agriculture, mining and manufacturing represent sectors with clear and definable products, which can be matched with reasonable accuracy between countries. This is less so for service sectors, where products are often not so clearly defined. For construction the only available information is on the total size of buildings produced. This type of information does not indicate what kind of building was produced, which materials were used, and so on. There is no information available on the prices of comparable buildings by sector. The approach used here is to match the total surface produced for four types of buildings and to revalue these using U.S. and Japanese prices. A problem here is the large difference in quality of buildings between the two countries. Japanese houses were often made of wood using simple paper screens for indoor separation. In addition, they included much less facilities than their U.S. counterparts. To adjust for this quality difference, I assumed that the average quality of Japanese buildings in 1939 was only 50 percent of that in the U.S. This adjustment is larger than the one made in the ICP project for 1975 (Kravis *et al.*, 1982), where the quality of Japanese houses was estimated to be approximately 75 percent of the U.S. My assumption here is that the quality of Japanese houses after the war has risen faster than that of their U.S. counterparts. This crude comparison gives a final PPP for construction of 4.03 Yen to the US$, again a relatively high level.

For transport, communication and utilities, most statistical offices publish some quantitative information on output. In transport, it can be measured in the number of passenger kilometres or ton kilometres produced. In utilities, the total amount of gas, electricity and water distributed also represents the production of the sector fairly well. In communication, output can be measured from the number of postal transactions, telephone calls, telegrammes sent and so on. In utilities I matched output of gas and electricity, in transport matches were made for passenger and freight transport by rail, and for passenger transport by motorbus lines. In communication, the only possible product matches were those for the number of telephones and for the number of telegrammes sent. In transport and

communication, this resulted in relatively low PPPs, 1.66 Yen to the US$ for transport and 1.89 Yen to the US$ for communication. The PPP for utilities was somewhat higher, 2.44 Yen to the US$.

TABLE 1

PURCHASING POWER PARITIES BY INDUSTRY, 1939, JAPAN AND THE U.S.

	PPP at Japanese Quantity Weights (Yen/US$)	PPP at U.S. Quantity Weights (Yen/US$)	PPP (Geometric Average of Quantity Weights) (Yen/US$)	Relative Price Level (U.S. = 100)
1. Agriculture, forestry, fisheries	4.96	5.20	5.08	132.0
2. Mining	4.90	7.43	6.03	156.8
3. Manufacturing	2.80	4.74	3.64	94.6
4. Construction	4.45	3.65	4.03	104.8
5. Public utilities	2.15	2.77	2.44	63.4
6. Transport & communication	1.28	2.19	1.68	43.6
Transport	1.23	2.23	1.66	43.1
Communication	1.75	2.04	1.89	49.1
7. Wholesale and retail trade	0.89	1.30	1.07	27.9
8. Other services	1.05	1.68	1.33	34.5
9. Government	1.41	1.41	1.41	36.8
Total economy	1.92	2.84	2.34	60.7
Exchange rate	3.85	3.85	3.85	100.0

Source: Based on matching discussed in text; basic product and price information Japan from Japan Statistical Association (1986), and from Ohkawa *et al.* (1974–88); U.S. from Bureau of the Census, various issues; exchange rate from Japan Statistical Association (1986), Vol. 4.

Note: The relative price level is the PPP divided by the exchange rate.

For the service sectors, wholesale and retail trade, other services and government much less information is available. For wholesale and retail trade I assumed that productivity and size of store are directly related. Establishments in wholesale trade in the U.S. are 2.25 times the size of those in Japan. In retail trade establishments in the U.S. are only 5 percent larger than those in Japan. I assumed that this same ratio is also applicable to productivity. From the available output and employment information a PPP can then be calculated. For wholesale and retail trade combined a final PPP of 1.07 Yen to the US$ results, indicating a very low price level in this sector. For government I simply assumed that productivity in Japan is half of that in the U.S. An approach assuming equal productivity would give a PPP and productivity result which are rather far out of line with other sectors of the economy. My assumption gives a PPP of 1.41 Yen to the US$. Finally, the PPP for other services is the weighted average of those in transport, communication and utilities and wholesale and retail trade. The resulting PPP for this sector is 1.33 Yen to the US$.

