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REAL GDP IN PRE-WAR EAST ASIA: A 1934–36 BENCHMARK PURCHASING POWER PARITY COMPARISON WITH THE U.S.

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This article provides estimates of purchasing power parity (PPP) converters for expenditure side GDP of Japan/China, Japan/U.S. and China/U.S. in 1934–36 through a detailed matching of prices for more than 50 types of goods and services in private consumption and about 20 items or sectors for investment and government expenditure. Linking with the earlier studies on the price levels of Taiwan and Korea relative to Japan, we derive the mid-1930s benchmark PPP adjusted per capita income of Japan, China, Taiwan and Korea at 32, 11, 23, and 12 percent of the U.S. level respectively. These estimates correct the consistent downward bias in East Asian income levels based on market exchange rate conversions. Compared with Angus Maddison's estimates based on the 1990 benchmark back-projection, our current-price based result are 18 and 44 percent lower for Japan and Korea, and 4 and 10 percent higher for Taiwan and China respectively in the mid-1930s. We develop a preliminary theoretical and empirical framework to examine the possible source of the biases in the back-projection method. The article ends with a discussion on historical implications of our findings on the initial conditions and long-term growth dynamics in East Asia.

INTRODUCTION

In the world history of modern economic growth, the East Asian miracle is a relatively recent phenomenon. The catch-up of Japan, Taiwan and Korea with the world's leading economies is a 20th century, or more precisely, a post-World War II (WWII) affair, while the economic surge of China is only a matter of the last two decades. However, as revealed by the burgeoning literature on economic growth,

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long-term historical factors provide us with crucial insights into both the causal determinants and the mechanism of modern economic growth. What were the initial conditions of East Asian economies prior to their take-off? Were there shared vital historical factors behind their miracles?

These questions cannot be properly answered without long-term series of national accounts. Among the East Asian economies, the most consistent and reliable long-term GDP series going back to the late-19th century are available only for Japan, partly thanks to the efforts of the Long-Term Economic Statistics (LTES) project under the leadership of Kazushi Ohkawa at the Institute of Economic Research of Hitotsubashi University in Japan.[1] The Hitotsubashi group extended this line of research to two former Japanese colonies, Taiwan and Korea, with the 1988 publication of a statistical volume compiled by Mizoguchi and Umemura. The volume provides annual estimates of GDP and its various components for these two economies during the period of Japanese occupation based on the detailed economic statistics of the colonial administrations. Compared with these countries, historical macroeconomic statistics for China remain sketchy. Solid economic statistics for standard national accounts are available only for the 1930s, leading to the pioneering reconstruction of China's GDP for the period 1931–36 carried out by Ou (1947), Liu (1946), and Liu and Yeh (1965).

These pre-war GDP series are all based on their domestic currencies. As is well-known, conversion of per capita incomes based on market exchange rates tends to systematically underestimate the real per capita income level of lower income countries since it fails to incorporate differences in the price level for non-tradable goods (Balassa, 1964; Samuelson, 1964). Yet research on the construction of purchasing power parity (PPP) converters for GDP for the pre-war period, especially for developing countries such as those in East Asia, have barely started. The national accounts datasets based on PPP conversion by the renowned Penn World Table group only cover the post-war period. Angus Maddison is possibly the only scholar to have attempted a systematic reconstruction of long-term national accounts for most countries around the world. To arrive at globally comparable series for the pre-war period, Maddison relied on the use of 1990 benchmark PPPs to project per capita GDP values backward using domestic real per capita GDP growth rates. This methodology, adopted due to the absence of historical PPP converters, has its inherent index number problems associated with factors such as long-term relative shifts in a country's terms of trade and economic structure.

The present paper develops a full-fledged reconstruction of a three-way, bilateral expenditure PPPs for Japan, China and the U.S. for 1934–36. We conduct a detailed matching of the prices of more than 50 types of goods and services for private consumption and about 20 expenditure items for private investment and government expenditure. We find that average consumer prices in China in 1934–36 are 73 percent that of Japan and 32 percent that of the U.S. respectively, while the average GDP price level in Japan is 43 percent that of the U.S. Linking with the

[1]For Japan, there is the 14 volume LTES publication in Japanese. For an abridged English version, see Ohkawa and Shinohara (1979).

Fukao *et al*. study (2006) on the relative price levels of Taiwan and Korea and using Japan as the bridge country, we derive the mid-1930s benchmark PPP-adjusted per capita income of Japan, China, Taiwan, and Korea at 32, 11, 23, and 12 percent of that of the U.S. respectively. These figures are consistently higher than their corresponding per capita GDP estimates based on current market exchange rates, which are 14, 3.6, 9, and 5.2 percent that of the U.S. level respectively. On the other hand, in comparison with Maddison's 1990 benchmark back-projected estimate, our current price values (expressed in 1990 dollars) are 18 and 44 percent lower for Japan and Korea, but 4 and 10 percent higher for Taiwan and China respectively (Maddison, 2003, p. 182).

Our new estimates have considerable implications for both the levels and growth trajectories of these four East Asian economies. In particular, Japanese as well as Korean per capita incomes were lower than previously thought. In fact, comparing our estimate with the data for other countries provided in Maddison (2003) suggests that Japan's per capita income during this period was only marginally higher than that of Malaysia or the Philippines. In other words, Japan launched her full military venture on the Asian continent with a per-capita income roughly comparable to some of the resource-rich Asian countries, most of which were still Western colonies. Our new benchmark PPP estimates, if projected backward and forward, shed new light on the initial GDPs of Japan and East Asia around the mid-19th century and the post-WWII period.

The remainder of this paper is divided into four sections. The first section describes our PPP estimation procedure and reports our current-price PPP estimates in 1934–36. In Section 2 we present our new estimates of per capita incomes in the four East Asian economies and compare them with those based on current market exchange rates as well as the backward projection estimates. Section 3 discusses the index number biases embedded in the back-projection method. Section 4, the summary section, provides a brief reassessment of initial conditions and long-term growth dynamics in East Asia based on our new findings.

1. Current-Price PPP Estimates for 1934–36

We adopt the methodology used by several rounds of the International Comparison Program (ICP) for the post-WWII benchmark periods.[2] We choose the 1934–36 period as our benchmark for several reasons. First, this period has been consistently used as the benchmark in the LTES project. Second, for Japan and her two former colonies, 1934–36 was a period of relative economic and price stability, falling between the severe deflation that lead to Japan's banning of gold exports in 1931–32 and the economic dislocation of the late 1930s brought about by the outbreak of the Sino-Japanese War.[3] In China, there was a major monetary reform by the Nationalist government in 1933 which replaced the traditional silver-based monetary system with a modern unified currency under the control of a Central Bank. More importantly, for the 1931–36 period, we have the first reasonably reliable benchmark GDP estimate. For East Asia in general, it was only during the

[2]For the ICP study, see Heston and Summers (1993) and Maddison (1995).
[3]For the general price level of 1934–36, see Ohkawa and Shinohara (1979, table A50, p. 388).

1930s that urban and rural household surveys became much more plentiful and reliable.

Our computation of relative price levels employs the standard binary matching of two countries. We derived the Fisher geometric mean as follows. For N number of goods and services, the price level in the currency of the numeraire or base country (sub- or superscripted as B here) relative to the price level of country i is calculated as follows:

$$P_{i,B}^{B}=\frac{\sum p_n^i q_n^B}{\sum p_n^B q_n^B}=\frac{\sum \frac{p_n^i}{p_n^B} p_n^B q_n^B}{\sum p_n^B q_n^B}=\sum \frac{p_n^i}{p_n^B}\omega_n^B$$

where p_n^i denotes absolute price level of commodities (or services) n in country i in base country currency and ω_n^B denotes the consumption expenditure weight for the period 1934–36. The summation sign is summed across N types of goods and services. We use the average market exchange rate in 1934–36 for conversion of absolute price levels. The formula using the consumption weight of country i is:

$$P_{i,B}^{i}=\frac{\sum p_n^i q_n^i}{\sum p_n^B q_n^i}=\frac{\sum p_n^i q_n^i}{\sum \frac{p_n^B}{p_n^i} p_n^i q_n^i}=\frac{1}{\sum \frac{p_n^B}{p_n^i}\omega_n^i}.$$

Finally, the geometric average of the two price indices (the Fisher index) $P_{i,B}=\sqrt{P_{i,B}^{i}\times P_{i,B}^{B}}$ gives us country i's absolute price level relative to that of the base country.

PPP Converter for Private Consumption: Japan and China

The information on prices and expenditure weights for Japan is largely drawn from the earlier PPP study of Yuan and Fukao (2002) and Fukao *et al.* (2006). There, prices for each item in Japan in most cases are calculated as the simple average of the retail prices in 12–14 major cities.

For China, we rely on more than 60 volumes of detailed retail price statistics compiled in 1955 by the Communist government (Gongnongye Shangpin Bijia Wenti Diaocha Yanjiu Ziliao Bangongshi, 1956–57). The volumes are entitled "Gongnongye Shangpin Bijia Wenti Diaocha Yanjiu Ziliao Huibian (Archive Materials for Studies of Industrial and Agricultural Commodity Prices)." The retail price information in these volumes is mostly culled from the account books of major stores in urban cities. The price statistics were published and circulated internally within the Chinese government to examine changes in relative prices of agriculture over industry between the 1930s the 1950s. Our retail prices used are the simple averages of 11 cities across China. For some of the services, such as transportation, communication and entertainment and so on, we use a multitude of sources such as local surveys, gazettes, and newspapers in both China and Japan.

TABLE 1

Consumption Price Levels of China Relative to Japan (1934–36; Japan = 1)

	Chinese Expenditure Weight	Japanese Expenditure Weight	Fisher Average
Total	0.65	0.83	0.73
Food	0.66	0.79	0.72
Lighting and heat	0.58	1.12	0.80
Clothing and bedding	0.63	1.16	0.86
Housing expenses	0.57	0.49	0.53
Miscellaneous	0.75	0.84	0.79

Source: See text.

We employ three levels of consumption weights, denoted as I, II and III in Appendix A, Table A1. The consumption weights at the most aggregate level (level I) are based on Zhang (2001, pp. 375–6) with adjustments in food and miscellaneous categories. Level II weights are based on various local urban and rural surveys with shares weighted by the urban and rural population figures. For level III, the most detailed level, we make use of two consumption surveys for Beijing and Shanghai to represent the different consumption patterns of Northern and Southern China. Our level III weights are derived as the weighted average of these two cities with weights equal to the population shares for China north and south of the Yangzi River.[4]

Table A1 shows a matching of 51 items. Among the five consumption categories as listed in Table 1, Chinese housing expenses are the cheapest followed by food prices, which reflects the differential resource endowment conditions and stages of development. Another notable feature in Table 1 is the large discrepancy between the relative price levels of lighting and heating based on Chinese versus Japanese expenditure weights (0.58 versus 1.12, see also Table A1). The disparity reveals China's very low rates of electrification and relatively high cost of electric power in comparison to that of Japan, a powerful indicator of the differential degree of economic modernization between these two countries for the period.[5] The overall relative price level of China is 73 percent that of Japan.

PPP Converter for Private Consumption: Japan and the United States

Price data for the U.S. in the mid-1930s are fairly abundant and reliable. For most of the food items, we rely on the Bureaus of Labor Statistics Bulletin No. 635 (US Department of Labor, 1938) which provides weighted averages of retail prices in 51 cities. For the retail prices of fuel and utilities as well as wage rates, we use the *Handbook of Labor Statistics* (1941). Other sources include the Statistical Abstract of the United States (1938) (US Department of Commerce, 1939) for items such as clothing and utilities, and micro data from a comprehensive national urban household survey of consumer purchases in 1935–36. This household-based dataset can

[4]Source and methods on these weights are reported in Yuan (2005, chapter 1).

[5]Total electric power generated in Japan is more than 10 times that in China (excluding Japanese-controlled Manchuria) in the 1930s. For total electric power generated in Japan and China in the 1930s, see Minami (1965) and Wang (1988) respectively.

TABLE 2
Consumption Price Levels of Japan Relative to the U.S. (1934–36; U.S. = 1)

	Japanese Expenditure Weight	U.S. Expenditure Weight	Fisher Average
Total	0.34	0.58	0.45
Food	0.37	0.62	0.48
Lighting and heat	1.06	0.89	0.97
Clothing and bedding	0.25	0.49	0.35
Housing expenses	0.59	0.67	0.63
Miscellaneous	0.28	0.48	0.36

Source: See text.

now be accessed through the Inter-university Consortium for Political and Social Research (ICPSR) website hosted by the University of Michigan (http://www.icpsr.umich.edu).

The Historical Statistics of the U.S. (bicentennial edition) provides us with the level I and II consumption expenditure weights. The detailed item weights in the mid-1930s are largely drawn from the cost of living survey in a Bureau of Labor Statistics publication (US Department of Labor, 1941a).

