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Technology and Long-run Economic Growth in Asia

Real GDP in pre-War East Asia:

A 1934-36 Benchmark Purchasing Power Parity Comparison with the U.S

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September 9th, 2005
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September 2005
Second Draft
Paper prepared for
the N.W. Posthumus Institute and Hitotsubashi University Conference
Technology and Long-run Economic Growth in Asia
September 8-9, 2005, Tokyo

Abstract

This paper provides comprehensive estimates of purchasing power parity (PPP) converters for Japan-China and Japan-U.S for consumption, private investment, government expenditure and GDP in 1934-36 through a detailed matching of prices for more than 50 types of goods and services and about 20 items and sectors for investment and government expenditure. We find that the 1934-36 average consumer prices of China are about 75% of Japan's and the average GDP price levels of Japan are 56% those of the U.S. Relying on our earlier studies on the relative price levels of Taiwan and Korea and using Japan as the bridge country, our estimates suggest that in the mid-1930s the benchmark PPP adjusted per capita income of Japan was 24.7% of the U.S. level, that of China was 8.6%, that of Taiwan 18.4%, and that of Korea 10.2%. Our estimates are corrected for the consistent bias that is found using market exchange rate conversions. Our finding, while confirming broadly Maddison's 1990 back-projected per capita income estimates for China, suggests that Japan's per capita income may have been 35.8% lower than Maddison's estimate. In addition, this paper examines more evidence and implications of our current-price benchmark based estimates.

- We are grateful for comments from Paul Rhode, John Devereux, Hak Kil Pyo and Jean Pascal Bassino as well as the participants of the UC Davis workshop "Estimating Production and Income Across Nations and over Time" held on May 31 – June 1, 2005. This paper is partly funded by the NSF "Global Prices and Income 1350-1950" project headed by Peter Lindert at UC Davis and the Ministry of Education 21st Century COE Program, "Research Unit for Statistical Analysis in Social Sciences," headed by Osamu Saito at Hitotsubashi University. All errors are the responsibility of the authors.

Real GDP in Pre-War East Asia:

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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 to be more precise – a post-WWII affair, while the surge of China is even more recent, occurring during the last two decades. However, as revealed by the burgeoning literature on economic growth, long-term or 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 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 publication in 1988 of a statistical volume compiled by Mizoguchi and Umemura. The volume provides annual estimates of GDP and its various components for these two economies in the period of Japanese occupation based on the detailed economic statistics of the colonial administrations. Compared with these countries, the availability of historical macroeconomic statistics for China remains sketchy. The earliest set of economic statistics approaching standard national accounts data are for the 1930s, laying the foundation for the pioneering reconstruction of China's GDP for the period 1931-36 carried out by Ou et al. (1947), Liu (1947), and Liu and Yeh (1965).

These pre-war GDP series are all based on their respective currencies, making cross-country comparisons difficult. This is because converting prices at market exchange rates tends to systematically underestimate the real per capita income level of the lower income countries since it fails to incorporate differences in the price

level for non-tradable goods (Balassa 1964; Samuelson 1964; Bhagwati 1984). 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, is still at a very early stage. The national accounts data sets 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 and conducted 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 the 1990 benchmark PPP to project GDP values backward using domestic real GDP growth rates. This methodology, adopted in the absence of historical PPP converters, has its inherent index number problems. Based on a full-fledged reconstruction of 1934-36 expenditure PPP for Japan, Taiwan and Korea, a recent study by Fukao, Ma and Yuan (2004) revealed serious inconsistencies in Maddison's pre-war per-capita GDP estimates for Taiwan and Korea. Backward projection suffers from index number problems which are caused by long-term relative shifts in a country's terms of trade and economic structure.

The present paper follows the earlier study by Fukao et al. on the PPPs of Japan, Taiwan and Korea. We develop PPP converter for consumption for Japan-China and PPP converter for GDP for Japan-U.S. For consumption, we conduct a detailed matching of the prices of more than 50 types of goods and services and about 20 expenditure items in the case of private investment and government expenditure. We find that average consumer prices in China in 1934-36 were about 75% of Japan's, while the average GDP price level in Japan was 55% that of the U.S. Relying on our studies on the relative price levels of Taiwan and Korea and using Japan as the bridge country, our estimates suggest that in the mid-1930s the benchmark PPP-adjusted per capita income of Japan was 24.7% of the U.S. level, that of China was 8.6%, that of Taiwan 18.4%, and that of Korea 10.2%. These figures are consistently higher than per capita GDP estimates based on current market exchange rates, which are 13.8% (as opposed to 24.7%) for Japan, 3.6% for China (versus 8.6%), 8.8% (versus 18.4%) for Taiwan and 5.2% (versus 10.2%) for Korea.

Our results for Taiwan and China are similar to Maddison's back-projected estimates in 1990 dollars. On the other hand, our estimate for Korea's per capita income level is only about half the level estimated by

[1] For Japan, there is the 14 volume series LTES publications in Japanese. For the English version, see the abridged one volume by Kazushi Ohkawa and Miyohei Shinohara. For an English version, see the abridged one-volume edition by Kazushi Ohkawa and Miyohei Shinohara.

Maddison, an issue examined in detail in Fukao et al. (2004). But the differences in our results are most striking and important for our bridge country, Japan. Our current-price PPP benchmark estimate suggests that Japan's per capita income may have been 35.8% lower than Maddison's 1934-36 Japanese per income (Maddison 2003, p.182). Comparing our estimate with the data for other countries provided in Maddison (2003) suggests that Japan's per capita income during this period was comparable to that of Malaysia or the Philippines.

While one could of course dispute Maddison's per-capita income estimates for other countries, other quantitative and descriptive evidence lends support to the notion that on the eve of the country's military adventure, Japan's per-capita income was fairly low, roughly comparable to some of the resource rich Asian countries, most of which were still Western colonies. If we project backward or forward from our benchmark PPP estimates, our study sheds new light on the initial conditions of East Asia both around the mid-19th century and the post-WWII period. We offer some explorations on its growth implications of our estimates.

The remainder of this paper is divided into two sections followed by a conclusion. The first section provides a detailed explanation of our PPP estimation procedure. We also report our findings on current-price PPP estimates in 1934-36. In section II we compare per capita incomes in the four East Asian economies and the U.S. using our current-price PPP estimates. We also compare our per capita income estimates based on the current-price PPP with the GDP estimates based on current market exchange rates as well as the backward projection estimates.

I. Current-Price PPP Estimates for 1934-36

The China-Japan PPP Estimate for Consumption

Our current-price PPP estimate between China and Japan draws on Yuan (2005). We adopt the methodology used by several rounds of the International Comparison Program (ICP) study for the post-WWII benchmark periods (For the ICP study, see Heston and Summers 1993 and Maddison 1995). The information on prices and expenditure weights required for the estimation are based on our earlier studies on Japan, Taiwan and Korea (Yuan and Fukao 2002; Fukao et al. 2004). Prices for each item in Japan in most cases are calculated as the simple average of the retail price in 12 to 14 major cities.