PPPs and price levels by sectors are shown in Table 1. Weighting all sectoral PPPs by their sectoral value added weights gives a PPP for total NDP of 2.34 Yen to the US$, which indicates a relatively low price level in Japan compared to the U.S. The spread in PPPs between the different sectors is considerable. High PPPs and price levels are observed in agriculture and mining, where the U.S. has

a large natural resource advantage. The PPP of manufacturing is quite close to the exchange rate, which was also quite often found for postwar comparisons for manufacturing (Van Ark, 1993). Apart from construction and utilities, which are often considered part of the secondary sector, PPPs and price levels in the service sectors are much lower. Although these estimates are much weaker than those for agriculture, mining and manufacturing, they are roughly consistent with the Balassa-hypothesis (Balassa, 1964), which for developing countries suggests low price levels in services sectors.

Next, these PPPs can be used to calculate real output (NDP) by sector. Total real NDP in Japan compared to the U.S. in 1939 was only 17.7 percent of that in the U.S. Most sectors are at output levels between 15 and 20 percent of the U.S., but output levels in construction, and wholesale and retail trade are somewhat higher, whereas mining, communication and government have much lower output levels.

TABLE 2

COMPARATIVE OUTPUT, EMPLOYMENT AND PRODUCTIVITY, 1939, JAPAN AS A % OF THE U.S.

	Real Net Domestic Product (%)	Relative Employment (%)	Real NDP per Person Employed (%)
1. Agriculture, forestry, fisheries	19.0	174.7	10.9
2. Mining	9.4	61.4	15.2
3. Manufacturing	16.1	64.8	24.8
4. Construction	24.4	53.0	46.0
5. Public utilities	15.2	30.7	49.3
6. Transport & communication	15.9	49.5	32.1
Transport	17.2	46.6	37.0
Communication	9.8	64.9	15.1
7. Wholesale and retail trade	25.3	42.6	59.5
8. Other services	17.5	37.0	47.4
9. Government	7.0	13.9	50.0
Total economy	17.7	65.4	27.0

Sources: NDP and employment Japan from Ohkawa *et al.*, Vol. 1—National Income (1974) and Vol. 2—Manpower, (1988); employment and NDP U.S. from Bureau of Economic Analysis (1986); conversion to common currency with PPPs (geometric averages) from Table 1.

Taking the ratio of real NDP and employment by industry gives real NDP per person employed. Unfortunately, the available information on hours worked for this period is rather weak, especially for Japan, so no adjustment for relative hours worked can be made. The available levels for the whole economy (Maddison, 1991) suggest that Japanese productivity would fall against the U.S.A. if adjustment for hours worked would be made. On average, the productivity level of Japan was 27 percent of that in the U.S. in 1939. The lowest productivity levels are those of agriculture and mining. Manufacturing takes an intermediate position with 25 percent of the U.S. level. This is only half of that found for Germany and the U.K. in the same year (Broadberry, 1992). My estimate for manufacturing is somewhat below the estimate of Yukizawa (Yukizawa, 1973) for 1935–39. His

study uses the Rostas (Rostas, 1948) approach, which is primarily based on a comparison of physical quantity ratios. Apart from this methodological difference, his study relates productivity to the census data and not to NDP as is the case in the present study. Relative high productivity is observed in the service sectors, with the exception of communication. The relative low productivity of agriculture, mining and manufacturing compared to that of the service sectors is a confirmation of the differential productivity framework underlying the Balassa-effect (Balassa, 1964; Kravis *et al.*, 1982).

Overall, these findings indicate that Japan was still quite far behind the U.S. position in 1939. There had been substantial growth in some sectors, especially in manufacturing, but the initial productivity gap was quite large, especially in agriculture and manufacturing.

3.2. *Productivity Levels in 1975*

For 1975 I have elsewhere (Pilat, 1991) elaborated in more detail on the productivity comparison. In most cases the procedures followed were similar to those in 1939, but more statistical material is available, especially for services, so the comparison can be of somewhat higher quality than that for 1939. Also, the ICP investigation for 1975 (Kravis *et al.*, 1982) provides information on PPPs and price levels of expenditure categories, which in some cases come quite close to measuring PPP and price levels by industry of origin.