Details of the matching and source notes are presented in Appendix A, Table A2. Table 2 summarizes our U.S.–Japan binary matching of 53 items of goods and services altogether. It shows that around the mid-1930s the average cost of food in Japan was less than half of that in the United States. The average cost of miscellaneous items in Japan, consisting mostly of services such as transportation, communication, education and entertainment, was only 36 percent of the U.S. level. In the case of lighting and heating which mostly consist of energy items, the Japanese price level was nearly identical to the U.S. level. Housing expenses, which include the rent of land—a scarce factor in Japan—were about 63 percent of the U.S. level. Table A2 suggests that Japanese nominal wage rates (for teachers, doctors and unskilled workers) were only about 10 percent the U.S. level based on mid-1930s exchange rates. The low wages and high energy and housing prices in Japan reflect differences in resource endowments and productivity levels during this period.[6] The overall relative price level of Japan relative to the U.S. turns out to be 45 percent for the mid-1930s benchmark.

PPP Converters for Private Consumption in East Asia

As a cross-check, we make a direct PPP comparison between the U.S. and China as shown in Appendix A, Table A3. While the majority of price data for this comparison are derived from those in Tables A1 and A2, we also include additional price data from various sources. Overall, about 50 items of goods and services were matched, showing an overall Chinese price level at 32 percent of the U.S. level. This ratio is nearly identical to the product of the China–Japan and Japan–U.S. relative price levels (73% × 45%), thus satisfying the transitivity conditions of multilateral comparison. Table 3 summarizes the major categories of the China–U.S. comparison, showing most Chinese price categories were only about

[6]For the relatively low Japanese labor productivity levels relative to those of the U.S. in the pre-WWII period based on a production sectoral level PPP comparison, see Pilat (1994).

TABLE 3

Consumption Price Levels of China Relative to the U.S. (1934–36; U.S. = 1)

	Chinese Expenditure Weight	U.S. Expenditure Weight	Fisher Average
Total	0.26	0.38	0.32
Food	0.27	0.35	0.31
Lighting and heat	0.70	0.92	0.80
Clothing and bedding	0.24	0.28	0.26
Housing expenses	0.15	0.24	0.19
Miscellaneous	0.21	0.47	0.32

Source: See text.

TABLE 4

Consumption Price Levels of East Asian Countries Relative to the U.S. (Fisher Average) (1934–36 U.S. = 1)

	China	Taiwan	Korea	Japan
Total	0.32	0.39	0.43	0.45
Food	0.31	0.42	0.45	0.48
Lighting and heat	0.80	0.77	0.80	0.97
Clothing and bedding	0.26	0.33	0.33	0.35
Housing expenses	0.19	0.46	0.55	0.62
Miscellaneous	0.32	0.30	0.26	0.36
Tradable*	0.77	0.88	0.93	*0.55*
Non-tradable*	0.68	0.78	0.71	*0.39*

Notes: *Relative price levels for tradable and non-tradable for Japan are calculated relative to the U.S. For the other three economies, they are computed relative to Japan.

1. Tradable goods for Korea and Taiwan can be found in Fukao *et al*. (2006).

2. Tradable goods for China: food, clothing and bedding, firewood, coal, matches, lamp oil, wooden boards, wash basins, hygiene products, soap, toothbrushes, medical alcohol.

3. Tradable goods for Japan are items marked with "1" in Table A2.

4. The individual weights for tradable and non-tradable items are the same consumption weights used in Tables A1, A2 and A3. For the Japan–China comparison, the aggregate weights used for tradables are 63 percent for Japan and 89 percent for China. For the Japan–U.S. comparison, the weights used for tradables are 47 percent for Japan and 42 percent for the U.S.

20–30 percent of the U.S. level, except that of lighting and heating which was 80 percent. This is consistent with the findings in Tables 1 and 2.

The studies by Yuan and Fukao (2002) and Fukao *et al*. (2006) matched 61 types of goods and services for the Japan–Korea comparison and 58 items for the Japan–Taiwan comparison. We combine the consumption PPPs from that research with our current result to convert the relative price levels of these two economies to the basis of the U.S. by using Japan as the bridge country and applying the Fisher averages across the five upper level consumption weights. The final results for all the four East Asian economies are presented in Table 4 which gives the price levels of China, Taiwan, Korea and Japan relative to the United States at 32, 39, 43, and 45 percent respectively. Overall, price levels in East Asia were far lower in comparison with the U.S. than within the region. Within East Asia, price levels within the Japanese colonial empire were closer to each other than with China, a fact consistent with Japan's colonial policy which forged a "free trade" zone within the empire by the 1930s.[7]

Table 4 also shows that overall price gaps for non-tradables between East Asia and the U.S. are larger than those for tradables. This is a clear confirmation of the theoretical predictions of the productivity and factor proportion differential models that posit lower price levels for non-tradables in relatively underdeveloped countries. As is well known, using market exchange rates ignores the lower prices—particularly of non-tradables—and thus underestimates the per capita income levels of less developed countries. The ranking of relative price levels presented in Table 4 is consistent with their per capita income levels relative to the United States, which we will show later.

PPP Converter for Private Investment and Government Expenditures: Japan and the United States

Expenditure side GDP consists of private consumption, investment, government expenditure, and net exports. In this section, we follow the standard practice of the International Comparison Projects (ICP) to estimate the other two components of GDP, private investment and government expenditure.[8] For China, relevant data for investment and government expenditure are unavailable. Liu and Yeh (1965, p. 68) indicated that private consumption accounted for 91 percent of Chinese GDP during the benchmark period. We therefore feel reasonably comfortable to use our consumption PPP as a proxy for our GDP PPP in this study.

Due to data limitations, our estimates of PPP converters for private investment and government expenditures for Japan–U.S. have to rely on somewhat crude assumptions. For estimation of PPP converter for private investment, we examine relative price levels of two main categories of private investment: equipment and construction in Japan and the United States. In the case of equipment investment, we use the relative price level calculated by Pilat (1994) for machinery and equipment for 1939. In the case of construction investment, we derive the price levels in Japan and the United States as weighted averages of price for construction materials and wages for construction laborers. The results, presented in Table 5, suggest that the price level for private investment is 50 percent of the U.S. level, higher than the price level for private consumption.

For government expenditure for Japan and the U.S., we divide it into two categories: labor and material costs. Labor costs are measured as the ratio of the average income per government employee in Japan and the U.S. Table 6 shows

[7]Taiwan and Korea became Japanese colonies in 1895 and 1910, respectively. By the 1910s, both Korea and Taiwan were set on a de-facto "Japanese yen exchange standard"—the two Central banks, the Bank of Korea and the Bank of Taiwan, issued their bank notes as circulating currency convertible to the Bank of Japan notes which served as the reserve currency. The currencies of Taiwan and Korea were also yen. The currencies of the three countries were convertible at the 1:1 exchange rate. By the 1930s, Taiwan, Korea and Japan had moved towards a free trade bloc protected by a common external tariff (Yamamoto, 2000).

[8]Consistent with ICP and other international comparison studies, we do not separately estimate PPP for net exports, partly because their share is small as a percentage of total GDP (especially for large countries) and partly because prices of traded goods are already included in other GDP components.

TABLE 5

Relative Price Levels for Private Investment for Japan and the U.S. in 1935

	Weight		Japanese Price Level (U.S. = 1)			
	Japan	U.S.	Japan/U.S.	Japanese Weight	U.S. Weight	Fisher Average
Equipment (machinery and equipment)	0.5	0.5	0.88	0.88	0.88	0.88
Construction				0.22	0.51	0.34
Cement	0.0625	0.075	0.68			
Pig iron	0.0625	0.075	0.78			
Nails	0.0625	0.075	0.72			
Tin plate	0.0625	0.075	0.87			
Wages	0.25	0.2	0.13			
Total	1.0	1.0		0.35	0.69	0.50

Source:

1. The Japan/U.S. relative price for equipment is from Pilat (1994, table 2.5, p. 27). Construction wages are from Table A2. Relative prices for the rest are from wholesale price statistics of both the U.S. and Japan.

2. The weights for Japanese equipment and construction investment are based on Emi (1971, p. 10); for the U.S. the weights are based on US Department of Commerce (1975) (Part I, 1947, p. 283). The shares of raw materials and labor for construction investment for the U.S. are from US Department of Commerce (1975) (Part I, p. 282); for Japan, they are from Fukao *et al*. (2006). We use simple average for individual items of raw materials in Construction for lack of better information.

TABLE 6

Relative Price Levels for Government Expenditure for Japan and the U.S. in 1935

	Weights		Japanese Price Level (U.S. = 1)			
	Japan	U.S.	Japan/U.S.	Japanese Weight	U.S. Weight	Fisher Average
Labor costs	0.24	0.45	0.07	0.07	0.07	0.07
Material costs				0.49	0.61	0.55
Food	0.03	0.02	0.48			
Textiles	0.03	0.01	0.35			
Wood products	0.03	0.06	0.95			
Medical costs	0.14	0.06	0.27			
Chemical products	0.11	0.09	1.33			
Metals & machinery	0.06	0.02	0.88			
Construction	0.08	0.24	0.34			
Transportation and communication	0.21	0.04	0.51			
Coal	0.02	0.01	0.89			
Electricity	0.05	0.01	0.96			
Total	1.01	1.00		0.21	0.37	0.28

Source:

1. Labor costs for Japan are based on the salaries of government employees taken from Emi and Shionoya (1966), which includes the additional bonus (see pp. 222–3 and footnote on p. 222 for the bonus part). Labor costs for U.S. are from US Department of Commerce (1975) (Part II, pp. 1100–1). Data on chemical products, metals & machinery, transportation and communication are from Pilat (1994, p. 24). The remaining figures are from Table A2.

2. The weight for labor and material costs for Japan is based on Emi and Shionoya (1966, pp. 31–2); the equivalent weight for the U.S. is based on US Department of Commerce (1975) (pp. 282–3). (The share of material costs is assumed to be equal to the share of total intermediate inputs in government purchases, while value added is assumed to be equal to labor costs. The U.S. shares used are for the 1950s and 60s.) The weights for materials for Japan are based on Fukao *et al*. (2006, table 5). The weights for materials for the U.S. are based on *Historical Statistics* (pp. 282–3).

TABLE 7

East Asian Price Levels Relative to the U.S. (1934–36)

	Expenditure Weight				Relative Price Level (Fisher average, U.S. = 1)		
	Taiwan	Korea	Japan	U.S.	Taiwan	Korea	Japan
Consumption	0.73	0.84	0.70	0.77	0.39	0.43	0.45
Private investment	0.20	0.11	0.18	0.08	0.47	0.49	0.50
Government expenditure	0.07	0.05	0.12	0.15	0.24	0.25	0.28
GDP	1.00	1.00	1.00	1.00	0.38	0.41	0.43

Source: Price levels and weights for Korea and Taiwan are based on Fukao *et al*. (2006). U.S. weights are based on U.S. Department of Commerce (1998, p. 147).

that the average Japanese government employees' compensation was only 7 percent of that of their U.S. counterparts in nominal terms. The second category, material cost, consists of government purchases from various sectors of the economy. Table 6 provides relative price levels and expenditure weights of ten materials. Their relative price level (of Japan over the U.S.) in weighted average turns out to be 55 percent, higher than that for private consumption. This seems plausible as government purchase draws a substantial share from the investment sector of which Japanese price levels were closer to that in the U.S. Overall, thanks to the much lower remuneration paid to employees in Japan, the Japanese government expenditure price level overall was only 28 percent of that of the U.S.

Using the current-price PPP converters for private consumption, private investment, and government expenditures for Korea and Taiwan (relative to Japan) from Fukao *et al*. (2006), and using Japan as the bridge country, we derive a full set of current-price PPP converters for GDP for the four East Asian economies for the mid-1930s, all converted to the base of the U.S., using the Fisher average. Details of the calculation procedures and the results are reported in Table 7.

2. East Asian Real GDPs in 1934–36

PPP and Market Exchange Rates

Table 8 presents the per capita GDP of the four East Asian economies in 1934–36 U.S. dollars. The first data row shows GDP estimates for the different countries in 1934–36 current prices converted to U.S. dollars at market exchange rates. Not surprisingly, GDP at exchange rates gives very low income estimates for East Asia in the mid-1930s: Japan's per capita income was only 13 percent of that of the U.S. and China was a mere 3.5 percent of the U.S. level. The second row of Table 8 presents the price levels of the four East Asian economies relative to the U.S.

Dividing the exchange rate-based per capita income estimates by the relative price levels, we can derive our 1934–36 benchmark PPP adjusted estimates, presented in the third row of Table 8. In comparison with the exchange rate conversion, our PPP converter more than doubles the per capita income of Japan and Korea and triples the per capita income of Taiwan and China. This is a major correction of the downward exchange rate bias.