For China, we rely on more than 60 volumes of detailed retail price statistics compiled in 1955 by the Communist government. The volumes are titled "Gongnonye Shangping Bijia Wenti Diaocha Yanjiu Ziliaoji"

(Archive Materials for Studies of Industrial and Agricultural Commodity Prices). The retail price information is mostly culled from the account books of major stores in urban cities. The price statistics were published and circulated internally within Chinese government and were intended for the government to study changes of agricultural-industrial relative prices between the 1930s and 1950s. The retail prices used in Yuan (2005) are the simple averages of the cities of Shanghai, Chongqing, Wuhan, Guangzhou, Beijing, Nanjing, Harbin, Xining, Shijiazhaung Zhengzhou, Erjiazheng and Tianjing. For some of the services, such as electricity, movies, and so on, he gathered information from local surveys and newspapers such as "Sichaun Jingji Cankao Ziliao" and "Dakong News."

The consumption weights at the aggregate level come from Zhang Donggang (2001, pp.375-6) with some adjustments. For medium and detailed level weights, we used various local surveys which we divided into an urban and into a rural group. We multiply the urban and the rural weight by the urban and rural population in China. In the case of food consumption, we use urban consumption surveys for Shanghai, Tienjin, Nanjing, Wuxi and rural surveys for Beijing, Dingxian, Jiangnin, Wuxin, Yuliangzhong, Shangxiawuzheng, Xanhu and Wujiang.

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 deflations that lead to Japan's ban on gold exports in 1931–32 and the economic dislocation of the late 1930s brought about by the outbreak of the Sino-Japanese War. For China, in contrast, the years 1934–36 were less stable, following, as they did a major monetary reform by the Nationalist government in 1933 and the abandonment of the traditional silver standard. At the same time, however, the per capita GDP estimates for 1931-1936 provide probably the only reasonably reliable benchmark for China for the entire pre-war period. Finally, it was only towards the 1930s that reliable Chinese, Taiwanese and Korean household budget and rural surveys with consumption expenditure information became available or plentiful.

Our computation of relative price levels employs the standard binary matching with fisher geometric mean. For n numbers of goods and services, the numeraire country's (sub- or superscripted as J here) price level relative to that of country i, is calculated as follows:

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

The formula using i country's consumption weights is:

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

Finally, the geometric average of the two price indices (the Fisher index) $P_{i,J} = \sqrt{P_{i,J}^i \times P_{i,J}^J}$ gives us i country's absolute price level relative to that of Japan.[2]

The details of the matching and data sources for China-Japan consumption price levels are presented in Appendix Table I which shows a matching of 51 items. Table 1 shows the relative price levels of China at 75% of that of Japan. In particular, food prices were the cheapest of all the relative prices.

Insert Table 1

The Japan-U.S. Consumption PPP

Price data for the mid-1930s U.S are fairly abundant and reliable. For most of the food items, we used retail prices in the Bureau of Labor Statistics publication (Bulletin No. 635) which provided weighted averages of retail prices in 51 urban cities in the U.S. We also used the *Handbook of Labor Statistics* (1941) for retail prices of fuel and utilities and wage rates. From the Statistical Abstract of the U.S (1938), we utilized a few wholesale prices (matched with Japanese wholesale prices) for a few items such as clothing and utilities. For other items, we made use of a massive national scale urban household survey of consumer purchases in 1935-36. This household based dataset can now be accessed through the University of Michigan based ICPSR website (http://www.icpsr.umich.edu).

The Historical Statistics of the U.S (bicentennial edition) provide us the upper and medium consumption expenditure weights. The detailed item weights in the mid-1930s largely draw from the cost of living survey in Bureau of Labor Statistics publication (Bulletin no. 699).

We present the details of the matching in Appendix Table II. Table 2 presents the summary results of our U.S-Japan binary matching of all together 53 items of goods and services. It shows that around the mid-1930s while the average cost of food and clothing in Japan were about half of that of the U.S level, the average cost of miscellaneous items in Japan which included mostly service sectors such as transportation, communication, education and entertainment were only about 40% of the U.S. level. In the case of Lighting and Heat which are mostly energy items, Japanese price levels were almost identical to the U.S level. Housing expenses, which included the rent of the relatively scarce land in Japan, were about 72% of the U.S level. The overall relative price levels of Japan over U.S come out to be 54% for the mid-1930s benchmark.

Insert Table 2 here

The relative price structure between U.S and Japan as revealed in Table 2 and Appendix Table II is instructive. For example, the Appendix Table II shows that Japanese nominal wage rates for most sectors were only about 10% the level of the U.S, if converted at the mid-1930s exchange rates. The low wage but high energy and housing price reflects the sharp differences in resource endowments and possibly productivity levels of the period.

In the Fukao et al. studies, we also matched 61 and 58 types of goods and services for Japan-Korea and Japan-Taiwan respectively. Combining the two studies and using Japan as the bridge country, we can convert our relative price levels to the base of the U.S. The results are presented in Table 3. It shows the relative price levels of China, Taiwan, Korea and Japan at 40%, 45%, 47% and 54% of that of the U.S respectively. Overall, relative 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 are closer and better integrated than with China. This is consistent with Japanese colonial policy towards the 1930s which forged a "free trade' zone within the empire.[3]

Insert Table 3

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[2] The summation sign is summed across the *n* types of goods and services. This will be true throughout the rest of the text.

[3]Japan acquired Taiwan and Korea as colonies in 1895 and 1910 respectively. By the 1910s, both colonial Korea and Taiwan were set on a de-facto "Japanese yen exchange standard," – the two colonial Central banks, the Bank of Korea and Bank of Taiwan, issued their bank notes as circulating currency convertible to the Bank of Japan notes which served as the de-facto reserve currency. All three bank notes were denoted as yen evaluated at the 1:1 exchange ratio within the empire By the 1930s, the three economies under the colonial empire became closer to a free trade bloc protected by a common external tariff (Yamamoto 2000).

Table 3 also shows that overall that relative price levels for non-tradables in East Asia relative to the U.S are lower than those for tradables. This is a clear confirmation the theoretical predictions of the productivity and factor proportion differential models that posit lower price levels for non-tradables for relatively underdeveloped countries. As is well known, exchange rates conversion of per capita GDP that ignored the relatively lower price levels - in particular, of non-tradables – of relatively underdeveloped countries is the source of underestimation of their per capita income levels.

The ranking of relative prices as revealed in Table 3 seems to be theoretical consistent to the ranking of per-capita income gaps among these five economies. In Table 4, we present the aggregate five-item upper level consumption expenditure weights. It shows that consumption expenditure patterns between China and Korea are roughly comparable, while those between Taiwan and Japan had much in common, with the U.S exhibiting the most "advanced" pattern with the lowest share in food items.

Insert Table 4

Investment and Government PPP for Japan-U.S

To estimate the other two components of GDP, private investment and government expenditure, is clearly more difficult. In the case of China, data was largely non-existent. In view of the estimate that private consumption accounts for 91% of Chinese GDP, we feel reasonably comfortable to substitute our consumption PPP for GDP PPP for our study (Liu and Yeh, p. 68). Our estimation of investment and government PPP for Japan-U.S would involve the use of somewhat crude assumption and incomplete data. For private investment, we estimate two main categories: equipment and construction investment. For equipment investment PPP, we use the relative price level calculated by Dirk Pilat (1993) for machinery and equipment for 1939. For construction investment, we assume its price level as a weighted average of price for construction materials and wages for construction laborers. The result is presented in Table 5, which shows Japanese price level for private investment is at 68% of that of the U.S, higher than that for private consumption.