For agriculture the comparison is based on a comparison of approximately 70 percent of total output in both countries. In addition, a separate comparison was made for fisheries, based on the total fish catch. For mining 15 products were matched, which covered more than eighty percent of gross output in both countries. For manufacturing a considerable sample of products could be matched (Szirmai and Pilat, 1900, with revisions). For transport, communication and utilities the approach was similar to that used for 1939, although many more products could be compared and the information on quantity and value of production was much better. For construction, health, government and other services proxy PPPs from the ICP project were used (Kravis *et al.*, 1982). For wholesale and retail trade, ICP PPPs for expenditure categories were weighted by the corresponding wholesale and retail category (see Smith and Hitchens, 1985). For finance, insurance, real estate and education rough output comparisons were made. That for finance assumed that total output in finance is equivalent to the total GDP of the economy multiplied by the degree of financial intermediation (measured as M^2 to GDP). For insurance relative output is based on the number of insurance policies. For real estate it is based on comparative estimates of the total residential capital stock in Japan and the United States, converted with ICP proxies for residential construction (Maddison, 1992). That for education was based on the total number of teacher and pupils, adjusted for the relative achievement levels of students in Japan and the U.S.[4]

The results of these calculations are shown in Table 3. There was still considerable variation in price and productivity levels of Japanese sectors compared to

[4]Based on the standard achievement tests for science subjects of the International Association for the Evaluation of Educational Achievement (IAEEA, 1991).

TABLE 3

COMPARATIVE OUTPUT, PRODUCTIVITY AND PRICE LEVELS JAPAN AND THE U.S., 1975
(geometric averages)

	Purchasing Power Parity (Yen/US$)	Real GDP Japan (U.S. = 100)	GDP per Person Engaged Japan (U.S. = 100)	GDP per Hour Worked Japan (U.S. = 100)	Relative Price Level Japan (U.S. = 100)
1. Agriculture, forestry, fisheries	641.6	23.3	9.4	14.4	216
2. Mining	315.2	6.7	31.2	28.6	106
3. Manufacturing	230.0	53.1	69.7	63.9	78
4. Electricity, gas and water	595.7	12.6	29.2	27.2	201
5. Construction	327.5	57.2	49.0	40.3	110
6. Transport and communication					
Transport and storage	346.9	37.7	39.8	34.2	117
Communication	300.5	19.5	44.4	37.9	101
7. Wholesale and retail trade					
Wholesale trade	315.3	41.9	53.0	46.0	106
Retail trade	332.5	20.1	49.2	36.7	112
8. Finance, insurance and real estate					
Finance	245.5	72.0	153.2	137.9	83
Insurance	211.3	42.8	106.0	96.3	71
Real estate	869.6	10.4	26.6	22.1	293
9. Services and government					
Education	153.6	41.8	196.9	154.4	52
Health	142.2	16.5	153.7	121.6	48
Other services	294.2	43.8	66.9	54.0	99
Government	259.0	21.5	125.5	98.8	87
Total economy	314.3	31.6	52.5	46.1	106

Source: Pilat (1991), with revisions.
Note: The exchange rate was 296.8 Yen to the US$ in 1975.

those in the U.S. Very high price levels were found in agriculture, utilities and real estate, which, at least for agriculture and real estate, are related to the extreme land scarcity in Japan. Productivity levels in these sectors were very low, below 30 percent of the U.S. level. In mining, construction, transport and communication, wholesale and retail trade and other services, PPPs were quite close to the exchange rate and price levels were therefore comparable to those in the U.S. Productivity levels in these sectors were between 30 and 55 percent of those in the U.S. on an hours worked basis. In manufacturing, finance and insurance, education, health and government, price levels were lower than in the U.S. and productivity levels were relatively high, some above those observed in the U.S. Productivity in Japanese manufacturing was still below that in the U.S., which was recently reconfirmed in a new benchmark comparison for 1987 (van Ark and Pilat, 1993).

For the economy as a whole, the 1975 exchange rate gave a reasonable indication of the purchasing power of the Japanese Yen. The PPP was only 6 percent above the exchange rate, although there was much variation between sectors. On average, Japanese productivity in 1975 was still far behind that in the

U.S. Low productivity in agriculture, mining and several market services resulted in a considerable gap with the U.S. level.