TABLE 8

1934–36 East Asian Per Capita GDPs in 1934–36 U.S. Dollars and Relative to the U.S.

	U.S.	Japan	Taiwan	Korea	China
1. Exchange rate converted estimate	574.7	77.1	49.2	29.1	20.1
	100%	13.4%	8.6%	5.1%	3.5%
2. Relative GDP price levels	1	0.43	0.38	0.41	0.32
3. PPP adjusted estimate = 1 ÷ 2	574.7	180.8	129.6	70.9	63.6
	100%	31.5%	22.6%	12.3%	11.1%

Source:

1. GDP for China from Liu and Yeh (1965, p. 68, table 10); for Japan from Ohkawa and Shinohara (1979), for Taiwan and Korea from Mizoguchi and Umemura (1988); for the U.S. from the *Historical Statistics of the U.S.* (the Bicentennial Edition, 1975).

2. 1934–36 exchanges rates: 1 U.S. dollar = 3.43 Japanese yen = 3.01 Chinese yuan (Hsiao, 1974, p. 192). Taiwanese and Korean currencies are fixed at 1:1 to the Japanese currency.

Existing studies on PPP for the pre-war East Asia are few and crude. The study by Clark (1940, p. 41) gave Japanese per capita income in 1925–34 at about 26 percent of the U.S. level, closer to our PPP result than that of exchange rate conversion. However, since both the GDP estimates and price levels used by Clark were long outdated, his study should not be viewed as a direct confirmation of our estimates. The more systematic Japan–U.S. PPP study was carried out by Pilat (1994) with 1939 as the benchmark year and using a production side PPP (versus the expenditure side PPP in this study) approach by matching the unit value ratios of comparable goods and services. His study (Pilat, 1994, p. 24) gives a price level for the overall Japanese economy relative to that of the U.S. at 60.7 percent, higher than our 42 percent figure based on the expenditure approach. The discrepancy is not surprising as the production based PPP matching weighs more heavily toward the tradable items whose prices are likely to be closer across countries.

A crude attempt at calculating purchasing power parities for China and the U.S. was done by Liu Ta-chung, a pioneer in the reconstruction of the 1931–36 Chinese per capita GDP. His market exchange rate conversion, similar to ours, gave the 1931–36 Chinese per capita GDP at 3.8 percent of the U.S. level (Liu, 1946, p. 72). To correct downward exchange rate bias, he compared Chinese and American prices for five categories of agricultural crops and arrived at a Chinese price level of 63 percent of the U.S. level (p. 73). Liu's current-price PPP conversion based on these relative price levels gave the 1931–36 Chinese per capita GDP at 5.7 percent of the U.S. level (Liu, 1946, p. 76). But recognizing that the price level differences in agricultural products were possibly the least important cause of the downward bias, Liu went on to adjust for other structural differences between the U.S. and Chinese economies, a concept that was not clearly spelled out in his study. His final adjustment raised the Chinese per capita income to 9 percent of the U.S. level, a level approaching but still lower than our PPP estimate for China relative to the U.S. as shown in Table 8.

Current-Price PPP versus 1990 Backward Projection

It is very instructive to compare our estimates with the massive dataset compiled by Angus Maddison. In Figure 1, we follow Maddison and convert all per

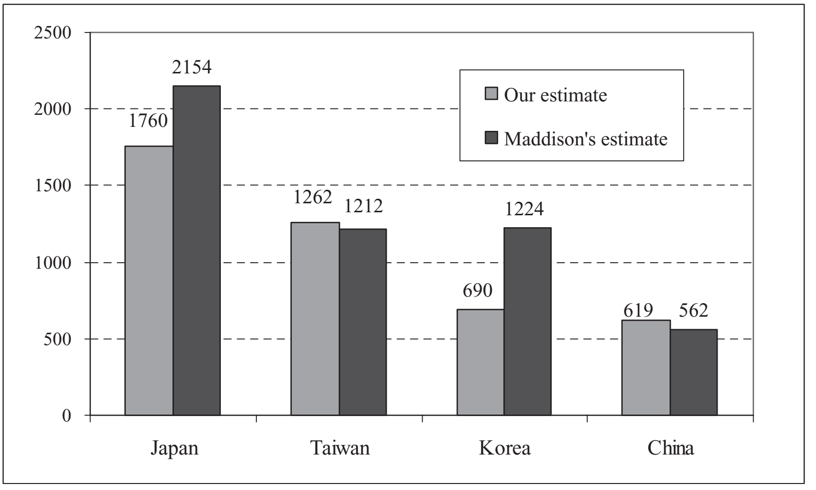

Figure 1. Comparison of Our Current Price PPP Per Capita GDP with Maddison's Back-Projected Estimate (in 1990 U.S. Dollars)

capita GDP estimates into 1990 dollars. Maddison's latest 2003 series provide a back-projected U.S. per capita GDP for 1934–36 at $5,590 in 1990 prices. We use this U.S. figure as the base and apply our relative price levels to derive the per capita incomes of the four East Asian economies in 1990 dollars. Figure 1 compares our 1934–36 benchmark PPP estimates with Maddison's 1990 back-projected estimates, both in 1990 prices.

Figure 1 shows that the deviations between our estimate and Maddison's for Taiwan and China are relatively small. However, his Korean estimate is nearly twice our level and his Japanese figure is 22 percent higher. Maddison's Japanese per capita income of $2,154 (in 1990 dollars) would make the Japanese level at about 39 percent of the U.S. level, higher than our estimate of $1,760, at 32 percent of the U.S. level for 1934–36. Likewise, while the per capita income difference between China and Japan according to Maddison is about 1 to 4, our current price PPP estimate reveals it to be about 1 to 3 for the mid-1930s period. Similar discrepancies in per capita incomes also hold true for Japan versus Taiwan and Korea.

Maddison's upward adjustment of Japanese per capita income from 13 percent (as implied by exchange rate conversion) to 39 percent of the U.S. level would imply a Japanese price level at only about 36 percent of the U.S. level, lower than the 43 percent derived from our study. Similarly, his adjustment of Korean per capita income from 5.1 to 22 percent of the U.S. level would indicate a Korean price level at only 23 percent of the U.S. level, only about half of the 41 percent level derived from our study.

Robustness Checks and Sensitive Test

The discrepancy between our estimates and Maddison's will be explored later. Here we carry out some robustness checks on our PPP estimate. One potential source of error in our PPP comparison is our use of urban price only for these five economies with differential urban–rural shares of population. While urban population shares in the U.S., Japan and Taiwan are roughly comparable, at 56, 54 and 48 percent respectively, the corresponding shares for Korea and China are much lower at 25 percent only.[9] Thus, purely urban-price-based price matching would overestimate the relative price levels of the more rural-based economies of Korea and China. A back-of-the-envelope calculation would show that for two economies with identical urban–rural price gap, national price level (weighted average of urban and rural prices) in a country with 25 percent urbanization would be 4.5 percent lower than a country with 50 percent share of urban population. On the other hand, this downward bias in price levels can also be potentially offset by the relatively lower quality of products and services in poorer and rural-based economies. Thus, our current study makes no adjustment in price level with respect to differential urban–rural population shares.[10]

A second issue is the coverage of our PPP study. With 50–60 items for private consumption and 15–20 items for investment and government expenditure categories, our study is superior to other known PPP research for the pre-WWII period. However, it is still relatively crude by the standard of the large-scale post-WWII ICP exercise that employed 153 categories with hundreds or thousands of individual item prices (Kravis *et al.*, 1982). To test the possible biases of the limited coverage, we match directly the individual categories items of our 1934–36 benchmark with the 153 categories in the 1967 round of ICP study, the earliest year available for Japan–U.S. comparison (see Kravis *et al.*, 1975, pp. 257–61). Altogether 46 out of 153 categories in 1967 can be matched.[11] The 1967 shares of these 46 categories amounted to 36 percent with Japanese weight and 47 percent with U.S. weight. Our PPP calculation (using Fisher average) based on these 46 categories alone yields a Japanese price level at 58 percent of the U.S., lower than the 63 percent level derived from the 153 categories in 1967. This 5 percent difference can be easily explained by the fact that most of the unmatched categories are new and modern products that appeared in the post-WWII period, whose relative price levels between Japan and U.S. were smaller than average. In view of the above, we believe that, were a full-scale ICP type of PPP study conducted for the 1934–35 benchmark, the price gap between the ideal ICP study and our study would be limited, certainly below the 5 percent difference.

Finally, we test to see how sensitive our PPP price level to the price of any individual item. We perform an experiment on our China–Japan data sets in Table A2 by dropping an individual item whose weight redistributed to all other items in the data set to re-compute the Fisher-PPP converter. We find that the overall deviation of the recomputed PPPs (with one item excluded each time) from the full-sample based PPP is very small (a standard deviation of 0.0065 for the mean China–Japan relative price level of 0.73). These tests give us some confidence

[9]For urban shares in the U.S., Japan, Taiwan, Korea and China, see US Department of Commerce (1975), *Part I* (p. 11), Bank of Japan (1966, p.14), Mizoguchi and Umemura (1988, pp. 263, 268), and Buck (1937, p. 362).

[10]For the urban–rural price gap in the U.K. and U.S., see Ward and Devereux (2003, p. 831).

[11]The 153 categories for 1967 can be found in Kravis *et al.* (1975, pp. 257–9). The matched 46 categories out of the 153 categories in 1967 are categories 1–3, 7, 9–10, 13–15, 17, 21–23, 28, 30, 33, 37, 38, 40, 48, 52, 54, 55, 58, 72, 75, 83, 85–87, 90, 97–100, 104–106, 125, 136, 137, 149–153.

TABLE 9

Comparison of Relative Price Levels in Pre- and Post-War Periods (U.S. = 100) (numbers in parentheses are PPP adjusted per capita incomes relative to the U.S.)

	Japan	Korea*	Taiwan	China	Sources
1934–36	*35 (39)*	*23 (22)*	*40 (22)*	*35 (10)*	*Maddison back-projection*
	43 (32)	**41 (13)**	**38 (23)**	**32 (11)**	**This study**
Expenditure based PPP					
1952	52 (18)				Watanabe and Komiya, 1958
1967	63 (48)				Kravis *et al*., 1975, pp. 238–9
1970	68 (59)	47 (12)			Kravis *et al*., 1982, pp. 13, 21
1973	95 (64)	43 (15)			Kravis *et al*., 1982, pp. 13, 21
1975	90 (68)	39 (21)			Kravis *et al*., 1982, pp. 13, 21
1985	93 (72)	53 (24)	57 (34)		Yotopulos and Lin, p. 14
1986				23 (8)	Maddison, 1998, pp. 153–4
Production based PPP					
1939	61 (27)				Pilat, 1994, p. 24
1965	55 (46)	38 (8)	33 (18)		Maddison, 1970, p. 295
1975	106 (53)	66 (18)			Pilat, 1994, pp. 118, 121
1985	101 (65)	66 (31)			Pilat, 1994, pp. 152, 154

*South Korea for the post-WWII period.

Source:

1952 is from Watanabe and Komiya 1958. The study did not include, for example, expenditure on energy and housing, the relatively high-priced items in Japan. It did not calculate relative per capita GDP for 1952. We recalculate it with the exchange rate at 1 U.S. dollar = 360 yen and the 52% relative price levels. The per capita GDP estimates for Japan and the U.S. in 1938 and 1952 current prices are from Ohkawa and Shinohara (1979, p. 283) and *Historical Statistics of the United States* (1975, pp. F10–30).

Maddison's PPP converter for China–U.S. in 1986 is based on study by Ren Rouen.

that the margin of errors in our estimate are within reasonable bounds and our PPP result is robust even judged by the stringent post-WWII ICP standard.

Table 9 presents a comprehensive comparison of the relative GDP price levels derived from our study against those in other PPP benchmark studies across different periods as well as Maddison's back-projection. The table shows clearly that the implicit relative price levels in Maddison's back-projected estimates for Japan and Korea—the two countries where our per capita GDP estimates differ most as shown in Figure 1—seemed implausibly low. Surprisingly, even his own production side based PPP studies on Japan and Korea for 1965 showed relative price levels and per capita GDP far closer to our study than his own back-projected estimate.

3. Backward Projection: Theoretical and Empirical Issues

Our finding of a significant discrepancy between GDP figures based on current price PPP and back-projected PPP have long been confirmed by various existing research such as the numerous rounds of post-war ICP studies (Kravis *et al.*, 1982; Heston and Summers, 1993; Maddison, 1998). By comparing past ICP results of every five years from 1970 and backward projected per capita GDP based on 1990 benchmark PPP, their studies reveal substantial gaps between the two values for many countries. Recent studies on long-term historical data of the U.S. and Europe also confirmed similar discrepancies (Ward and Devereux, 2003, 2005). We see two major sources of errors arising out of back-projection from the 1990 benchmark. The first is likely to occur in the linking of a long-term real GDP series which consists of disparate volume series often reconstructed with varying quality, definitions and benchmarks. The second is the index number bias inherent in the back-projection procedure which cast the later period price or quantity weights to the current period ones. Below, we turn to these two issues.