Insert Table 5

We divide government expenditure price levels for Japan-U.S into two categories of labor and material costs. The labor cost is measured by ratio of the average salary per government employee between Japan and the U.S. Table 6 shows that average Japanese government employee is only paid 7% of his or her U.S counterpart in

nominal terms. The second category, material cost, denotes government purchase from various sectors of the economies. In Table 6, we listed 12 sectors and their average weighted price level (of Japan over U.S) comes out to be 66%, higher than that for private consumption. This is understandable as government purchase involves quite a substantial share from the investment sector of which Japanese price levels were relatively higher. But overall, Japanese government expenditure price level is 45% of that of the U.S thanks to its much lower employee remuneration standard.

Insert Table 6

Since Fukao et al. (2004) already calculated investment and government PPP for Korea and Taiwan (relative to Japan), we now have a full set of GDP PPP for these East Asian economies for the mid-1930s all convertible to the U.S base. The result is presented in Table 7.

Insert Table 7

II. 1930s East Asian Income in International Perspectives

PPP versus Exchange Rates

Table 8 presents per capita GDPs of these East Asian economies in 1934-36 U.S dollars. The first data row shows the exchange rate converted estimates in 1934-6 current prices for these five economies. Not surprisingly, exchange rate conversion shows very low level of East Asian incomes relative to that of the U.S in the mid-1930s: Japanese per capita income was only 14% of that of the U.S; and China was at a mere 3.6% of the U.S level in per capita terms. The second row of Table 4 presents the relative price levels of the four East Asian economies relative to the U.S derived using Japan as the bridge country.

Insert Table 8

Dividing the exchange rate based per capita income estimates by the relative price levels, we can derive our 1934-36 benchmark consumption PPP adjusted estimates, which are presented in the third row of Table 8. In comparison with the exchange rate conversion, our PPP converter almost doubled per capita income of Japan and Korea, and more than doubled per capita income of Taiwan and China relative to the U.S level. There is no doubt that our PPP conversion is a major correction of the downward exchange rate bias.

In the pre-War period, there are a few other pre-existing preliminary PPP studies on East Asia. Colin Clark (1940) gave Japanese per capita income in 1925-34 at about 26% of the U.S level, almost identical to our

result (1940, p. 41). However, his result should not be viewed as a direct confirmation of ours as both his Japanese per capita GDP and relative price levels are no longer accurate by today's standard. Nonetheless it may represent the perception of the per-capita income differences at the time. A more systematic Japan-U.S PPP study was carried out by Dirk Pilat (1993, 1994) for 1939 benchmark year. Based on a output PPP approach by matching the unit value ratios of comparable goods and services, his study gives a price level for the overall Japanese economy relative to that of the U.S at 60.7%, a result surprisingly close to our 56% figure based on the expenditure approach (1994, p.24).

A more serious, yet still very crude, attempt for China-U.S PPP study is made by Liu Ta-chung, a pioneer in the reconstruction of the 1931-36 Chinese per capita GDP. His exchange rate conversion, like ours, gave the 1931-36 Chinese per capita GDP at 3.8% of the U.S level (1947, p. 72). To correct for the possible downward bias of the 1930s Chinese per capita incomes, he compared five categories of Chinese and American agricultural crop prices and derived the Chinese price level at 63% of the U.S. level.[4] This relative price level adjustment enabled him to use the Chinese per capita income from 3.8% of the U.S level to 5.7% (p.76). But recognizing the price level differences in agricultural products were possibly the least of the problems for 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. Nonetheless, his final adjustment raised the Chinese per capita income to 9% of the U.S level, in surprising conformity with our PPP estimate for China-U.S as shown in Table 8.

Current Price PPP versus 1990 Backward Projection

It is most instructive to compare our estimates with the massive dataset from Angus Maddison. Here, we follow Maddison to convert all per capita GDP estimates into 1990 dollars. Maddison's latest 2003 series gives a back-projected U.S per capita GDP in 1934-36 equal to 5,590 US$ in 1990 prices. We use this U.S figure as our basis and apply our relative price levels to derive the per-capita incomes for 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.

Insert Figure 1.

[4] Calculated from Liu, 1947 p. 73 using simple averages.

The contrast between the two estimates is striking in the case of Japan. According to Maddison, Japanese per capita income in 1934-36 stood at 2,154 in 1990 dollars, roughly 39% of the U.S level. This is almost 50% higher than the 1,431 dollars derived from our PPP estimate. Figure 1 shows that Maddison's Taiwan estimate happens to be fairly close to ours but his Korean estimate is more than twice the level of ours. Maddison's estimate for China is the closest to our PPP estimate. This is quite important as the 1930s per capita income estimates were often used as the benchmark index to link with per capita income estimates for the beginning of the Communist era around 1950. [5]

The discrepancy between our Korean per capita incomes estimate and that of Maddison was explored in detail in Fukao et al. (2004). Our discussion here would focus on our discrepancy on Japan. Maddison's upward adjustment of Japanese per capita income from 14% (as implied by exchange rate conversion) to 39% level of the U.S level would give the Japanese price levels at only about 36% of the U.S level, much lower than the 56% derived from our study. Table 9 presents our relative GDP price levels against a series of other PPP benchmark studies for both the pre- and post-War period. As indicated earlier, Pilat's production based PPP study for 1939 is very close to ours and thus arrives at a PPP converted Japanese per capita income at 27% of that of the U.S, similar to our 25% level for the mid-1930s.[6] The PPP study by Watanabe and Komiya (1958) is clearly less thorough than the ICP studies of Kravis et al. The study did not include, for example, the relatively high-priced energy and housing expenditure. Still, it shows Japanese price levels for private consumption were already 52% of the U.S level even when her per capita income was only 18% of that of the U.S. By the 1970s, with a rising relative Japanese per capita income, her consumption price levels rapidly converge to the U.S level. In sum, whether poor or rich, the Japanese price levels have always seemed to be relatively high.

Insert Table 9

Backward projection method as adopted in Maddison entails index problems which could be potentially serious especially across a long span of time. In the case of East Asia, GDP estimates for the WWII period are highly questionable. This could seriously affect the reliability of the level of real domestic GDP used for

[5] See Liu and Yeh, Perkins for the linking of 1930s and 1950s GDP data.

[6] Pilat (1994) used the labor force as the denominator for his per capita income. Since the labor force participate rate in the U.S and Japan were very close at 41 and 45% respectively for the mid-1930s, his estimate is thus comparable to ours. Labor force estimates are from *Historical Statistics,* p. 126 and Ohkawa and Shinohara, p.392.

backward projection. Furthermore, during the Post-WWII period, East Asia had seen enormous economic transformation. Rapid shifts in terms of trade or economic structures could induce serious biases from backward projection. Disentangling all these factors and identifying the cause of discrepancies between current price PPP and back-projected PPP estimates remains as our future research agenda. We attach Appendix A that provides a mathematical decomposition of index number biases from backward projection and an empirical test which shows the impact of terms of trade change on the long-term levels of real GDP projected.

1934-36 PPP adjusted East Asia per capita Incomes: Levels and Growth Implications

Maddison's pre-War Japanese GDP estimates have been widely cited in major growth textbooks and academic publications. What is the implication of a drop from 2,154 dollars per capita income level to US$1,383 (in 1990 prices) in the mid-1930s? If we compare this other countries in the 2003 Maddison data set, it would only amount to half of that of Italy and lower than almost all the Western European countries including Portugal and Greece for the mid-1930s. Clearly, one has good reason to question other back-projected estimates in the Maddison data set. In fact, a recent preliminary study by Ward and Devereux (2005) reveals Italian per capita income in the 1930s were half as much as that of Maddison's figure, thus making Italy about the same level as Japan by our estimate.