3.3. *The Present Productivity Gap*

How have these levels changed since 1975? In the 1980s Japan emerged as the main challenger of the U.S. leadership position in the world economy. Japanese products flooded the world market and in several areas U.S. companies faced severe competition from Japan. Still, in levels of GDP per capita and GDP per hour worked, there remains a considerable gap between Japan and the U.S. Even today there is a duality within the Japanese economy, with some sectors on the edge of world productivity leadership, mainly in manufacturing, and some sectors far below international best practice, in particular agriculture, wholesale and retail trade and some other services.

TABLE 4

PRODUCTIVITY GAP AND COMPARATIVE PRICE LEVEL, JAPAN–U.S. 1990

	GDP per Person Japan/ U.S. (%)	GDP per Hour Worked Japan/U.S. (%)	Purchasing Power Parity (Yen/US$)	Comparative Price Level (U.S. = 100)
1. Agriculture	9.1	13.8	548.4	378.7
2. Mining	68.7	67.4	168.1	116.1
3. Manufacturing	100.6	91.2	156.8	108.3
4. Construction	75.5	65.0	249.2	172.1
5. Electricity, gas & water	43.3	41.3	454.9	314.2
6. Transport & communication	39.1	32.1	332.9	229.9
7. Wholesale & retail trade	87.8	65.2	208.9	144.3
8. Finance, insurance & real estate	68.5	60.3	306.1	211.4
9. Services & Government	109.4	90.5	165.0	114.0
Total economy	77.7	66.0	211.7	146.2

Sources: Updated from Table 3; GDP and employment Japan from EPA (1991; 1993), hours worked from Ministry of Labour (various issues); U.S. GDP, employment and hours series from BEA (1986; 1992; various issues).

Table 4 shows updated productivity results for 1990, based on the 1975 benchmark comparison. There has been considerable catch up in mining, manufacturing, construction and wholesale and retail trade, but in agriculture, utilities, transport and communication little progress was made. Adjusting for hours worked lowers comparative productivity in Japan considerably, from on average 78 percent on a person engaged basis to only 66 percent on an hours worked basis. The largest productivity differences are currently found in agriculture, utilities, and transport and communication. In manufacturing, and services and government the productivity gap has become small or has disappeared altogether. Overall, there remains a considerable gap in productivity between the two countries, partly caused by large variations in productivity within Japan. Even in manufacturing, there is a considerable duality between a branch such as machinery and equipment on the one hand, which is roughly at the same productivity level as the U.S., and

food manufacturing on the other hand, which has only one third of the U.S. productivity level (van Ark and Pilat, 1993).

Relative price levels in Japan have increased since 1975. The strong appreciation of the yen since 1985 has pushed some sectoral price levels up to extreme heights. Most obvious this is the case in agriculture, where currently relative price levels are almost four times those in the U.S. It is much less the case in manufacturing, where companies have been extremely efficient in reducing costs in response to the sharp revaluation. Within manufacturing there are considerable differences between exporting sectors, such as metals and machinery and equipment, and producers for the home market, such as food and textiles, where price levels have been much slower to adjust to the adjustment of the yen (van Ark and Pilat, 1993).

4. A Long Term Perspective of Productivity Levels

4.1. *The Development of Labour Productivity by Sector*

The benchmark comparisons give a rough indication how productivity by sector has changed between 1939 and 1975. A more comprehensive picture can be derived by backdating and updating the benchmark results to intermediate years. Table 5 shows GDP per person for detailed series for the period 1885 to 1990. Only some of these series could be backdated as far as 1885, most are only available from 1910 onwards. A number of interesting results emerge.

First, the productivity of Japan's agricultural sector has stagnated relative to the U.S. since 1885. The agricultural sector has been important in Japanese economic growth as a supplier of labour, as a market for industrial goods and as an early exporter. There has been considerable productivity growth, but not enough to catch up with the U.S. Land productivity is extremely high, but small landholdings have been a constraint on fast productivity growth. Especially in the postwar period Japanese agriculture has fallen behind other sectors of the economy. To keep agricultural incomes up, the sector has been heavily protected, leading to extremely high price levels. In its turn, excessive protection has led to a lack of rationalisation in agriculture, expressed in excessive input use, inefficient part-time farming and slow productivity change (van der Meer and Yamada, 1990).