The Making of Real GDP Series in East Asia and the U.S.

Long-term domestic real GDP series used for a period of 60 years between 1930 and 1990 rarely come from a single continuous series. Instead, disparate series with multiple benchmarks or varying definitions, quality and coverage were often "patched together." For example, the coverage and definition of GDP statistics have been revised in the transition from the 1968 SNA to the 1993 SNA. The procedure of using the late-year benchmark to link backward, while useful in updating the past series of real GDP from the old definition to the new definition, could potentially change the original values of the current price nominal GDP in the earlier period and lead to discrepancy between back-projected and current price estimates. Below, we trace Maddison's linking procedure for the five economies under study here.

We first examine Taiwan and China where the discrepancies between current and back-projected estimates are the smallest. The Taiwan real GDP series used by Maddison is the most consistent, based entirely on the 1912–90 series meticulously reconstructed by Mizoguchi and others using 1960 price as the benchmark. Maddison's Taiwan 1990 benchmark PPP came from the Penn World Table, which in turn was based on the 1985 benchmark PPP by Yotopoulos and Lin (1993), updated to 1990 with domestic real GDP growth rates (see Maddison, 2003, p. 153; Fukao *et al.*, 2006). Maddison's Chinese GDP series is presented in detail in his 1998 OECD publication. As is well-known, both the level and trend of Chinese GDP in the post-WWII Communist period are highly controversial due to major differences in definitions and coverage. Maddison's linking of Chinese GDP series between the 1930s and 1950s relied on the careful work of Liu and Yeh (1965) and others. In fact, Maddison used the 1930s GDP to revise the real GDP level for the Communist period (pp. 149–55). Maddison's 1990 benchmark PPP is updated from 1986 benchmark PPP estimated by Ren Ruoen (Maddison, 1998, pp. 153–4).

In contrast, Maddison's linking of Korea real GDP seems the most problematic. There are no consistent GDP series for Korea between 1938 and 1953. Maddison linked the colonial series and post-WWII series by combining a host of disparate independent estimates added with assumptions about the split of territories and population between North and South Korea in the post-war period (Maddison, 2003, p. 153). Although further investigation is necessary, we suspect the large margin of errors inherent in Maddison's linking give rise to the striking discrepancy between the current price and back-projected per capita income estimate for 1934–36 Korea (see Fukao *et al.*, 2006 for details).

Finally, we turn to examine the linking of U.S. and Japanese real GDP series. The U.S. real GDP series is the most straightforward as Maddison's entire series from 1929 onward is from the official Department of Commerce, Bureau of Economic Analysis (BEA) statistics from which we also derive the mid-1930s benchmark current price estimate (Maddison, 2003, pp. 79–80). Discrepancies, if any, between the old and new versions of the BEA series are mostly for the post-war period rather than the 1930s figures and they are usually in the range of 5–6 percent.[12]

For Japan, Maddison used the same Ohkawa and Shinohara GDP series for the pre-war period as we did. However, the series ended in 1940 and the post-war series began only after 1952. Maddison's most recent study filled the war period gap by utilizing an independent study on wartime GDP by Mizoguchi and Nojima (1993). We trace and compare the nominal GDP figures for the three different linking periods at 1940, 1952 and 1960. We find the discrepancies between the nominal figures in different series at each linking periods are relatively minor, and overall the linking procedure by Maddison might lead to a 5.45 percent upward revision of the original Ohkawa and Shinohara series for the pre-war period.[13] Since both the Japanese and U.S. series seem to be raised by about 5–6 percent in this process, updating the real GDP series of both the U.S. and Japan based on the late series is not likely to impact greatly the levels of their nominal GDP in the 1930s.

To sum up, except for Korea, Maddison's linking procedure has been reasonably consistent for the other four economies in this study. Therefore, to explain Maddison's 22 percent upward bias for Japanese per capita income estimate, we look beyond the linking procedure and examine the index number problem bias in back-projection.

Backward Projection Bias: An Index Number Formulation

One difference between our PPP study and the ICP based studies is the use of PPP Fisher average versus the multilateral Geary Khamis (GK) method. It is well-known that the GK method yields lower PPP and thus higher PPP-adjusted real GDP estimates of lower income countries than the Fisher average.[14] According to Maddison's survey (1995, table C-6, p. 172), the Fisher-based PPP only exceeds the GK by about 5–6 percent in 1990, a ratio he used to update the original Fisher-based PPP Taiwan (1985 benchmark) and China (1986 benchmark) into the GK index. For our index number formulation, we present everything in terms of GK international price.

We express the 1990 benchmark backward projected real per capita GDP in benchmark year t (t is 1934–36 in this study) as in equation (1):

[12]See US Department of Commerce (1975), *vol. 1* (p. 224) for the old version and http://www.bea.doc.gov/bea/dn/gdplev.xls for the new version.

[13]The nominal GDP figures for 1940 used by Mizoguchi and Nojima come from Japanese government publications (Keizai Shingi-cho, 1953; Keizai Kikaku-cho, 1963). It is equal to 99 percent of the nominal GDP figures in the Ohkawa and Shinohara series in 1940. Nominal GDP figures used by Maddison to link 1952 and 1960 come from the OECD National Income Statistics (1976, 1999) and are both equal to about 1.03 of the old series. Overall, the linking of the three series in total revised upward the level of real GDP series by 5.45 percent.

[14]The overestimation of per capita GDP in low income countries and thus the underestimation of global inequality due to the use of GK method is explored in detail in Dowrick and Akmal (2005).

(1) $$y_i^E(t,90) = \frac{\mathbf{p}_t^i \mathbf{q}_t^i}{\mathbf{p}_t^i \mathbf{q}_{90}^i} \mathbf{p}_{90}^G \mathbf{q}_{90}^i$$

where $\mathbf{p}_t^i$ denotes a row price vector for commodities (or services) of types *1* through N in country i at time t, and $\mathbf{p}_{90}^G$ denotes the row vector of the reference price (Geary-Khamis (GK) international price), for year 1990. Similarly, $\mathbf{q}_t^i$ and $\mathbf{q}_{90}^i$ are the corresponding column vectors of country i's real per-capita net output.

The first term on the right-hand side of the above equation is the ratio of country i's real per-capita GDP at time t over that in 1990 measured in year t price. The second term is country i's 1990 real per-capita GDP in 1990 GK price. The product of the two terms gives $y_i^E(t,90)$, the Maddison style 1990 back-projected real per-capita GDP of country i at time t, with the superscript E standing for back-projection or extrapolation. These estimates are equivalent to the "Maddison's estimate" for East Asia in Figure 1.

Our 1934–36 benchmark GDP in current price U.S. dollars as shown in row 3 of Table 8 can be formally written as $y_i^C(t) = \frac{\mathbf{p}_t^G \mathbf{q}_t^i}{\mathbf{p}_t^G \mathbf{q}_t^{US}} \times \mathbf{p}_t^{US} \mathbf{q}_t^{US}$, where superscript C stands for current price. This is the ratio of country i's real per-capita GDP to that of the U.S. multiplied by the real per-capita U.S. GDP at time t (1934–36 in this study). To derive our 1934–36 East Asian GDP in 1990 dollars (shown as "Our estimate" in Figure 1), we first divide our current price per capita income estimate, $y_i^C(t)$, by that of the U.S., $y_{US}^C(t) = \mathbf{p}_t^{US} \mathbf{q}_t^{US}$ and then multiply Maddison's 1990 back-projected U.S. estimate, $y_{US}^E(t,90)$. With some cancellation and rearranging of terms, we derive equation (2) as follows:

(2) $$y_i^C(t) \div y_{US}^C(t) \times y_{US}^E(t,90) = \frac{\mathbf{p}_t^G \mathbf{q}_t^i}{\mathbf{p}_t^G \mathbf{q}_t^{US}} \times \frac{\mathbf{p}_t^{US} \mathbf{q}_t^{US}}{\mathbf{p}_t^{US} \mathbf{q}_{90}^{US}} \times \mathbf{p}_{90}^G \mathbf{q}_{90}^{US}.$$

Clearly, since equations (1) and (2) are based on different index number formulae, it can only be pure coincidence that the two figures are equal. To analyze the deviation of these two estimates, we conduct a log-decomposition of the ratio of equations (1) over (2). Rearranging the terms, we express the full log-decomposition identity in equation (3) as follows:

(3) $$\begin{aligned} &\left\{\ln\left(y_i^E(t,90)\right) - \ln\left(y_{US}^E(t,90)\right)\right\} - \left\{\ln\left(y_i^C(t)\right) - \ln\left(y_{US}^C(t)\right)\right\} \\ &= \underbrace{\left\{\ln\left(\frac{\mathbf{p}_t^G \mathbf{q}_{90}^i}{\mathbf{p}_t^G \mathbf{q}_t^i}\right) - \ln\left(\frac{\mathbf{p}_t^i \mathbf{q}_{90}^i}{\mathbf{p}_t^i \mathbf{q}_t^i}\right)\right\}}_{\text{weight inconsistency effect}} + \underbrace{\left\{\ln\left(\frac{\mathbf{p}_{90}^G \mathbf{q}_{90}^i}{\mathbf{p}_t^G \mathbf{q}_{90}^i}\right) - \ln\left(\frac{\mathbf{p}_{90}^G \mathbf{q}_{90}^{US}}{\mathbf{p}_t^G \mathbf{q}_{90}^{US}}\right)\right\}}_{\text{terms of trade effect}} \\ &\quad - \left\{\ln\left(\frac{\mathbf{p}_t^G \mathbf{q}_{90}^{US}}{\mathbf{p}_t^G \mathbf{q}_t^{US}}\right) - \ln\left(\frac{\mathbf{p}_t^{US} \mathbf{q}_{90}^{US}}{\mathbf{p}_t^{US} \mathbf{q}_t^{US}}\right)\right\}. \end{aligned}$$

Equation (3), as cumbersome as it appears, has nice interpretative properties: a positive (or negative) value implies an overestimate (or underestimate) of the t period per capita income using the 1990 back-projection method. We summarize the first two terms in equation (3) as "weight inconsistency" effect, also defined by

Szilágyi (1984). It is the log-difference between country *i*'s real GDP growth rates from *t* to 1990 measured using the *t* period GK price and that based on the *t* period domestic price. This weight inconsistency effect, similar to the so-called "Gerschenkron effect," stems from the divergence in domestic real GDP growth rates derived from the use of international price versus domestic price of the *t* period. As partly shown in our matched price items for the mid-1930s, prices in East Asia relative to the U.S. tended to be relatively lower in the primary and service sectors but higher in manufacturing and industrial goods. As international price at time *t* assigns relatively lower weights than domestic price to the expanding manufacturing sector but higher weights to the slow-growing primary sector and service sectors, real GDP growth rate measured using the 1930s international price would be smaller than that using domestic price. Holding other things constant, the weight-inconsistency effect in our case is likely to be negative, implying that back-projection underestimates country *i*'s real GDP at time *t*.

The second component, captured by the next two terms, is bracketed as "terms of trade effect" in equation (3). It is the log-difference of international GK prices between *t* and 1990 for country *i* and the U.S., each weighted by their respective net output in 1990. With certain assumptions, this is equivalent to country *i*'s Paasche terms of trade index relative to the U.S. This "terms of trade" effect, indicates that if country *i*'s Paasche terms of trade improves (or deteriorates) relative to that for the U.S., then backward projection will overestimate (or underestimate) country *i*'s output at time *t*.

Intuitively, this can be understood by the following hypothetical example. Suppose there are two open economies *A* and *B*. Country *A* is a producer of primary goods and country *B* is a producer of manufacturing goods. Assume two countries' total GDP are equal, measured at the international prices in 1930. By 1990, both countries have doubled their output but international prices for primary goods have also doubled, while those for manufacturing goods remain constant. This would imply that country *A*'s GDP is twice that of country *B* based on 1990 prices due to the terms of trade improvement. If we project backward based on the 1990 international price, we will overestimate the relative standing of country *A* over *B* in comparison to that based on the 1930 international price. Since the East Asian economies are more similar to country *A* type than is the U.S., our conjecture is that back-projection leads to overestimation biases of their per capita incomes in the 1930s.

The final two un-bracketed terms in equation (3) are the log-difference between two U.S. quantity indices measured by GK price and U.S. prices respectively at time *t*. Since our PPP study for 1934–36 benchmark is based on the U.S. as the base country, the difference between U.S. and GK prices in 1934–36 is trivial and can be ignored.