If we reinsert our Japanese estimate into Maddison's data set for Asian countries, Japanese per capita income would end up being equal to those for Malaysia and the Philippines. This may not seem so anomalous if compared with some of the recent Asian real wage studies such as Bassino and Eng (2002) and Bassino (2005). They show that the 1935 daily nominal wages for unskilled laborers and carpenters in Tokyo were not much higher than those in Bangkok, Singapore or Penang of the British Malaya. As consumer price levels, particularly food prices, were much cheaper in those Southeast Asian cities, their studies reveal that Tokyo real wage lower than in those cities.

Backward and forward projection of our mid-1930s PPP adjusted income estimate for the pre-War period sheds new light on Japan's initial conditions in early Meiji and the early post-WWII. For example, projecting backward from the level of US$1,383 in the mid-1930s - rather than Maddison's US$2,154 – gives a 1880s Japanese per capita income only about 600$ (1990 prices). In other words, on the eve of her first wave of industrialization in the 1880s, the Japanese economy was near subsistence, not richer than those of her Asian neighbors, whom Japan was to overtake or even colonize in the following few decades. Again the recent real

wage literature seems to confirm that. 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 the low income European countries such as Italy. They only consistently rose above the Chinese level after the 1890s and reached a little more than twice China's level by the 1920s, a result consistent with the per capita GDP differences indicated in this mid-1930s PPP study.

Our study of an overall lowered pre-War GDP level for Japan brings added significance to the post-War Japanese economic miracle. The catch-up or convergence of Japan 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. The income divergence between China and Japan, Taiwan and Korea became several times wider in the 1980s than in the 1930s. In this regard, China's rapid economic growth since the 1980s, particularly in some of her coastal regions, may well be viewed partly as a catch-up to her historical potential.[7]

Of course, the large question is: why is that Japan - rather than Malaysia or Thailand - caught up so quickly in the post-War period despite their possibly common starting points? We can provide some conjectures. Bassino's wage data shows the skill premium between unskilled laborers and carpenters in Tokyo is lower 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 (2003) reveals that despite the much larger per capita income gap, average years of schooling in Japan were already over 60% those of the U.S level in the 1930s. 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 bound for a course of convergence in the pre-War era were it not for the interruption of the War? This PPP study raises new questions as well as possible new answers to old questions.

Conclusion

Our study provides a set of pre-War benchmark conversion standards for comparison of income, consumption as well as other monetary indicators for East Asia in global perspective. Our pre-War consumption PPP confirms that the exchange rate conversion consistently under-estimated per capita incomes of East Asia. Our PPP result also reveals possible biases derived from the 1990 backward projection method. In

particular, we find that the Japanese per capita income in the mid-1930s or the entire pre-War period is much lower than widely believed, a result that could drastically alter our existing interpretation of long-term economic growth in East Asia. It could also carry enormous implications for understanding the casual determinants of economic growth. In fact, our finding that Japan, or East Asia in general, was historically very poor, spells a positive message for today's large developing world: initial poverty itself is not a fatal constraint a nation's aspiration to prosperity.

[7] See Ma (2004) for study of the regional economic growth in China's Lower Yangzi region in the early 20th century.

Appendix Table I. Chinese Price Level Relative to Japan (1934-36；Japan=1）

Items	Chinese Weight				Japanese weight				Price (in Japanese Yen)				Chinese Price Level		
	U	M	L	Item weight	U	M	L	Item weight	Unit	Japan	China	China/Japan	Chinese Weight	Japanese weight	Fisher average
All													**0.654**	**0.856**	**0.748**
Food	68.65				40.90								**0.661**	**0.778**	**0.717**
Grain		68.48				35.32									
Rice			69.88	32.86			93.26	13.47	1 Kg	0.24	0.16	0.67			
Wheat			30.12	14.16			6.74	0.97	1 Kg	0.21	0.15	0.72			
Vegetables		8.82				8.87									
Soybeans			1.72	0.10			13.87	0.50	1 Kg	0.23	0.12	0.52			
Other beans			7.30	0.44			9.85	0.36	1 Kg	0.19	0.07	0.40			
Potatoes			5.93	0.36			2.90	0.11	1 Kg	0.07	0.03	0.43			
Cabbages			63.05	3.82			43.67	1.58	1 Kg	0.08	0.06	0.76			
fresh vegetables			2.33	0.14			9.90	0.36	1 Kg	0.08	0.04	0.44			
fresh vegetables			9.01	0.55			9.90	0.36	10 monm	0.18	0.13	0.75			
Apple			0.14	0.01			2.48	0.09	100 monı	0.15	0.34	2.26			
Oranges			0.29	0.02			2.48	0.09	100 monı	0.08	0.16	2.03			
Banana			0.09	0.01			2.48	0.09	1 Kg	0.20	0.46	2.32			
Other fruits			10.14	0.61			2.48	0.09	100 monı	0.1	0.16	1.57			
Ingredients		7.41				8.53									
Soysauce			17.98	0.92			26.97	0.94	1 liter	0.27	0.54	1.98			
Miso			8.00	0.41			17.67	0.62	1 Kg	0.22	0.21	0.94			
Sugar			11.60	0.59			11.46	0.40	1 Kg	0.40	0.71	1.79			
Salt			8.26	0.42			3.50	0.12	1 Kg	0.07	0.23	3.18			
Oil			54.16	2.76			40.40	1.41	1 liter	1.03	0.77	0.74			
Meat and Fish		5.86				13.54									
Pork			38.11	1.53			5.26	0.29	1 0 0 g	0.14	0.05	0.36			
Beef			27.05	1.09			12.78	0.71	1 0 0 g	0.16	0.04	0.26			
Chicken			2.48	0.10			1.95	0.11	1 0 0 g	0.21	0.08	0.39			
Fresh fish			14.92	0.60			20.49	1.13	1 Kg	0.71	0.50	0.70			
Salty fish			3.84	0.15			20.49	1.13	1 Kg	1.15	2.11	1.84			
Other Fisher goods			6.35	0.26			20.49	1.13	1 Kg	0.75	0.22	0.30			
Eggs			5.89	0.24			14.26	0.79	1 Kg	0.62	0.42	0.68			
Milk			1.36	0.05			4.26	0.24	1 bottle	0.37	0.71	1.90			
Others		1.00				23.82									
Sweets			11.70	0.08			25.00	2.44	1 Kg	0.16	0.14	0.87			
Preserved vegetables			21.56	0.15			25.00	2.44	1 Kg	0.16	0.14	0.87			
Tofu			25.13	0.17			25.00	2.44	一丁	0.07	0.03	0.52			
Other processed food			41.61	0.29			25.00	2.44	100 monı	0.07	0.07	0.98			
Drinks and Tobacco		8.42				9.92									
Tobacco			51.37	2.97			39.12	1.59	1 packet	0.15	0.18	1.21			
Alcohol			20.94	1.21			48.74	1.98	1 liter	0.85	0.18	0.21			
Tea			27.69	1.60			12.14	0.49	1 0 0 g	0.19	0.22	1.17			
Lighting and Heat	8.32				4.80								**0.411**	**1.363**	**0.748**
Electricity		0.31	100.00	0.03		47.60	100.00	2.28	1 KWH	0.14	0.20	1.87			
Fuel		96.97				48.92		0.00							
Coal			5.99	0.48			11.80	0.28	10Kg	0.27	0.26	0.94			
firewood			77.03	6.22			38.80	0.91	10Kg	0.26	0.09	0.35			
charcoal			1.65	0.13			40.80	0.96	10Kg	0.81	1.14	1.41			
lamp oil			15.32	1.24			8.60	0.20	1kg	0.26	0.32	0.88			
Others match		2.72	100.00	0.23		3.48	100.00	0.17	1packet	0.06	0.06	0.94			
Clothing and Bedding	8.48				10.71								**0.857**	**0.929**	**0.892**
Clothing		80.28				72.84									
Bleached cotton			79.44	5.41			49.77	3.88	1 roll	0.59	2.10	0.83			
man's white shirt			11.32	0.77			49.77	3.88	1 piece	2.13	2.28	1.07			
cotton			9.24	0.63			0.46	0.04	1Kg	0.98	0.81	0.83			
Personal Items		19.72				27.16									
sports shoes			50.00	0.84			69.73	2.03	1 pair	0.70	1.25	1.78			
umbrella			50.00	0.84			30.27	0.88	1 piece	0.89	0.53	0.60			
Housing	5.29				10.73								**0.701**	**0.569**	**0.631**
Rent		61.61	50.00	1.63		97.30	50.00	5.22	1 room (4	5.09	2.736	0.538053			
carpenter wage			50.00	1.63			50.00	5.22	daily	1.97	1.09	0.553299			
Furniture		38.39				2.70									
Wooden board			50.00	1.02			50.00	0.14	1 tsubo	1.98	2.01	1.02			
washing basin			50.00	1.02			50.00	0.14	1 piece	0.31	0.56	1.77			
Mis.	9.25				32.86								**0.811**	**0.988**	**0.895**
Trans. Ricksaw wage		4.89	100.00	0.45		6.20	100.00	2.04	daily	2.67	0.62	0.23			
Educa.		1.55				5.83		0.00							
Teacher			100.00	0.14			90.57	1.74	monthly	65.91	45.60	0.69			
Hygience		9.92				10.40		0.00							
soap			50.00	0.46			50.00	1.71	1 piece	0.09	0.28	2.93			
toothbrush (Tokyo)			50.00	0.46			50.00	1.71	1 piece	0.15	0.27	1.78			
								0.00							
Medicin alcohol		5.82	100.00	0.54		12.80	100.00	4.21	1 bottle	0.83	0.83	1.00			
Entertai Movie		19.15	100.00	1.77		21.27	100.00	6.99	once	0.30	0.23	0.76			
Other Newspapers		58.67	100.00	5.43		43.50	100.00	14.29	1 set	0.05	0.05	0.91			