The most spectacular development of productivity has been in manufacturing. Japan started from productivity levels of less than 10 percent of the U.S., which correspond to those in today's developing countries (van Ark, 1991). Presently, manufacturing has reached productivity levels close to those in the U.S., and in some manufacturing branches Japan has taken the lead (van Ark and Pilat, 1993). Manufacturing has been the leading sector in Japan's process of economic development. Most exports are and have been manufacturing products, changing from textile products in the early stages of development to machinery, electronics and transport equipment in the present situation.

The construction sector has been only slightly less dynamic than manufacturing, with extremely fast productivity growth, especially in the postwar period. In transport and communication, and in electricity, gas and water there is still a substantial productivity gap between both countries. Rail transport is of high

TABLE 5

COMPARATIVE LABOUR PRODUCTIVITY LEVELS BY SECTOR, GDP PER PERSON, JAPAN AS A % OF THE U.S., 1885–1990

	Agriculture, Forestry & Fisheries	Mining	Manufacturing	Construction	Transport & Communication	Electricity, Gas & Water	Other Services and Government	Whole Economy
1885	8.4	7.4	7.9	n.a.	n.a.	n.a.	n.a.	12.9
1900	9.4	15.9	14.8	n.a.	n.a.	n.a	n.a.	15.7
1910	10.2	19.6	11.5	10.2	36.7	22.3	38.9	16.4
1920	12.9	13.3	13.3	12.0	34.2	31.5	51.1	19.0
1929	10.9	16.9	15.9	16.4	47.6	62.5	41.8	19.4
1939	10.9	15.2	24.8	46.0	32.1	49.3	55.6	27.0
1953	5.8	4.5	22.5	19.8	15.6	15.5	42.6	19.8
1965	8.3	11.2	36.3	19.7	25.5	22.1	48.0	30.7
1975	9.4	31.2	69.7	49.0	39.2	29.2	67.9	52.5
1990	9.1	68.7	100.6	75.5	39.1	43.3	91.2	77.7

Sources: 1885–1939 based on 1939 benchmark and time series for output and input as follows. Japanese series are from Ohkawa *et al.*, *op. cit.* Vol. 1 and 2; U.S. from BEA (1986) and from Kendrick (1961). 1953–90 are based on 1975 benchmark and time series as follows: Japanese GDP and employment from EPA (1991; 1993) and from Ohkawa and Rosovsky (1973); U.S. GDP and employment from BEA (1986; 1992; various issues).

quality, but roads are relatively few and are heavily congested. The shorter distances in Japan compared to the United States may have a detrimental effect on productivity as well, due to the effect of terminal services. For shorter distances terminal services, such as loading and unloading, are of greater importance than they are for long distances and are therefore likely to have a negative effect on the average productivity level (Smith, Hitchens and Davies, 1982). The productivity of utility services is also still behind that in the U.S. Sewerage connections are still not universal and heating facilities are generally poor.

In other services and government, where output measurement is the most difficult, the available evidence suggests only a small remaining productivity gap.[5] Within services, the spread in productivity levels is substantial. Productivity in distribution is still rather far behind U.S. levels, partly due to the small size of retail outlets, but in services like education and health quality is quite high and price levels are below those in the United States.

On average, GDP per person in Japan has risen from only 13 percent of the U.S. in 1885 to 78 percent in 1990, an almost sixfold increase in more than hundred years. Before the war, productivity had already doubled, but most of the catch up with U.S. levels took place in the postwar period. The war caused a sharp drop in productivity levels. Levels in 1953 were still substantially behind those in 1939.