Our index number formulation reveals that the bias effects of weight-inconsistency and terms of trade are in fact opposite in direction. Thus both the direction and magnitude of bias are a function of the relative strength of these mutually offsetting factors. This important insight may explain the lack of any systematic direction in biases as revealed in this study as well as the post-WWII ICP. Ideally, one could empirically test the back-projection bias using long-term data on economic structure and terms of trade. Unfortunately, such an empirical test faces several difficulties. As indicated earlier, long-term real GDP series themselves are rarely consistently back-projected from the 1990 benchmark according to our idealized index number formulation. Often, GDP series with multiple benchmarks or varying definitions are linked together, which could compound existing biases, making it extremely complicated, if not impossible, to disentangle.

In Appendix B, we present a preliminary test on the terms of trade (TOT) effect based on our index number formulation and the ICP data for the post-war period. We assume that weight consistency effect is insignificant and small given the much shorter span of 1970 and 1990 covered in the ICP study. Our regression does confirm a statistically significant coefficient with the right sign. We then apply our finding to the case of Japan and U.S. between 1935 and 1990. We find similar confirmation of this relationship between TOT and back-projection biases. However, our preliminary calculation shows that this TOT improvement in Japan relative to the U.S. can only account for 3 percent of the upward biases, clearly a small fraction in relation to the 22 percent overestimate we found in this study. But, this test is far from ideal due to the various data problems illustrated in Appendix B and that the weight consistency effect is likely to be more significant for the 60 year period between the mid-1930s and 1990 than five year period used in ICP data. While much more research is needed, we believe that the reconstruction of current price benchmark PPP study remains as the most important cross-check on back-projected estimates.

4. Implications and Summary

Pre-war GDP estimates for Japan and East Asia based on back-projection have been widely cited in major textbooks and academic publications on economic growth. Our new current-price based estimates thus carry large implications. First, they realigned the 1930s per capita income ranking and gap among the four East Asian economies studied. Chinese per capita income in the 1930s was 35 percent of the Japanese level according to our estimate, compared with Maddison's 26 percent. This ratio for the Japanese colony of Taiwan is 72 percent, much higher than Maddison's 56 percent. Meanwhile, our estimates show that Taiwanese per capita income is 82 percent higher than Korea, whereas Maddison shows they are comparable (see Figure 1). Second, our estimate of 1934–35 Japanese per capita estimate of $1,760 (in 1990 prices) would—if inserted in the Maddison dataset—rank Japan lower than almost all other Western European countries, including Spain, Italy and Greece, only marginally higher that of Malaysia or the Philippines for that period. These intriguing findings seem to point to the need for a more comprehensive research on pre-war PPP for other countries as well.

Back-casting our mid-1930s PPP adjusted income estimate sheds further light on Japan's initial conditions in the early Meiji period. For example, projecting backward from the level of $1,760 (in 1990 prices) in the mid-1930s—rather than Maddison's $2,154—gives an 1880s Japanese per capita income of about $600, only marginally higher than those in China and India but lower than in the Philippines and Thailand (see Maddison, 2003, p. 180). In other words, on the eve of the first wave of industrialization in the 1880s, the Japanese economy was near subsistence, no richer than those of its Asian neighbors, whom Japan was to overtake or even colonize in the following few decades.

This is quite a reassessment of prevailing views on both the initial conditions and the dynamics of long-term economic growth for Japan and Asia in general. We have reason to believe that our result is much more consistent with available information on economic structures, consumption patterns and historical realities. Recent studies based on the comparison of real wages seem to lend tentative support to this reassessment. For example, Bassino and Ma (2005) and Allen *et al.* (2005) show that Japanese real wages in the 18th century were close to those in China and low-income European countries such as Italy. Real wages only consistently rose above the Chinese level after the 1890s and reached more than twice China's level by the 1920s, a result consistent with the per capita GDP differences indicated in this PPP study for the mid-1930s. Studies by Bassino and van der Eng (2002) and Bassino (2005) also reveal that daily nominal wages for unskilled laborers and carpenters in Tokyo in 1935 were not much higher than those in Bangkok, Singapore, or Penang in British Malaya. As consumer price levels, particularly food prices, were much lower in those Southeast Asian cities, their studies suggest that real wages in Tokyo were lower than in those cities.

In this regard, the respectable Japanese economic growth in the pre-WWII period should be deemed as catching up (or overtaking) with the resource rich Southeast Asia in level terms but keeping up with the world income leaders in growth terms. Japanese and subsequently Taiwanese and Korean economic convergence with the world income leaders is truly a post-war phenomenon. This is particularly striking if one compares the pre- and post-war income gaps within East Asia. Income differentials of Japan, Taiwan, and Korea versus China in the 1980s were multiples of those in the 1930s. In this regard, China's rapid economic growth since the 1980s, particularly in some of her coastal regions, is partly a making up for her missed opportunities.

Of course, the big question is: why was it Japan—rather than Malaysia or Thailand—that caught up so quickly in the post-war period despite their possibly common starting points? We can offer some conjectures. Bassino's (2005) wage data shows that the skill premium for carpenters vis-à-vis unskilled laborers in Tokyo was smaller than in any of the Southeast Asian cities, indicating the existence of a large pool of skilled workers in Japan in comparison with Southeast Asia. A recent study by Godo and Hayami (2002) revealed that in the 1930s, average years of schooling in Japan were already over 60 percent of the U.S. level despite the much greater lag in per capita income. Japan then already had some of the world's most dynamic industries, a sizable entrepreneurial class, a competent bureaucracy and, of course, a nation state. Was Japan already on a course of convergence in the pre-war era but was thrown off course by the war? This PPP study provides new answers and raises new questions.

In sum, our study provides a set of pre-war benchmark PPP converters that allow us to carry out comparisons of income, consumption, and other monetary indicators for East Asia in a global context. Our pre-war PPP converters confirm that market exchange rate conversion consistently underestimated per capita incomes of East Asia. They also reveal biases associated with the 1990 backward projection method. Our preliminary theoretical and empirical analysis pointed out the direction of such bias and set out a framework for future research which will enable us to quantify the magnitude of this bias and to eventually "consistentize" our new levels with growth trend in the long-term GDP series for East Asia and beyond.

Our finding that Japanese per capita income in the mid-1930s or the entire pre-war period was lower than widely believed is a major revision of our existing interpretation of long-term economic growth in Japan and East Asia. It may also have further reverberations on our interpretation of the determinants of long-term economic growth. The fact that Japan, or East Asia in general, were historically very poor, is perhaps a message of blessing for developing countries today: initial poverty itself is no curse to a nation's aspirations for prosperity.

Appendix A: Tables

TABLE A1
Chinese Price Level Relative to Japan (1934–36; Japan = 1)

			Chinese Weight			Japanese Weight				Absolute Price				Chinese Price Level			
		Items	I	II	III	I	II	III	Unit	Japan	China	China/Japan in PPP	PPP/ER	Chinese Weight	Japanese Weight	Fisher Average	Sampling Cities of China*
	Total	Exchange rate								Yen	Yuan	Yuan/Yen	ER = 0.88 Yuan/yen	**0.65**	**0.83**	**0.73**	
Food			**68.7**			**40.9**								**0.66**	**0.79**	**0.72**	
	Grain			68.5	100.0		35.3	100.0						**0.68**	**0.67**	**0.68**	
		Rice			69.9			93.3	1 kg	0.24	0.14	0.59	0.67	1.04	0.62		***1-11***
		Wheat			30.1			6.7	1 kg	0.21	0.13	0.63	0.72	0.42	0.05		***1-11***
	Vegetables and fruits			8.8	100.0		8.9	100.0						**0.70**	**0.77**	**0.73**	
		Soybeans			1.7			13.9	1 kg	0.23	0.11	0.45	0.52	0.03	0.07		***1-11***
		Other beans			7.3			9.8	1 kg	0.19	0.06	0.35	0.40	0.18	0.04		*1-3,5-8,10,11*
		Potatoes			5.9			2.9	1 kg	0.07	0.03	0.38	0.43	0.14	0.01		*1,2,4,6,7,9-11*
		Cabbages			63.0			43.7	1 kg	0.08	0.06	0.66	0.75	0.84	0.33		*1,2,4,6,8-11*
		Green onion			2.3			9.9	1 kg	0.08	0.03	0.39	0.44	0.05	0.04		*1,4,6,7,9,11*
		Drying vegetables			9.0			9.9	10 monme (37.5 g)	0.18	0.12	0.66	0.75	0.12	0.07		*1,4,7,10*
		Apples			0.1			2.5	100 monme (375 g)	0.15	0.30	1.99	2.26	0.00	0.06		*1-4,6,9-11*
		Oranges			0.3			2.5	100 monme (375 g)	0.08	0.14	1.78	2.03	0.00	0.05		*1-4,6,9-11*
		Bananas			0.1			2.5	1 kg	0.20	0.40	2.03	2.31	0.00	0.06		*1-4,6,9-11*
		Other fruits			10.1			2.5	100 monme (375 g)	0.10	0.14	1.37	1.56	0.06	0.04		*1,2,4,6,10*
	Ingredients			7.4	100.0		8.5	100.0						**0.98**	**1.27**	**1.12**	
		Soysauce			18.0			27.0	1 litter	0.27	0.47	1.74	1.98	0.09	0.53		***1-11***
		Miso			8.0			17.7	1 kg	0.22	0.18	0.82	0.93	0.09	0.17		*2,7,9,11*
		Sugar			11.6			11.5	1 kg	0.40	0.48	1.21	1.38	0.08	0.16		***1-11***
		Salt			8.3			3.5	1 kg	0.07	0.22	3.00	3.41	0.02	0.12		***1-11***
		Oil			54.2			40.4	1 litter	1.03	0.67	0.65	0.74	0.73	0.30		***1-11***
	Meat and fish			5.9	100.0		13.5	100.0						**0.36**	**0.80**	**0.54**	
		Pork			38.1			5.3	100 g	0.14	0.04	0.32	0.36	1.06	0.02		***1-11***
		Beef			27.0			12.8	100 g	0.16	0.04	0.23	0.26	1.05	0.03		***1-11***
		Chicken			2.5			2.0	100 g	0.21	0.07	0.34	0.39	0.06	0.01		*1-8,10*
		Fresh fish			14.9			20.5	1 kg	0.71	0.38	0.54	0.61	0.24	0.12		*1-4,6,8-10*
		Salty fish			3.8			20.5	1 kg	1.15	1.85	1.62	1.84	0.02	0.38		*1-4,9,10*
		Other seafood			6.3			20.5	1 kg	0.75	0.20	0.26	0.30	0.21	0.06		*1,2,4,9,10*
		Eggs			5.9			14.3	1 kg	0.62	0.37	0.59	0.67	0.09	0.10		***1-11***
		Milk			1.4			4.3	1 bottle	0.37	0.62	1.67	1.90	0.01	0.08		*1,2,4,8,9*
	Others			1.0	100.0		23.8	100.0						**0.77**	**0.80**	**0.79**	
		Sweets			11.7			25.0	1 kg	0.16	0.12	0.76	0.86	0.14	0.22		*1,2,4*