Source: Yuan (2005).

Appendix Table II. Japanese Price Level Relative to US (1934-36年：US=1)

Commodities		Japanese weight			US weight			US Units	Japanese Units	Prices			Ratio to exchange rates	Japanese Price Level			Sample size of the US ICPSR data	Tradables
		U	M	L	U	M	L			US	Japan	Japan/US in PPP		Japanese weight	US weight	Fisher Average		
Total	Exchange Rate									dollars	yen	Yen/dollar	3.33	**0.48**	**0.61**	**0.54**		
Food		**41.3**			**33.2**									**0.44**	**0.64**	**0.53**		
Grain and bread			39.7	100.0		12.0	100.0	Unit	Unit					**0.41**	**0.61**	**0.50**		1
	Rice			92.9			3.1	1lb	1Kg	0.08	0.2380	1.30	0.39					
	Wheat flour			5.8			16.7	1lb	1Kg	0.05	0.23	2.11	0.64					
	Bread 1, a			1.2			80.6	1lb	1lb	0.08	0.17	2.05	0.62					
Meat			2.7	100.0		19.8	100.0							**1.03**	**0.97**	**1.00**		1
	Beef			63.9			51.7	1lb	1kg	0.14	1.28	4.04	1.21					
	Pork			26.8			34.1	1lb	1kg	0.32	1.40	2.01	0.60					
	Chicken			9.4			14.2	1lb	1kg	0.29	2.08	3.21	0.96					
Fish			8.3	100.0		1.3	100.0							**0.29**	**0.26**	**0.27**		0
	Flounder/Halibut 1, a			54.4			52.3	1 lb	100 monme	0.24	0.15	0.77	0.23				43	
	Mackerel a			43.0			16.5	1 lb	100 monme	0.12	0.113	1.19	0.36				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							**0.48**	**0.89**	**0.65**		0
	Milk			23.0			77.6	1qt.	1go (180cc)	0.12	0.08	3.52	1.06					
	Eggs			77.0			22.4	1doz	1Kg	0.36	0.62	1.03	0.31					
Ingredients			8.5	100.0		3.0	100.0							**0.84**	**0.84**	**0.84**		1
	salt a			10.3			10.3	1 lb	1kg	0.053	0.117	1.01	0.30					
	sugar			89.7			89.7	1lb	1kg	0.056	0.370	3.00	0.90					
Vegetables and fruits			9.2	100.0		12.7	100.0							**0.34**	**0.37**	**0.35**		1
	Cabbages			6.7			7.2	1lb	1kg	0.040	0.080	0.90	0.27					
	Onion1			5.4			11.3	1lb	1kg	0.044	0.104	1.06	0.32					
	Sweet potato			20.4			4.1	1lb	1Kg	0.04	0.08	0.87	0.26					
	Potato			18.5			33.0	1lb	1Kg	0.02	0.08	1.47	0.44					
	spinach			12.1			8.2	1 lb	1 kan	0.076	0.30	0.48	0.14					
	bananas			18.5			14.4	1lb	1kg	0.06	0.20	1.41	0.42					
	apple 1, a			18.5			21.6	1 lb	1 kg	0.054	0.15	1.26	0.38				545	
Processed food			19.1	100.0		7.0	100.0							**0.36**	**0.36**	**0.36**		1
	peanut oil and vegetable shortening			50.0			50.0	1lb	1kg	0.20	0.62	1.38	0.42					
	canned pink salmon 1,			50.0			50.0	1 lb	1 can (235 g)	0.151	0.080	1.027	0.308				120	
Alcohol			4.8	100.0		14.5	100.0							**0.49**	**0.49**	**0.49**		1
	beer a			100.0			100.0	1 quart (946 milliliters)	1bottle (720 milliliters)	0.27	0.33	1.63	0.49				3	
Tea and drinks			1.2	100.0		2.6	100.0							**0.37**	**0.37**	**0.37**		1
	tea			100.0			100.0	1lb	1kg	0.68	1.86	1.24	0.37					
Tobacco	cigarette a		3.9	100.0		8.1	100.0	1 package	1 package	0.135	0.15	1.11	0.33	**0.33**	**0.33**	**0.33**	704	1
Household Utilities		**4.8**			**5.8**									**1.12**	**0.91**	**1.01**		
Fuel expenses			52.4	100.0		75.6	100.0							**1.26**	**0.90**	**1.06**		1
	coal			12.9			97.1	10Kg	1kg	0.0042	0.0272	2.96	0.89					
	firewood a			87.1			2.9	10Kg	10Kg	0.06	0.27	4.40	1.32				6	
Electricity	electricity		47.6	100.0		24.4	100.0	1kwh	1kwh	0.05	0.16	3.20	0.96	**0.96**	**0.96**	**0.96**		0
Clothing and Bedding		**10.6**			**13.3**									**0.51**	**0.51**	**0.51**		1
Cloth			33.3	100.0		33.3	100.0							**0.75**	**0.75**	**0.75**		
	Raw silk 2, b			20.0			20.0	1 lb	1 kg	1.50	11.23	3.40	1.02					
	Cotton yarn 2, b			20.0			20.0	1 lb	1 kg	0.30	1.19	1.78	0.53					
	muslin 2, b			20.0			20.0	1 yard	1 yard	0.15	0.49	3.22	0.97					
	woolen yarn 2, b			20.0			20.0	1 lb	500 g	1.64	2.71	1.48	0.45					
	serge 2, b			20.0			20.0	1 yard	1 m	1.075	3.01	2.55	0.77					
Wages for processing			33.3	100.0		33.3	100.0							**0.11**	**0.11**	**0.11**		
	tailor and embroider			100.0			100.0	daily	daily	0.60	1.80	0.38	0.113					
Personal Items			33.3	100.0		33.3	100.0							**0.66**	**0.66**	**0.66**		
	men's leather shoes			100.0			100.0	1 pair	1 pair	3.73	8.25	2.21	0.66					
Housing and Furniture		**10.2**			**21.0**									**0.75**	**0.69**	**0.72**		
Monthly housing rent			85.3	100.0		69.5	100.0	1 room (assumed to be 20 sq. m.)	1.65 sq. m.	4.768	1.06	2.69	0.81	**0.81**	**0.81**	**0.81**	664	0
Furniture equipment and supplies			14.7	100.0		30.5	100.0							**0.40**	**0.40**	**0.40**		1
	Furniture maker			50.0			50.0	hourly	daily	0.50	1.80	0.45	0.14					
	wooden boards			50.0			50.0		3.3 sq.m		0.17		0.67					
Miscellaneous Expenses		**33.2**			**26.7**									**0.36**	**0.50**	**0.42**		
Transp. & communication			6.2	100.0		43.8	100.0							**0.65**	**0.67**	**0.66**		
	subway (New York and Tokyo) 1			20.2			22.9	1 ride	1 ride	0.05	0.10	2.00	0.60					0
	Gasoline			20.2			22.9						0.89					1
	bus drivers and rickshaw pullers			20.2			22.9	hourly	daily	0.584	2.70	0.54	0.16					0
	automobile			20.2			22.9						1.12					1
	postcard			19.4			8.3	1 piece	1 piece	0.01	0.015	1.50	0.45					0
Health and Hygiene			23.2	100.0		23.3	100.0							**0.37**	**0.37**	**0.37**		
	Doctor salaries			28.0			37.1	annual	annual	2196.50	633.00	0.29	0.09					0
	Medicine			28.0			37.1		300 pills		160.00		0.67					1
	men's haircut 1, a			21.6			14.0			0.385	0.40	1.04	0.31				2886	0
	toilet soap 1, a			22.4			11.8	1 piece	1piece	0.0657	0.093	1.42	0.43				2838	1
Education, books, and newspapers			11.3	100.0		8.8	100.0							**0.40**	**0.46**	**0.43**		0
	Tuition and fees for elementary school 1, a			23.6			22.8	annual	monthly	2.19	0.400	2.19	0.66				1828	
	tuition and fees for college and university 1, a			23.5			22.7	annual	monthly	138.500	12.478	1.08	0.32				137	
	wood pulp			5.3			5.5	100 lbs	1 kg	2.004	0.180	4.04	1.21					
	teacher salaries			5.3			5.4	annual	monthly	1974.50	65.91	0.40	0.12					
	newspapers 1, a			42.3			43.6	1 issue	1issue	0.063	0.05	0.79	0.24				74	
Entertainment, religious and welfare	Movies1 1, a		59.3	100.0		24.1	100.0	per show	per show	0.29	0.30	1.03	0.31	**0.31**	**0.31**	**0.31**		0