Figure 2 shows a slightly more dynamic perspective, for agriculture, mining and manufacturing, and services. The update is based on the 1975 benchmark, but the 1939 benchmark gave almost the same results for these three sectors, suggesting a reasonable consistency between the two benchmarks and the time series. The comparative productivity development of agriculture shows an almost flat line, fluctuating around 10 percent of the U.S. level. In manufacturing, there was some catch up from 1885 to 1900, from 1905 to 1920 and from 1925 to 1940. This final period of catch up is partly a reflection of the Great Depression, which affected Japan much less than the U.S., and the militarisation of the Japanese economy in the late 1930s, which gave a strong stimulus to manufacturing production. Most of the catch up in manufacturing took place after the Second World War. After the war, it took until the late 1950s before Japanese productivity levels matched prewar levels. Since then productivity in manufacturing has shown very fast growth, to levels close to those in the U.S. In the early 1980s, manufacturing productivity growth in the U.S. was fairly rapid, and Japan's productivity level stagnated for some years.

Productivity in the service sector started at a higher level in 1885 than agriculture and mining and manufacturing. Productivity growth in the prewar period was rapid, up to a fairly high level of 60 percent of the U.S. in 1943. The peak in service productivity during the 1940s may be somewhat too high, since the Japanese time series are quite weak for the war period and information on services is somewhat limited. There were, and still are, considerable differences between

[5]It is important to note here that there are substantial methodological differences between Japan and the U.S. in the construction of volume series in the national accounts. This is especially the case for service sectors (OECD, 1987; Gordon and Baily, 1991). Especially for government, but also for construction and some other non-market services the U.S. methods may lead to a substantial understatement of productivity growth, compared to Japanese national accounting methods.

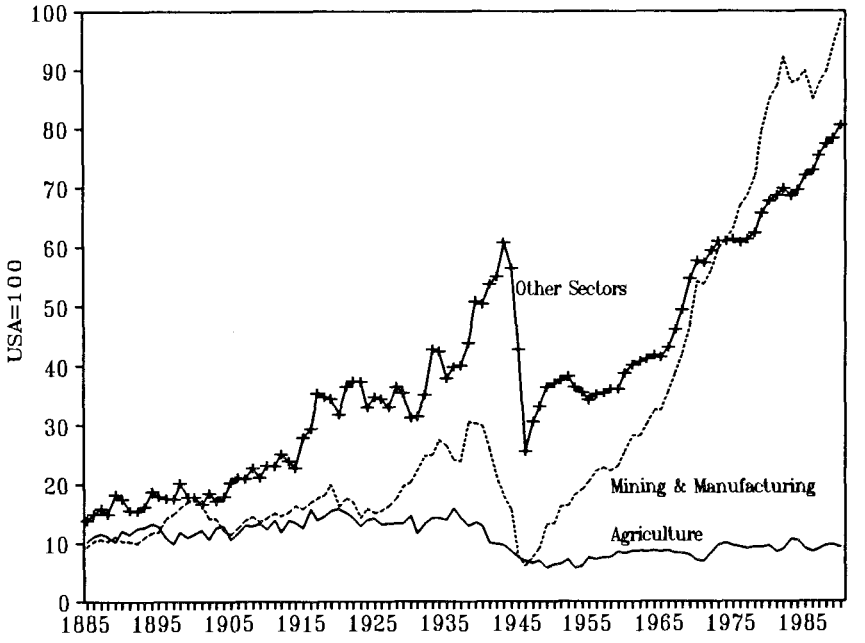

Figure 2. Relative GDP per Person in Main Sectors Japan/U.S., 1885–1990, U.S. = 100.

Source: Based on 1975 benchmark; Japanese series from Ohkawa *et al.*, *op. cit.*, Vol. 1 and 2, and from EPA (1991; 1993); U.S. based on Kendrick (1961) and BEA (1986, 1992; various issues).

productivity levels in sub-sectors of services. The war caused an enormous drop of productivity levels within this sector, and it took until the 1970s before prewar levels were regained. Currently productivity levels in services are on average at 80 percent of those in the U.S., but Table 4 has shown that there is quite some variation between the different service industries.