		Preserved vegetables (pickles)			21.6			25.0	1 kg	0.16	0.12	0.76	0.86	0.25	0.22		*1,2*
		Tofu			25.1			25.0	1 cake	0.07	0.03	0.45	0.52	0.49	0.13		*3,4,6,8-10*
		Other processed food			41.6			25.0	100 monme (375 g)	0.07	0.06	0.86	0.97	0.43	0.24		
	Drinks and tobacco			8.4	100.0		9.9	100.0					0.00	**0.59**	**0.71**	**0.65**	
		Tobacco			51.4			39.1	1 package	0.15	0.16	1.06	1.20	0.43	0.47		***1-11***
		Alcohol			20.9			48.7	1 litter	0.85	0.15	0.18	0.21	1.02	0.10		***1-11***
		Tea			27.7			12.1	100 g	0.19	0.19	1.03	1.17	0.24	0.14		***1-11***
Lighting and Heating			**8.3**			**4.8**								**0.58**	**1.12**	**0.80**	
	Electricity a)			0.3	100.0		47.6	100.0	1 kwh	0.14	0.16	1.16	1.31	**1.31**	**1.31**		
	Fuel			97.0	100.0		48.9	100.0						**0.57**	**0.94**	**0.73**	
		Coal			6.0			11.8	10 kg	0.27	0.11	0.41	0.46	0.13	0.05		***1-11***
		Firewood			77.0			38.8	10 kg	0.26	0.12	0.45	0.52	1.49	0.20		*1,4,6,8-11*
		Charcoal			1.7			40.8	10 kg	0.81	1.00	1.24	1.41	0.01	0.57		*3,4,6,8-11*
		Lamp oil			15.3			8.6	1 kg	0.26	0.28	1.09	1.24	0.12	0.11		***1-11***
	Others	Matches		2.7	100.0		3.5	100.0	1 packet (10 boxes)	0.06	0.05	0.82	0.94	**0.94**	**0.94**	**0.94**	***1-11***
Clothing and Bedding			**8.5**			**10.7**								**0.63**	**1.16**	**0.86**	
	Clothing			80.3	100.0		72.8	100.0						**0.63**	**1.23**	**0.88**	
		Cotton weaver's wage (female) *b)*			79.4			49.8	daily	0.65	0.32	0.49	0.56	1.42			
		Sweatshirt			11.3			49.7	1 piece	0.88	1.48	1.68	1.91	0.06	0.95		***1-11***
		Cotton			9.2			0.5	1 kg	0.98	0.71	0.72	0.82	0.11	0.00		***1-11***
	Personal items			19.7	100.0		27.2	100.0						**0.66**	**0.95**	**0.79**	
		Sports shoes			25.0			34.9	1 pair	0.70	1.07	1.53	1.74	0.14	0.61		***1-11***
		Shoemaker's wage *b)*			25.0			34.9	daily	1.77	0.73	0.41	0.47	0.53	0.16		***1-11***
		Umbrella			50.0			30.3	1 piece	0.89	0.47	0.53	0.60	0.84	0.18		*1-4,8-10*
Housing			**5.3**			**10.7**								**0.57**	**0.49**	**0.53**	
	Rent			61.6	100.0		97.3	100.0						**0.46**	**0.47**	**0.46**	
		Monthly housing rent *c)*			33.4			33.4	1 room (7.43 sq.	5.09	1.72	0.34	0.38	0.87	0.13		*9,11*
		Carpenter's wage *b)*			33.3			33.3	daily	1.97	0.96	0.49	0.55	0.60	0.18		
		Brick d)			33.3			33.3	1000 pieces	22.18	9.11	0.41	0.47	0.71	0.16		***1-11***
	Furniture			38.4	100.0		2.7	100.0						**0.97**	**1.13**	**1.05**	
		Wooden board			33.4			33.4	3.3 sq. m.	1.98	1.68	0.85	0.96	0.35	0.32		
		Sawer's wage *b)*			33.3			33.3	daily	1.55	0.91	0.59	0.67	0.50			
		Wash basin			33.3			33.3	1 piece	0.31	0.49	1.56	1.77	0.19	0.59		***1-11***
Miscellaneous Expenses			**9.2**			**32.9**								**0.75**	**0.84**	**0.79**	
	Trans.			4.9	100.0		**6.2**	100.0						**0.40**	**0.85**	**0.58**	
		Rickshaw pullers' wage *b)*			50.0			50.0	daily	2.67	0.54	0.20	0.23	2.18	0.11		

TABLE A1 (*continued*)

	Items	Chinese Weight I	Chinese Weight II	Chinese Weight III	Japanese Weight I	Japanese Weight II	Japanese Weight III	Unit	Absolute Price Japan	Absolute Price China	China/Japan in PPP	PPP/ER	Chinese Price Level Chinese Weight	Chinese Price Level Japanese Weight	Fisher Average	Sampling Cities of China*
	Average railroad fares per passenger km *e)*			50.0			50.0		0.01	0.02	1.30	1.47	0.34	0.74		
Education			1.5	100.0		5.8	100.0						**0.37**	**0.81**	**0.55**	
	Teachers' wage *b)*			50.0			50.0	monthly	65.91	12.50	0.19	0.22	2.32	0.11		
	Pencil			50.0			50.0		0.03	0.04	1.23	1.40	0.36	0.70		***1-11***
Hygiene			9.9	100.0		10.4	100.0						**1.17**	**1.39**	**1.28**	
	Soap			25.0			25.0	1 piece	0.10	0.20	2.00	2.27	0.11	0.57		***1-11***
	Toothbrush (Tokyo)			25.0			25.0	1 piece	0.15	0.21	1.40	1.59	0.16	0.40		***1-11***
	Haircut *f)*			50.0			50.0	once	0.40	0.30	0.75	0.85	0.59	0.43		
Medicine	*Liushenwan (Chinese medicine) g)*		5.8	100.0		12.8	100.0	1 tablet	0.05	0.01	0.26	0.30	**0.30**	**0.30**	**0.30**	1
Entertainment	Movie *h)*		19.2	100.0		21.3	100.0	once	0.30	0.20	0.67	0.76	**0.76**	**0.76**	**0.76**	
Other	Newspapers *h)*		58.7	100.0		43.5	100.0	1 set	0.05	0.04	0.80	0.91	**0.91**	**0.91**		

Notes on PPP calculation: The column under "China/Japan in PPP" is the ratio of Chinese price over Japanese price in the previous two columns. In the case of rice, it is equal to 0.14 ÷ 0.24 = 0.59. The column under "PPP/ER" is the number in the "China/Japan in PPP" column divided by the exchange rate which is equal to 0.88. The numbers under the columns of "Chinese weight," "Japanese weight" and "Fisher Average" are calculated based on the index number formulae given in the introduction to Section 1.

Source notes:

*The number of cities in our sample is ordered as follows: 1. Shanghai, 2. Shijiazhuang, 3. Chongqing, 4. Guangzhou, 5. Zhengzhou, 6. Nanjing, 7. Lanzhou, 8. Hangzhou, 9. Tianjin, 10. Wuhan, 11. Beijing.

1. The original price data are mainly from "Archival Materials for Studies of Industrial and Agricultural Commodity Prices." For some cities where prices are missing for some items in our sample, we use the average prices of their neighboring cities as follows: for Chongqing, we use the average prices of Nanchong, Jianyang, Lizhuang; for Wuhan, we use the average of Shashi, Shuanggou, Shadaoguan, Ziqiu; for Guangzhou, we use Shantou; for Beijing, we use Zhangjiakou; for Nanjing, we use the average of Wuxi, Erjiazheng, Suqian, Xuzhou; for Lanzhou, we use the average of Xining and Huangyuan; for Shijiazhuang, we use the average of Baoding, Dingxian, Tangshan; for Zhengzhou, we use the average of Zhengping and Linbao; for Hangzhou, we use the average of Pinghu and Yiwu. Prices for Beijing are the average of 1934–35 from *China Economic Statistics Annals*.

2. For weights, see the text. For Housing and Miscellaneous, we use simple average for the lower level weights.

(a) Average of Chongqing and Wuxi. Chongqing from *Sichaun Economic Reference Materials* for 1935 (Zhang, 1939), Wuxi is the average of 1934–35 from *China Economic Statistics Annals*. Japan is for Tokyo only.

(b) Teachers' wages in China are estimated from Hao Jinhua (2005), "Income of Private School Teachers in 1920–30s" in *Fujian luntan* (Fujian Tribune). The Monthly wages converged from annual salaries. Japan is from *Statistical Annals of Japanese Empire*. Ricksaw Pullers' daily wages in China from Shanghai Local Gazette Office (at http://www.shtong.gov.cn/). Other Chinese wages from *China Economic Statistics Annals* with daily wages converted into monthly income by multiplying 25 days. Japanese wages from Ohkawa *et al*., *LTES, Vol. 8*.

(c) Average of Tianjin and Beijing. Tianjin from *Nankai Economic Indices*, Beijing from *China Economic Statistics Annals*. Japan is for Tokyo.

(d) Wholesale prices.

(e) The railroad fares per passenger-km is the average of Jing-han line (1936), Bei-ning line (1935) and Jingpu line (1935) reported in *World Rail Statistics.* Japan is from *Ministry of Railroad.*

(f) Chinese price from Wuhan Local Gazette Office (http://www.whfz.gov.cn/. Japanese price is for Tokyo.

(g) Japan is from *Asahi News* for 1934–36.

(h) *Dagong Daily* for 1934–36.

(i) Price of gasoline is from 'Newspaper Article in digital version' at Kobe University (http://www.lib.kobe-u.ac.jp/sinbun/e-index.html); the original source is *Chugai shogyo simpo* 1935.9.26.

3. Source information on prices and weights for Japan can be found in Yuan and Fukao (2002) and Fukao *et al.* (2006).

TABLE A2

Japanese Price Level Relative to U.S. (1934–36; U.S. = 1)

	Items	Japanese Weight I	Japanese Weight II	Japanese Weight III	U.S. Weight I	U.S. Weight II	U.S. Weight III	U.S. Units	Japanese Units	Prices: U.S.	Prices: Japan	Prices: Japan/U.S. in PPP	Prices: PPP/ER	Japanese Price Level: Japanese Weight	Japanese Price Level: U.S. Weight	Japanese Price Level: Fisher Average	Sample Size of the U.S. ICPSR Data	Tradables
Total	Exchange rate									dollars	yen		ER = 3.43 Yen/US$	**0.34**	**0.60**	**0.45**		
Food		**41.3**			**33.2**									**0.37**	**0.62**	**0.48**		
Grain and bread			39.7	100.0		12.0	100.0	Unit	Unit					**0.39**	**0.60**	**0.48**		**1**
	Rice			92.9			3.1	1 lb	1 kg	0.08	0.24	1.30	0.38					
	Wheat flour			5.8			16.7	1 lb	1 kg	0.05	0.23	2.11	0.62					
	Bread *1*, *a*			1.2			80.6	1 lb	1 lb	0.08	0.17	2.05	0.60					
Meat			2.7	100.0		19.8	100.0							**0.91**	**0.94**	**0.93**		**1**
	Beef			63.9			51.7	1 lb	1 kg	0.14	1.28	4.04	1.18					
	Pork			26.8			34.1	1 lb	1 kg	0.32	1.40	2.01	0.59					
	Chicken			9.4			14.2	1 lb	1 kg	0.29	2.08	3.21	0.94					
Fish			8.3	100.0		1.3	100.0							**0.26**	**0.25**	**0.26**		**0**
	Flounder/halibut			54.4			52.3	1 lb	100 monme	0.24	0.15	0.77	0.22				43	
	Mackerel *a*			43.0			16.5	1 lb	100 monme	0.12	0.11	1.19	0.35				24	
	Salmon *1*, *a*			2.5			31.1	1 lb	100 monme	0.24	0.17	0.85	0.25				24	
Milk and eggs			2.5	100.0		18.9	100.0							**0.36**	**0.86**	**0.56**		**0**
	Milk			23.0			77.6	1 qt.	1 go (180cc)	0.12	0.08	3.52	1.02					
	Eggs			77.0			22.4	1 doz	1 kg	0.36	0.62	1.03	0.30					
Ingredients			8.5	100.0		3.0	100.0							**0.73**	**0.81**	**0.77**		**1**
	Salt *a*			10.3			10.3	1 lb	1 kg	0.05	0.12	1.01	0.29					
	Sugar			89.7			89.7	1 lb	1 kg	0.06	0.37	3.00	0.87					
Vegetables and fruits			9.2	100.0		12.7	100.0							**0.29**	**0.36**	**0.32**		**1**
	Cabbage			6.7			7.2	1 lb	1 kg	0.04	0.08	0.90	0.26					
	Onion *1*			5.4			11.3	1 lb	1 kg	0.04	0.10	1.06	0.31					
	Sweet potato			20.4			4.1	1 lb	1 kg	0.04	0.08	0.87	0.25					
	Potato			18.5			33.0	1 lb	1 kg	0.02	0.08	1.47	0.43					
	Spinach			12.1			8.2	1 lb	1 kan	0.08	0.30	0.48	0.14					
	Bananas			18.5			14.4	1 lb	1 kg	0.06	0.20	1.41	0.41					
	Apples *1*, *a*			18.5			21.6	1 lb	1 kg	0.05	0.15	1.26	0.37				545	
Processed food			19.1	100.0		7.0	100.0							**0.34**	**0.35**	**0.35**		**1**
	Peanut oil and			50.0			50.0	1 lb	1 kg	0.20	0.62	1.38	0.40					
	Canned pink			50.0			50.0	1 lb	1 can (235 g)	0.15	0.08	1.03	0.30				120	
Alcohol			4.8	100.0		14.5	100.0							**0.48**	**0.48**	**0.48**		**1**
	Beer *a*			100.0			100.0	1 quart	1 bottle (720)	0.27	0.33	1.63	0.48				3	
Tea and drinks			1.2	100.0		2.6	100.0							**0.36**	**0.36**	**0.36**		**1**
	Tea			100.0			100.0	1 lb	1 kg	0.68	1.86	1.24	0.36					
Tobacco	Cigarettes *a*		3.9	100.0		8.1	100.0	1 package	1 package	0.14	0.15	1.11	0.32	**0.32**	**0.32**	**0.32**	704	**1**
Household Utilities		**4.8**			**5.8**									**1.06**	**0.89**	**0.97**		
Fuel expenses			52.4	100.0		75.6	100.0							**1.21**	**0.88**	**1.03**		**1**
	Coal			12.9			97.1	10 kg	1 kg	0.00	0.03	2.96	0.86					
	Firewood *a*			87.1			2.9	10 kg	10 kg	0.06	0.27	4.40	1.28				6	
Electricity	Electricity		47.6	100.0		24.4	100.0	1 kwh	1 kwh	0.05	0.16	3.20	0.93	**0.93**	**0.93**	**0.93**		**0**