Notes:

1. In the case of Japanese data, items marked with 1 are the averages of Tokyo in 1934-36, items marked with 2 are the wholesale prices of Tokyo in 1935. All other prices are the 1934-36 averages of consumer prices. In the case of US data, items marked with *a* are based on micro data of Study of Consumer Purchases in the United States (ICPSR 8908), items marked with *b* are the wholesale prices of US in 1935.

2. Barber wages are from Handbook of Labor Statistics (HLS), vol. II, p.38. Bus driver wages are from HLS, vol. 1, p. 980. Japan's wages are for Rickshaw wages. Doctor salary for US is an average of dentists and chiropodists (HLS, vol. II p. 298-300. Teacher salary for US is from Table 12, p. 311 in HLS vol. ll, p. 311. Electricity prices for US from HLS, vol. 1, p.666-667. Embroider wages for US from HLS, vol. ll, p.94.
3. 1 lb=453.6 grams, 1 momme=375 grams.
4. US rent is based on 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. Japan's rent is the weighted average of rents in Tokyo and six other biggest cities, Osaka, Kyoto, Nagoya, Kyoto, Kobe, and Yokohama. As weights, we used number of households in each city in 1935 (Teikoku Tokei Nenkan 1938). The average rent per 1.65 sq.m. in Tokyo is from Keizai Shingi-cho (1953). We calculated rent in other cities using information of rent per house (apartment) in Tokyo and the other six cities, which is reported in Clark (1940).
5. In the case of wooden boards and medicine, the Japanese price levels are assumed to be two third of the US price levels.

Appendix A. On the Gap between GDP Comparisons Based on Current Price PPP and Those Based on Backward Projection

In this paper we found that per capita GDP comparisons between East Asian countries and the U.S. in the pre-war period based on current price PPP frequently reveal substantially different results from Maddison's (1995, 2003) long term statistics, which are calculated by backward projection based on 1990 benchmark PPP.[8] Actually, the founders of the Penn World Tables (Heston and Summers 1993) were well aware of this issue, that is, the gap between current price PPP comparisons and backward projected comparisons based on the PPP of later years. By comparing past ICP (International Comparison Program) results of every five years from 1970 and backward projected per capita GDP based on 1990 benchmark PPP, they found large gaps between the two values for many countries.[9]

Despite the potential importance of this issue, there are few theoretical and empirical comprehensive analyses.[10] In this appendix, we examine what factors might cause the gap between the Maddison-style 1990 benchmark back projected real per capita GDP comparison and the current-benchmark based per capita GDP comparison and empirically test the implications of our theoretical analysis.

A Theoretical Analysis

The 1990 benchmark backward projected real per capita GDP in year *t* is

$$y_i^{\,E}(t,90) = \frac{\sum_{n=1}^{N} p_n^i(t)e_n^i(t)}{\sum_{n=1}^{N} p_n^i(t)e_n^i(90)} \sum_{n=1}^{N} p_n^G(90)e_n^i(90)$$

where $e^i_n(t)$ denotes country *i*'s real per-capita net output (total output minus intermediate input) of the *n*th good or service at time *t*, $p^i_n(t)$ stands for country *i*'s price of the *n*th good or service at time *t*, and $p^G_n(t)$ is the reference price (such as the Geary-Khamis (GK) international price) of the *n*th good or service of country *i* in year *t*. The first term in the right-hand side of the above equation denotes the inverse of this country's real GDP growth from *t* to 1990. As we shall discuss later, in Maddison's work (Maddison 1995, 2003) this term is calculated in a more sophisticated way. He calculates the long-term growth of real GDP by linking real GDP series of different benchmark years.

The per capita GDP estimate of year *t* based on current reference prices is

$$y_i^{\,C}(t) = \sum_{i-1}^{N} p_n^G(t)e_n^i(t)$$

Based on these two definitions, the gap between (a) the logarithmic value of the ratio of country *i*'s per capita GDP to country *j*'s per capita GDP derived by 1990 benchmark backward projection and (b) the logarithmic value of the two countries' per capita GDP ratio based on current reference prices is expressed by

[8] Ward and Devereux (2003, 2005) also found large discrepancies between the two estimates in in their comparison of North American and European countries.