4.2. *Sectoral Contributions to Catch Up and Convergence*

A country catches up with another if its income or productivity growth rate exceeds that of the other country. In the comparison between Japan and the U.S., this was mainly the case after the Second World War. By following a sectoral approach to catch up it is possible to distinguish two components. Catch up can either be the consequence of faster productivity growth in the various sectors of the economy, or it can result from a structural (or allocative) effect, which causes the composition of employment over sectors of the economy to change from low- (mainly agriculture) to high-productivity sectors of the economy. Labour productivity of the economy as a whole can be defined as:

$$P = \sum_{i=1}^{n} \frac{Y_i}{L_i} * \frac{L_i}{L} = \sum_{i=1}^{n} P_i * E_i \qquad (2)$$

where P is labour productivity, Y output, L employment, E_i the employment share of sector i and $i = 1, \ldots, n$ is the number of sectors distinguished. Differentiating

with respect to time gives the following relation between total output and sectoral output growth (Syrquin, 1986):

$$y = \sum_{i=1}^{n} \frac{Yi}{Y} * y_i. \tag{3}$$

Where small lettering indicate growth rates. For productivity growth the following relation can be derived (Syrquin, 1986):

$$p = \sum_{i=1}^{n} \frac{Y_i}{Y} * p_i + \sum_{i=1}^{n} \frac{Y_i}{Y} * e_i. \tag{4}$$

The first part of formula (4) measures the direct sectoral contributions to productivity growth, whereas the second part calculates the allocative or structural effect. In an international comparison productivity catch up can be attributed either to differences in sectoral growth rates between countries, or to structural changes in both economies. The allocative effect used here is not the same as the effect of improved resource allocation which is often used in growth accounting studies (Denison and Chung, 1976). The latter effect considers resource allocation separately from all other sources of growth. Most growth accounting studies find that this effect is quite small and explains no more than 10 percent of the total growth rate. The allocative effect shown in this paper mainly reflects whether or not the employment share of a particular sector has changed over time, thereby also affecting the contribution of that sector to overall productivity growth.

For each sector, these two components of productivity growth can be calculated, giving a rough indication of the importance of each sector in total productivity growth. In an international comparison, it is the difference between the productivity growth rates of the two countries that matters. For the nine main sectors presented in Table 6, these effects have been calculated for the period 1953–90. The first effect consists of sectoral productivity growth multiplied by its average sectoral share in the initial and final year. For both Japan and the U.S., the most important sector in this respect is manufacturing, which contributes 37 and 44 percent respectively to total weighted productivity growth. This is partly the result of the considerable share of manufacturing in the total economy, and partly of the fast productivity growth in this sector. Important contributions to Japanese productivity growth are also provided by some of the service sectors, in particular wholesale and retail trade. In the U.S., the contribution of services to total productivity growth is much smaller.

The second element is the allocation effect. This is negative if the employment share of the sector decreases, and is positive if it increases. In Japan, the largest negative component is that for agriculture, which had a rather large share in employment in 1953 and a substantial reduction over the period. For finance, insurance and real estate, and for services and government there are considerable positive contributions. Overall, Japan has a fairly large positive allocation effect, which contributes almost 20 percent to total productivity growth. In the U.S., most of the sectoral allocation effects are negative. Especially the large negative contribution of manufacturing plays an important role in this respect. Some of

the services have a positive allocation element, but the overall allocation effect is slightly negative.

In both countries, most of overall productivity growth is the result of productivity growth within sectors. In Japan, it is almost 80 percent, and in the U.S. the allocation effect is negative, so all productivity growth results from growth within sectors. This result also implies that most of Japan's catch up with the U.S. is explained by productivity growth within sectors. Dollar and Wolff (Dollar and Wolff, 1993) have recently shown that a similar pattern can be found for several industrialised economies.

Of total productivity growth in Japan since 1953, more than 30 percent can be allocated to manufacturing. The contributions of agriculture and mining are negligible. Important contributions are made in the services sectors, due to their considerable, and increasing size, and to rapid productivity growth in these sectors. In the U.S., total productivity growth is much more dominated by the service sector. The contributions of agriculture, mining and construction are negative, and manufacturing's contribution is only 20 percent of the total.

For Japan's catch up with the U.S., the difference between the sectoral contributions is important. The importance of manufacturing is apparent since more than 35 percent of total catch up is due to this sector. Construction and finance, insurance and real estate also make important contributions, even though their share in the total economy is fairly small. Japanese wholesale and retail trade, still known as a fairly backward sector compared to the U.S., has been able to achieve considerable productivity gains and contributes a substantial part to total catch up. The final important sector is services and government. This sector is the largest of those distinguished here and as such makes a considerable contribution.