TABLE A2 (*continued*)

Items		Japanese Weight I	Japanese Weight II	Japanese Weight III	U.S. Weight I	U.S. Weight II	U.S. Weight III	U.S. Units	Japanese Units	Prices U.S.	Prices Japan	Prices Japan/U.S. in PPP	Prices PPP/ER	Japanese Price Level Japanese Weight	Japanese Price Level U.S. Weight	Japanese Price Level Fisher Average	Sample Size of the U.S. ICPSR Data	Tradables
Clothing and Bedding		**10.6**			**13.3**									**0.25**	**0.49**	**0.35**		**1**
Cloth			33.3	100.0		33.3	100.0							**0.65**	**0.72**	**0.69**		
	Raw silk *2*, *b*			20.0			20.0	1 lb	1 kg	1.50	11.23	3.40	0.99					
	Cotton yarn *2*, *b*			20.0			20.0	1 lb	1 kg	0.30	1.19	1.78	0.52					
	Muslin *2*, *b*			20.0			20.0	1 yard	1 yard	0.15	0.49	3.22	0.94					
	Woolen yarn *2*, *b*			20.0			20.0	1 lb	500 g	1.64	2.71	1.48	0.43					
	Serge *2*, *b*			20.0			20.0	1 yard	I m	1.08	3.01	2.55	0.74					
Wages for			33.3	100.0		33.3	100.0							**0.11**	**0.11**	**0.11**		
	Tailors and			100.0			100.0	daily	daily	0.60	1.80	0.38	0.11					
Personal items			33.3	100.0		33.3	100.0							**0.65**	**0.65**	**0.65**		
	Men's leather			100.0			100.0	1 pair	1 pair	3.73	8.25	2.21	0.65					
Housing and Furniture		**10.2**			**21.0**									**0.59**	**0.75**	**0.66**		
Monthly housing rent			85.3	100.0		69.5	100.0	1 room	1.65 sq. m.	4.77	1.06	2.69	0.79	**0.79**	**0.79**	**0.79**	664	**0**
Furniture, equipment and supplies			14.7	100.0		30.5	100.0							**0.24**	**0.68**	**0.40**		**1**
	Furniture makers'			50.0			50.0	hourly	daily	0.50	1.80	0.45	0.13					
	Wooden boards			50.0			50.0						1.23					
Miscellaneous Expenses		**33.2**			**26.7**									**0.28**	**0.51**	**0.37**		
Transp. & communication			6.2	100.0		43.8	100.0							**0.39**	**0.61**	**0.49**		
	Subway (New			20.2			22.9	1 ride	1 ride	0.05	0.10	2.00	0.58					**0**
	Gasoline *i*			20.2			22.9	yen per	gallon	66.50	43.50		0.65					**1**
	Bus drivers' or			20.2			22.9	hourly	daily	0.58	2.70	0.54	0.16					**0**
	Automobile			20.2			22.9	unit	unit values	2587.9	601.96	4.30	1.12					**1**
	Postage for a			19.4			8.3	1 piece	1 piece	0.01	0.02	1.50	0.44					**0**
Health and hygiene			23.2	100.0		23.3	100.0							**0.21**	**0.58**	**0.35**		
	Doctors' salaries			28.0			37.1	annual	annual	2196.5	633.00	0.29	0.08					**0**
	Aspirin and cold			28.0			37.1	100 pills	10 pills	0.59	0.25	4.24	1.24					**1**
	Men's haircut *1*,			21.6			14.0	once	once	0.39	0.40	1.04	0.30				2886	**0**
	Toilet soap *1*, *a*			22.4			11.8	1 piece	1 piece	0.07	0.09	1.42	0.41				2838	**1**
Education, books, and newspapers			11.3	100.0		8.8	100.0							**0.29**	**0.39**	**0.34**		**0**
	Tuition and fees			23.6			22.8	annual	monthly	2.19	0.40	2.19	0.64				1828	
	Tuition and fees			23.5			22.7	annual	monthly	138.50	12.48	1.08	0.32				137	
	Wood pulp			5.3			5.5	100 lbs	1 kg	2.00	0.18	4.04	1.18					
	Teachers' salary			5.3			5.4	annual	monthly	1974.5	65.91	0.40	0.12					
	Newspapers *1*, *a*			42.3			43.6	1 issue	1 issue	0.06	0.05	0.79	0.23				74	
Entertainment, religious and welfare																		**0**
	Movies *1*, *a*		59.3	100.0		24.1	100.0	per show	per show	0.29	0.30	1.03	0.30	**0.30**	**0.30**	**0.30**		

Notes:

1. For Japan, items marked with 1 are the average value for Tokyo in 1934–36, while items marked with 2 are the Tokyo wholesale prices in 1935. All other prices are the 1934–36 averages of consumer prices.

2. For the U. S., items marked with "a" are based on micro-data from the Study of Consumer Purchases in the United States (ICPSR 8908), while items marked with "b" are the wholesale prices for the U.S. in 1935.

3. Gasoline prices for the U.S. and Japan are from *Chugai shogyo simpo* 1935.9.26, at http://www.lib.kobe-u.ac.jp/sinbun/e-index.html. Prices are all in Japanese yen.

4. Bus drivers' wages are from the HLS, vol. I, p. 980. In the case of Japan we used rickshaw wages.

5. For automobiles, unit values with values and quantities in the U.S. and Japan are from the 1939 Census of Manufactures and Factory Statistics (Bureau of the Census, 1939).

6. Doctors' salaries for the U.S. are the average of those of dentists and chiropodists (HLS, vol. II, pp. 298–300).

7. Teachers' salaries for the U.S. are from table 12, p. 311 in HLS, vol. II, p. 311.

8. Electricity prices for the U.S. are from the HLS, vol. I, pp. 666–7.

9. Embroiderers' wages for the U.S. are from the HLS, vol. II, p. 94.

10. 1 lb = 453.6 grams; 1 momme = 375 grams.

11. Wholesale prices for the U.S. are from the Statistical Abstract 1938. Wholesale prices for Japan are for Tokyo and are from the Historical Statistics of Japan (CD-ROM).

12. U.S. rent data are based on the micro-data of households in two metropolises (New York and Chicago) and six big cities (Providence, RI; Columbus, OH; Atlanta, GA; Omaha–Council Bluffs, NE–IA; Denver, CO; and Portland, OR). The rent includes neither heating nor furnishing.

13. Rent data for Japan are the weighted average of rents in Tokyo and six other big cities (Osaka, Kyoto, Nagoya, Kyoto, Kobe, and Yokohama). As weights, we used the number of households in each city in 1935 (taken from Nihon Teikoku Toukei Nenkan (Statistical Annals of the Japanese Empire, 1938).

14. The average rent per 1.65 sq.m. in Tokyo is from Toukei Shiryou Dai 78 Go (Pre-War Standard Consumption Level—Method of Calculation for Tokyo (1), Statistical Materials No. 78) by Keizai Shingi-cho Chosabu Tokeika (Statistical Survey Department of the Economic Council) (Keizai Shingi-cho, 1953). We calculated rent in other cities using information of rent per house (apartment) in Tokyo and the other six cities reported in Clark (1940).

15. For price of wooden boards for making furniture, we use the average of prices for firewood and wood pulp.

16. For medicine pills, prices are for aspirin and cold medicines respectively.

TABLE A3

Chinese Price Level Relative to U.S. (1934–36; U.S. = 1)

	Items	Chinese Weight I	Chinese Weight II	Chinese Weight III	U.S. Weight I	U.S. Weight II	U.S. Weight III	U.S. Units	Chinese Units	Absolute Price U.S.	Absolute Price China	Absolute Price China/U.S. in PPP	Absolute Price PPP/ER	Chinese Price Level Chinese Weight	Chinese Price Level U.S. Weight	Chinese Price Level Fisher Average
Total	**Exchange rate**									Dollar	Yuan	ER = 3.01 Yuan/US$		**0.26**	**0.38**	**0.32**
Food		**68.7**			**33.2**									**0.27**	**0.35**	**0.31**
Grain			68.5			12.1								**0.29**	**0.40**	**0.34**
	Rice			69.9			3.1	1 lb	1 kg	0.08	0.14	0.77	0.26	2.73	0.01	
	Wheat			30.1			96.9	1 lb	1 kg	0.05	0.13	1.22	0.40	0.74	0.39	
Vegetables and fruits			8.8			12.7								**0.15**	**0.25**	**0.20**
	Potatoes			14.9			37.1	1 lb	1 kg	0.02	0.03	0.48	0.16	0.93	0.06	
	Cabbages			36.0			7.2	1 lb	1 kg	0.04	0.06	0.65	0.21	1.73	0.02	
	Spinach *a)*			36.0			8.3	1 lb	1 kg	0.08	0.05	0.32	0,11	3.42	0.01	
	Onion			2.3			11.3	1 lb	1 kg	0.04	0.03	0.32	0.11	0.22	0.01	
	Apples			5.3			7.2	1 lb	1 kg	0.06	0.58	4.10	1.36	0.04	0.10	
	Oranges *b)*			5.3			7.2	1 lb	1 kg	0.25	0.38	0.69	0.23	0.23	0.02	
	Bananas			0.1			21.6	1 doz (2 kg)	1 kg	0.33	0.40	0,55	0.18	0.00	0.04	
Ingredients			7.4			3.0								**0.67**	**1.23**	**0.91**
	Sugar			11.6			90.0	1 lb	1 kg	0.06	0.48	3.90	1.29	0.09	1.16	
	Salt			88.4			10.0	1 lb	1 kg	0.05	0.22	1,90	0.63	1.40	0.06	
Meat and fish			5.9			40.0								**0.26**	**0.32**	**0.29**
	Park			38.1			5.6	1 lb	100 g	0.32	0.04	0.64	0.21	1.80	0.01	
	Beef			27.0			8.5	1 lb	100 g	0.14	0.04	1.17	0.39	0.70	0.03	
	Chicken			2.5			2.3	1 lb	100 g	0.29	0.07	1.09	0.36	0.07	0.01	
	Eggs			5.9			3.5	1 doz	1 kg	0.36	0.34	0.94	0.31	0.19	0.01	
	Milk			1.4			12.2	1 qt.	1 bottle	0.12	0.62	2.42	0.80	0.02	0.10	
	fish			25.1			67.9	1 lb	1 kg	0.24	0.38	0.71	0,24	1.06	0.16	
Others			1.0			7.0								**0.09**	**0.09**	**0.09**
	Preserved vegetables (pickles)			100.0			100.0	1 lb	1 kg	0.20	0.12	0.27	0.09	11.29	0.09	
Drinks and tobacco			8.4			25.2								**0.25**	**0.39**	**0.32**
	Cigarettes			51.4			32.12	1 package	1 package	0.14	0.16	0.54	0.18	2.89	0.06	
	Beer *c)*			20.9			57.50	1 quart	*1 bottle*	0.27	0.54	1.53	0.51	0.41	0.29	
	Tea			27.7			10.38	1 lb	100 g	0.68	0.19	1.28	0.43	0.65	0.04	
Lighting and heating		**8.3**			**5.8**									**0.70**	**0.92**	**0.80**
Electricity			0.3	100.0		24.4	100.0	1 kwh	1 kwh	0.05	0.16	3,20	1.06	**1.09**	**1.09**	**1.09**
Fuel			99.7			75.6								**0.70**	**0.86**	**0.78**
	Coal			23.0			97.10	10 kg	10 kg	0.04	0.11	2.62	0.87	0.26	0.84	
	Firewood			77.0			2.90	10 kg	10 kg	0.06	0.12	1.99	0.66	1.17	0.02	
Clothing and bedding		8.5			13.3									**0.24**	**0.28**	**0.26**
Clothing			80.3			66.7								**0.23**	**0.25**	**0.24**