[9] The Penn World Table data (including the most recent Version 6.1 data) on per capita GDP in international dollars is calculated by backward projection based on the 1996 benchmark year. The method is similar to Maddison's approach.

$$
\begin{aligned}
\ln\left(\frac{y_i^{\,E}(t,90)}{y_j^{\,E}(t,90)}\right)-\ln\left(\frac{y_i^{\,C}(t)}{y_j^{\,C}(t)}\right) &= \left\{\ln\left(\frac{\sum_{n=1}^{N}p_n^i(90)e_n^i(90)}{\sum_{n=1}^{N}p_n^i(90)e_n^i(t)}\right)-\ln\left(\frac{\sum_{n=1}^{N}p_n^i(t)e_n^i(90)}{\sum_{n=1}^{N}p_n^i(t)e_n^i(t)}\right)\right\} \\
&-\left\{\ln\left(\frac{\sum_{n=1}^{N}p_n^j(90)e_n^j(90)}{\sum_{n=1}^{N}p_n^j(90)e_n^j(t)}\right)-\ln\left(\frac{\sum_{n=1}^{N}p_n^j(t)e_n^j(90)}{\sum_{n=1}^{N}p_n^j(t)e_n^j(t)}\right)\right\} \\
&+\left\{\ln\left(\frac{\sum_{n=1}^{N}p_n^G(90)e_n^i(90)}{\sum_{n=1}^{N}p_n^G(90)e_n^i(t)}\right)-\ln\left(\frac{\sum_{n=1}^{N}p_n^i(90)e_n^i(90)}{\sum_{n=1}^{N}p_n^i(90)e_n^i(t)}\right)\right\} \\
&-\left\{\ln\left(\frac{\sum_{n=1}^{N}p_n^G(90)e_n^j(90)}{\sum_{n=1}^{N}p_n^G(90)e_n^j(t)}\right)-\ln\left(\frac{\sum_{n=1}^{N}p_n^j(90)e_n^j(90)}{\sum_{n=1}^{N}p_n^j(90)e_n^j(t)}\right)\right\} \\
&+\left\{\ln\left(\frac{\sum_{n=1}^{N}p_n^G(90)e_n^i(t)}{\sum_{n=1}^{N}p_n^G(t)e_n^i(t)}\right)-\ln\left(\frac{\sum_{n=1}^{N}p_n^G(90)e_n^j(t)}{\sum_{n=1}^{N}p_n^G(t)e_n^j(t)}\right)\right\}
\end{aligned}
\qquad \text{(A1)}
$$

The above equation decomposes the logarithmic value of the deviation of the backward projection estimation from the current price benchmark estimation into five components.

The first component, which measures the discrepancy between real growth rates using the later period price weights and the past period price weights in country *i*, is broadly known as the Gerschenkron effect. This effect tends to be larger for economies experiencing greater structural and relative price changes during the studied period. Whether or not this effect over- or underestimates country *i*'s per capita income in period *t* depends on whether there is a positive or negative correlation between the changes in the relative prices and net output of the corresponding sectors. The second component measures the Gerschenkron effect for country *j*.

If we use the long-term real GDP growth based on recent prices, the Gershenkron effect will become smaller. Actually, Maddison, in his work (1995, 2003) calculated the long-term growth of real GDP by linking real GDP series of different benchmark years.[11] Because of this approach, the real GDP series in Maddison's formula are based on multiple benchmark prices.

Furthermore, in many countries the coverage and the definition of GDP statistics have occasionally revised. For example, the transition from the 1968 SNA to the 1993 SNA has changed the definition of GDP. In such cases, Maddison can automatically adjust the past series of real GDP based on the old definition to the recent

[10] Szilágyi (1984) analyzed this issue from a more general theoretical viewpoint.

definition by his link approach, although this is not a very rigorous way of adjustment.[12] If the current price GDP of year *t*, which is used for the calculation of the per capita GDP estimate based on current reference prices, is not adjusted to the recent SNA definition and coverage, we will have another component in the gap between Maddison's estimate and the per capita GDP estimate based on current reference prices, which is not explicitly shown in Equation (A1). Let us call this component the change-of-coverage effects.

The number of real GDP series based on different benchmark prices is not identical among countries. In some countries, the existing historical real GDP statistics might be already adjusted to the most recent SNA definition and coverage. But in other countries they might not be adjusted. Because of these differences among countries, it is very difficult to evaluate the Gershenkron effect and the change-of-coverage effects. For a reliable estimation, we need to carefully examine which original GDP series Maddison used for each country.

In the case of Japan, we checked all the original real and nominal GDP series that Maddison used. Appendix Table III reports the change-of-coverage effects for Japan. According to this table, compared with Maddison's estimation, which implicitly adjusts changes of GDP definition by the link method, Ohkawa-Shinohara (1979) statistics underestimate pre-war period GDP by 5.45 percent.

Appendix Table III. Comparison of Japan's Nominal GDP among Original Statistics (billion yen)

		1940	1952	1960	Total GAP
Ohkawa and Shinohara (1979)	a	36.861			
GDP estimation based on income distribution statistics, White Paper on National Income 1963 FY Version (Kokumin Shotoku Hakusho, 1963 Nendo Ban), on which Mizuguchi based his pre-war/post-war link	b	36.458	6,020.2		
OECD National Income Statistics, 1976	c		6,215	15,503	
OECD National Income Statistics, 1999	d			16,011	
Gap		b40/a40=0.989	c52/b52=1.032	d60/c60=1.033	(b40/a40)*(c52/b52)*(d60/c60)=1.0545
		The link of real GDP at this year was conducted by Mizoguchi	The link of real GDP at this year was conducted by Maddison	The link of real GDP at this year was conducted by Maddison	

[11] Since SNA statistics in each country have a different number of available GDP series based on different benchmark years, Maddison's link procedure is different across countries.

[12] Let $y_i^R*(t, T)$ denote the most recent series of real GDP statistics based on year T prices for year $T<t$, and let $y_i^R**(t, T')$ denote the older series of real GDP statistics based on year T' ($T'<T$) prices for year $t<T$. Then, the year t ($t<T$) real GDP based on year T prices of the link approach is $y_i^R**(t, T') \, y_i^R*(T, T) / y_i^R**(T, T')$.

The third and the forth component can be called the price inconsistency effect, which is created by the inconsistency between prices used for backward projection and the reference prices for international comparison.[13] This effect tends to be larger if the economy experienced large structural changes during the studied period or if the price structure of the economy is very different from the reference price structure.

Finally we focus on the last component in Equation (A1). This component will take a positive value if the change in reference prices from year *t* to 1990 is more favorable to country *i* than to country *j*. In order to understand this component intuitively, let us conduct the following thought experiment. Suppose that there are two small countries, which face exogenously determined international prices. We use the international price as the reference price. Country A only produces semiconductors. It doubled its output from 1980 to 1990. But the international price of its output declined to one half in the same period. Country B only produces low-tech products. Both its total output and the international price of its output stayed constant during the same period. There is no population growth in the two countries. The two countries have the same level of per capita GDP in 1990 at current international prices. Then, we have the following relationship.

$y_A^E(80, 90)=0.5\, y_B^E(80, 90)$

$y_A^C(80)= y_B^C(80)$

The backward projection method underestimates the past GDP of countries which experienced a deterioration in their terms of trade.