These calculations show that the Japanese catch up with U.S. productivity levels is due mainly to faster productivity growth in manufacturing, construction and some of the service sectors. In most of these sectors catch up is related to strong productivity performance in the Japanese sectors, but in construction and some of the services U.S. productivity performance has been particularly weak. The apparently poor performance of these U.S. sectors may partly result from measurement problems (Gordon and Baily, 1991).

5. Concluding Remarks

Disaggregated comparisons of output, productivity and prices by industry of origin are feasible, also for historical benchmarks. They show that relative productivity is not uniformly spread between countries and between sectors. Between developed and developing countries, there appear to be considerable differences between tradable and non-tradable sectors. Sheltering sectors from international competition can keep price levels high and productivity low even in tradable sectors. In Japan's case, this is definitely the case for agriculture. Research for more countries is feasible, especially for the postwar period. Much of the information is available from regular statistical publications and the ICP investigation has provided valuable information on price levels of services.

The spread in productivity and price levels between Japan and the U.S. is large. In some services productivity levels have been close from the start. In others

TABLE 6

SECTORAL CONTRIBUTIONS TO PRODUCTIVITY GROWTH JAPAN AND U.S., 1953–90 (Annual Compound Growth Rates, in Percent)

	Japan			U.S.				
	Weighted Productivity Growth (in %) (1)	Allocation Effect (in %) (2)	Total Sectoral Effect (in %) (3)	Weighted Productivity Growth (in %) (4)	Allocation Effect (in %) (5)	Total Sectoral Effect (in %) (6)	Difference Japan/U.S. (Col. 3–Col. 6) (in %) (7)	Contribution of Sector to Total Difference (in %) (8)
Agriculture	0.39	−0.38	0.01	0.11	−0.13	−0.01	0.02	0.6
Mining	0.04	−0.03	0.01	0.07	−0.12	−0.04	0.06	1.5
Manufacturing	1.47	0.15	1.62	0.60	−0.34	0.25	1.37	35.4
Construction	0.28	0.15	0.43	−0.03	−0.00	−0.04	0.46	12.0
Utilities	0.15	0.01	0.16	0.09	−0.01	0.07	0.09	2.2
Transport & communication	0.29	0.03	0.31	0.17	−0.06	0.11	0.21	5.4
Wholesale & retail trade	0.62	0.11	0.73	0.23	0.07	0.31	0.42	11.0
Finance, insurance & real estate	0.34	0.45	0.79	0.10	0.18	0.28	0.51	13.3
Services & government	0.43	0.62	1.04	0.04	0.29	0.33	0.72	18.6
Total	4.01	1.11	5.11	1.37	−0.12	1.25	3.86	100.0

Sources: Based on formula 4; Japanese data from EPA (1991; 1993); U.S. from BEA (1986; 1992; various issues).

the gap was enormous in 1885 and has decreased considerably. Manufacturing makes a large contribution to Japan's catch up with the U.S. This is not surprising. Manufacturing is usually seen as the most dynamic sector in the economy, and is probably the sector must open to technological diffusion. It is in manufacturing that Japan is presently threatening U.S. leadership. In some sub-sectors of manufacturing Japan has already taken over the lead (Van Ark and Pilat, 1993). Some of the service sectors have also made important contributions to catch up, but others have stagnated at low productivity levels. For the economy as a whole, Japan's productivity performance presents much less of a challenge to U.S. productivity leadership. Productivity in agriculture and some services is still far behind U.S. levels. It is here that the challenge for Japan lies. Will Japan be able to catch up in these sectors of the economy? If the Japanese economy is becoming more open to international competition this may be an important question. It is not likely that Japan will take over the productivity lead from the United States in the short term. The productivity gap is still quite large.

Much research needs to be done. Why do some sectors catch up and why do others fall behind? Do the factors which determine catch up depend only on national characteristics or can we learn some general lessons, also at the sectoral level? Where measurement is concerned many problems remain. The measurement of output in services is no simple task and some of the indicators used in this paper are admittedly rough. More efforts are currently being made to develop better indicators.

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