		Sweatshirt			50.0			50.0	each	each	1.50	1.48	0.99	0.33	1.53	0.16	
		Tailors and embroiderers			50.0			50.0	daily	daily	0.60	0.32	0.53	0.18	2.82	0.09	
	Personal items			19.7			33.3								**0.32**	**0.32**	**0.32**
		Men's leather shoes *d)*			100.0			100.0	1 pair	1 pair	2.73	2.63	0.96	0.32	3.12	0.32	
Housing			**5.3**			**21.0**									**0.15**	**0.24**	**0.19**
	Rent			61.6			69.5								**0.16**	**0.19**	**0.18**
		Monthly housing rent *i)*			50.0			50.0	1 room	1 room	4.77	1.72	0.36	0.12	4.17	0.06	
		Brick *b)*			50.0			50.0	1000 pieces	1000 pieces	11.84	9.11	0.77	0.26	1.96	0.13	
	Furniture			38.4			30.5								**0.14**	**0.37**	**0.22**
		Furniture makers' wage			50.0			50.0	hourly	daily	0.50	0.91	0.23	0.08	6.62	0.04	
		Wooden board *h)*			50.0			50.0						0.66	0.76	0.33	
Miscellaneous Expenses			**9.2**			**26.7**									**0.21**	**0.47**	**0.32**
	Trans.			4.9			43.8								**0.10**	**0.52**	**0.23**
		Bus driver and rickshaw puller's wage			33.3			50.0	hourly	daily	0.58	0.54	0.12	0.04	8.61	0.02	
		Average railroad fares per passenger-km			33.3			30.0			0.01	0.02	1.31	0.45	0.75	0.13	
		gasoline			33.3			20.0	gallon	gallon	66.50	122.50		1.84	0.18	0.37	
	Educ.			1.5			5.0				0.00				**0.05**	**0.13**	**0.08**
		Teachers' wage			50.0			50.0	annual	annual	1974.50	150.00	0.08	0.03	19.81	0.01	
		college and university *e)*			50.0			50.0	annual	annual	138.50	100.00	0.72	0.24	2.08	0.12	
	Hygience			9.9			6.0								**0.31**	**0.43**	**0.37**
		Soap			25.0			22.8	1 piece	1 piece	0.07	0.20	3.04	1.01	0.25	0.23	
		Toothbrush			25.0			22.7	each	each	0.28	0.21	0.75	0.25	1.00	0.06	
		Haircut *g)*			50.0			54.5	once	once	0.39	0.30	0.78	0.26	1.93	0.14	
	Medicine	Aspirin *f)*		5.8	100.0		17.3	100.0	1 bottle	1 bottle	0.59	1.46	2.47	0.82	**0.84**	**0.84**	**0.84**
	Entertainment	Movie		19.2	100.0		24.1	100.0	per show	once	0.29	0.20	0.69	0.23	**0.24**	**0.24**	**0.24**
	Other	Newspapers		58.7	100.0		3.9	100.0	1 issue	1 set	0.06	0.04	0.63	0.21	**0.22**	**0.22**	**0.22**

Source: See Tables Al and A2 except as noted below.
(a) The average price of Beijing, Shanghai, Nanjing from *China Economic Statistics Annals* 1934–1935.
(b) Prices of bricks and orange in the U.S. are from Statistical Abstract of the United States 1938.
(c) The average price of Wuhan, Chongqing and Shanghai. The units are 1 quart = 946 milliliters in the U.S. and 1 bottle = 720 milliliters in China.
(d) Price is for Chongqing.
(e) College tuition is the median value of private colleges reported in ″College Tuitions in the 1930s″ by Cheng Mingyuan in *Nanfang Zhoumuo*, Dec. 4, 2003.
(f) Price is for Morris County, New Jersey 1935 (http://www.gti.net/mocolib1/prices/193s.html); price for China is for Wuhan. Each bottle is 100 pills.
(g) Haircut is calculated as the product of the U.S—Japan and Japan—China prices.
(h) Wooden board uses the price of firewood.
(i) One room is 20 square meters in China.

Appendix B: An Empirical Analysis of the Relationship between Terms of Trade Change and Back-Projection Bias

We empirically test the implication of our theoretical analysis using the data in Heston and Summers (1993). Table 3 of Heston and Summers (1993) reports

$$\text{(B1)} \qquad \ln\left(\frac{y_i^E(t,90)}{y_{EU}^E(t,90)}\right) - \ln\left(\frac{y_i^C(t)}{y_{EU}^C(t)}\right)$$

for $t = 1970$, 75, 80, and 85 and $i =$ each of 23 OECD countries. The variables with EU denote values for three European countries (the U.K., West Germany and Italy).

The weight consistency effect is only significant for countries experiencing substantial structural change. Since the OECD countries in 1970–90 were already quite developed and relatively homogenous, our statistical test will focus on the terms of trade effect, treating the weight consistency effect as a random error. By taking first differences of equation (B1) over time, we derive the following:

(B2)

$$\left\{\ln\left(\frac{y_i^E(t+5,90)}{y_{EU}^E(t+5,90)}\right) - \ln\left(\frac{y_i^C(t+5)}{y_{EU}^C(t+5)}\right)\right\} - \left\{\ln\left(\frac{y_i^E(t,90)}{y_{EU}^E(t,90)}\right) - \ln\left(\frac{y_i^C(t)}{y_{EU}^C(t)}\right)\right\}$$

$$= \left\{-\ln\left(\frac{\sum_{n=1}^{N} p_n^G(t+5)q_n^i(t+5)}{\sum_{n=1}^{N} p_n^G(t)q_n^i(t+5)}\right) + \ln\left(\frac{\sum_{n=1}^{N} p_n^G(t+5)q_n^{EU}(t+5)}{\sum_{n=1}^{N} p_n^G(t)q_n^{EU}(t+5)}\right)\right\}$$

+ error term (composed of weight inconsistency effect and other observation errors).

The first term on the right-hand side of the equation denotes the terms of trade effect.

To simplify the terms of trade effect we make the following additional assumptions: (i) each country's balance of goods and services trade is close to zero; (ii) each country has a similar demand structure; and (iii) the GK price vector is close to the domestic price vector of each country and the international price vector. Denoting $x_n^i(t)$ as net exports of commodity n in country i in year t, the first term on the right-hand side of equation (B2) can be approximated by

$$-\sum_{n=1}^{N}\left(\frac{p_n^*(t)x_n^i(t+5)}{\sum_{n=1}^{N} p_n^*(t)q_n^i(t+5)}\frac{p_n^*(t+5)-p_n^*(t)}{p_n^*(t)}\right) + \sum_{n=1}^{N}\left(\frac{p_n^*(t)x_n^{EU}(t+5)}{\sum_{n=1}^{N} p_n^*(t)q_n^{EU}(t+5)}\frac{p_n^*(t+5)-p_n^*(t)}{p_n^*(t)}\right)$$

and, given our assumptions, could be further simplified as follows:

$$-m^i(t+5)\{\ln(T^i(t+5)) - \ln(T^i(t))\} + m^{EU}(t+5)\{\ln(T^{EU}(t+5)) - \ln(T^{EU}(t))\}$$

where $m^i(t+5)$ denotes the simple average of country i's export–GDP ratio and import–GDP ratio. We call m the trade dependence ratio. $T^i(t)$ denotes country i's terms of trade at time t. As the terms of trade effect of the three European countries will affect the PPP gap in the same way, we use time dummies to control for this.

From the above analysis we obtain the following model for our econometric test.

$$\left\{\ln\left(\frac{y_i^E(t+5,90)}{y_{EU}^E(t+5,90)}\right)-\ln\left(\frac{y_i^C(t+5)}{y_{EU}^C(t+5)}\right)\right\}-\left\{\ln\left(\frac{y_i^E(t,90)}{y_{EU}^E(t,90)}\right)-\ln\left(\frac{y_i^C(t)}{y_{EU}^C(t)}\right)\right\}$$
$$=\alpha-\beta m^i(t+5)\left\{\ln\left(T^i(t+5)\right)-\ln\left(T^i(t)\right)\right\}+\sum_T\gamma^T DUM^T(t)+\varepsilon^i(t)$$

where $DUM_T(t)$ is the time dummy. Since Heston and Summers (1993) report that the current benchmark comparison of 1970 is not fully reliable, we used data for $t = 1975$, 80, and 85.

The regression using the above equation with the data from Heston and Summers (1993) is tabulated in Table B1; β, the coefficient of the cross-term of the change in the terms of trade and the trade dependence ratio, is the key variable. Based on our theoretical considerations, we expect β to be close to -1. When a country's terms of trade deteriorate, the extrapolation bias will increase. This effect will be larger for countries with a high trade dependence. Table B1, reporting the results of our regression, shows that the β coefficient is close to -1 and statistically significant, thus confirming our theory.

TABLE B1

The Estimation Result on the Terms-of-Trade Effect

	Coefficients	Standard Error	t
α	–0.0147	0.019	–0.763
β	–0.651	0.156	–4.167
Γ^{80}	3.46E-05	0.025	0.001
Γ^{85}	0.0943	0.025	3.751

R square = 0.49. Sample size is 31.

Based on these findings, we turn to the terms of trade (TOT) effect for Japan and the U.S. between 1935 and 1990 as studied in our paper. Figure B1 presents our terms of trade indices for Japan and the U.S. linked from 1935 to 1990. It shows that the U.S. terms of trade deteriorated by 54 percent compared with those of Japan. This would imply, according to our decomposition, an upward bias in the 1930s Japanese per capita income based on the 1990 back-projection, a result consistent with our earlier empirical findings. We quantify the upward bias based on the following formula derived above:

$$m^{\text{Japan}}(1990)\left\{\ln\left(T^{\text{Japan}}(1990)\right)-\ln\left(T^{\text{Japan}}(1935)\right)\right\}-$$
$$m^{\text{US}}(1990)\left\{\ln\left(T^{\text{US}}(1990)\right)-\ln\left(T^{\text{US}}(1935)\right)\right\}.$$

Since trade dependency ratio (the average of exports and imports over GDP) was 10 percent for Japan and only 8 percent for the U.S. respectively in 1990, the terms of trade improvement for Japan between 1935 and 1990 would only account for about 3 percent upward bias in the 1990 backward projection method, clearly a small fraction in relation to the 22 percent overestimate we found in this study.

However, the limited impact of the terms of effect in our empirical test should be carefully interpreted. A major problem is that our long-term TOT indices are constructed by linking disparate series where both quantity weights and quality of products (also the number of new products) have changed quite substantially at each linking period. In the case of Japan, there was a hyperinflation and a corresponding huge depreciation of yen after WWII. Our Japan series is based on Yamazawa and Yamamoto's link ratio of TOT between 1934–36 and 1952–54. But due to the change in Japan's trade structure, the number of goods they could match was limited: altogether 163 goods for exports and 135 goods for imports, but only 3 and 12 for export and imports respectively in the case of machinery. The figure also reveals the highly volatile TOT fluctuation in the short run. All these affect the reliability of our empirical test.

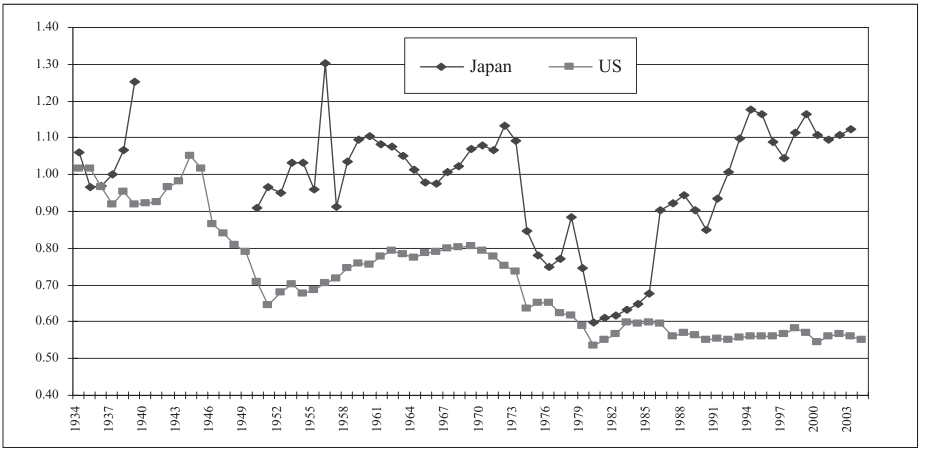

Figure B1. Terms of Trade Indices for the U.S. and Japan (unit value index of total exports/unit value index of total imports), 1934–36 = 1

Source:
Japan:
1934–54: *Estimates of Long-Term Economic Statistics of Japan Since 1868*, Vol. 14 : Foreign Trade and Balance of Payments, edited by Ippei Yamazawa and Yuzo Yamamoto, Toyo Keizai Shinposha, 1979;
1954–60: *Historical Statistics of Japan*, Vol. 3, 1985, Editorial Supervision: Statistics Bureau, Management and Coordination Agency, Japan Statistical Association, Tokyo, Japan;
1960–2000: *Nihon Kanzei Kyokai* (Japan Tariff Association) "Gaikoku Boeki Gaikyo (General Situation of Japan's International Trade).
U.S.:
1934–55: *Historical Statistics of the United States*, Bicentennial Edition, Colonial Time to 1970, Part 2, 1975, U.S. Department of Commerce, Bureau of the Census (1975);
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1984–2000: Downloaded from the website of Bureau of Labor Statistics, http://www.bls.gov/data/home.htm.

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