An Empirical Analysis

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

$$\ln\left(\frac{y_i^E(t,90)}{y_{EU}^E(t,90)}\right)-\ln\left(\frac{y_i^C(t)}{y_{EU}^C(t)}\right) \qquad \text{(A2)}$$

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 UK, West Germany and Italy).

The Gerschenkron 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 Gerschenkron effect as a random error. Based on similar reasoning we also treat the price inconsistency effect as a random error.

By taking a first difference of equation (A2) over time and treating the Gerschenkron effect and the price inconsistency effect as components of the error term, we derive the following:

[13] Szilágyi (1984) called this as "weight inconsistency" factor.

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

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

+ error term (composed of the Gerschenkron effect and the price inconsistency effect)

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

Let $d^i_n(t)$ and $x^i_n(t)$ denote domestic demand and net exports of commodity n in country i in year t. We have an equality, $e^i_n(t) = d^i_n(t) + x^i_n(t)$. To simplify the terms of trade effect we make the following additional assumptions.

i) Each country's balance of trade and services is close to zero:

$$\sum_n p^*_n(t)x^i_n(t) = 0 \quad for \quad \forall t \ and \ \forall i$$

where $p^*_n(t)$ denotes the international price of commodity n at period t.

ii) Each country has a similar demand structure:

$$a^i_n(t)/a^i_{n'}(t) = a^j_n(t)/a^j_{n'}(t) \quad for \quad \forall t, \forall n, \forall n', \forall i, and \ \forall j$$

iii) The GK price vector is close to the domestic price vector of each country and the international price vector.

Then, the first term on the right-hand side of equation (A2) can be approximated by

$$\ln\left(\frac{\sum\left\{p_n^*(t+1)-p_n^*(t)\right\}x_n^i(t)}{\sum p_n^*(t)e_n^i(t)}\right)-\ln\left(\frac{\sum\left\{p_n^*(t+1)-p_n^*(t)\right\}x_n^{EU}(t)}{\sum p_n^*(t)e_n^{EU}(t)}\right)$$

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

$$m^i(t)\left\{\ln\left(T^i(t+1)\right)-\ln\left(T^i(t)\right)\right\}-m^{EU}(t)\left\{\ln\left(T^{EU}(t+1)\right)-\ln\left(T^{EU}(t)\right)\right\}$$

where $m_i(t)$ 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.

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

$$=\alpha-\beta m_i(t)\left\{\ln\left(T_i(t+5)\right)-\ln\left(T_i(t)\right)\right\}+\sum_T\gamma_T DUM_T(t)+\varepsilon_i(t)$$

where $DUM_{\square}(t)$ 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 as follows. Notice that *D8085* and *D8590* are time dummies. 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. Appendix Table IV, reporting the results of our regression, show that the β coefficient is close to –1 and statistically significant, thus confirming our theory.

Appendix Table IV. 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
D8085	3.46E-05	0.025	0.001
D8590	0.0943	0.025	3.751

R square = 0.49

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Table 1. Consumption Price Levels of China Relative to Japan (1934-36 Japan =1)

	Based on Chinese Quantity Weight	Based on Japanese Quantity Weight	Fisher Average
Total	0.654	0.856	0.748
Food	0.661	0.778	0.717
Lighting and Heat	0.411	1.363	0.748
Clothing and Bedding	0.857	0.929	0.892
Housing Expenses	0.701	0.569	0.76
Miscellaneous	0.811	0.988	0.895

Notes: see the text

Table 2. Consumption Price Levels of Japan Relative to the U.S (1934-36 U.S =1)

	Based on Japanese Expenditure Weight	Based on U.S Expenditure Weight	Fisher Average
Total	**0.48**	**0.61**	**0.54**
Food	0.44	0.64	0.53
Lighting and Heat	1.12	0.91	1.01
Clothing and Bedding	0.51	0.51	0.51
Housing Expenses	0.75	0.69	0.72
Miscellaneous	0.36	0.50	0.42

Source: see the text

Table 3. Consumption Price Levels of East Asia Relative to the U.S (1934-36 U.S. =1)

	China	Taiwan	Korea	Japan
Total (Fisher Average)	0.42	0.46	0.50	0.54
Food	0.38	0.46	0.50	0.53
Lighting and Heat	0.74	0.78	0.81	1.01
Clothing and Bedding	0.45	0.48	0.48	0.51
Housing Expenses	0.45	0.52	0.63	0.72
Miscellaneous	0.38	0.34	0.30	0.42
Tradable	0.42	0.50	0.52	0.56
Non-tradable	0.38	0.40	0.37	0.52

1. In the case of China, Taiwan, and Korea, the relative price level for each consumption category is calculated multiplying the Fisher average price level of these countries in comparison to Japan by the Fisher average price level of Japan in comparison to the U.S. The relative price levels for total consumption of these three countries are calculated as Fisher averages based on each country's consumption weights and U.S. weights, which are reported in Table 4.
2. Tradable goods for Korea: food, coal, firewood, charcoal, oil, cotton, bleached cloth, underwear, socks, shoes, umbrellas, Western umbrellas, cement, kneaded tiles, tea bowls, soap, health pills, writing paper.
3. Tradable goods for Taiwan: food, firewood, charcoal, coke, cotton, muslin, cotton flannel, cement, tatami mats, kneaded tiles, cedarboard, soap, writing paper, Minogami paper.
4. Tradable goods for China: food, clothing and bedding, firewood, coal, match, lamp oil, wooden board, washing basin, hygien products, soap, toothbrush, medical alcohol.
5. Tradable goods for Japan are items marked as "1" in Appendix Table II.
6. For Japan-Taiwan comparison, Japanese and Taiwanese weights used for the tradables are 60 and 63 percent respectively. For Japan-Korea comparison, Japanese and Korean weights used for the same three categories are 62 and 83 percent respectively. For Japan-China comparison, Japanese and Chinese weights are 63 and 89 percent respectively. For Japan-U.S, Japanese and US weights are 56 and 59 percent respectively.

Table 4. Aggregate Consumption Expenditure Weights in 1934-36

	China	Taiwan	Korea	Japan	U.S.
Food	68.65	47.99	65.82	41.3	33.2
Lighting and Heat	8.32	5.84	9.75	4.8	5.8
Clothing and Bedding	8.48	6.87	7.15	10.6	13.3
Housing Expenses	5.29	7.67	5.57	10.2	21.0
Miscellaneous	9.25	31.63	11.71	32.2	26.7

Source Notes: The urban expenditure weights for Taiwan and Korea are from Mizoguchi, "Worksheet No. 9," The rural weights from Mizoguchi (1975, p.10). For Japanese weights and data source, see the explanation in Appendix 1. Chinese weights are largely based on Zhang Donggan (2001, p.375-6). The rural share of population in Taiwan and Korea are 52 and 75 per cent respectively, calculated from M&U volume, pp. 235, 237, 263 and 268.

Table 5. Relative Price Levels for Private Investment for Japan and 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				0.45	0.51	0.48
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	0.14			
Total	1.0	1.0	0.68	0.67	0.70	0.68

Source notes:

1. Japan/US price levels for equipment (metals and machinery) is from Pilat (1994), Table 2.5, p. 27. construction wages from Appendix Table II. Price levels for the rest are wholesale prices for both U.S and Japan.
2. Weights for equipment and construction investment for Japan are based on Emi (1971), p. 10; for U.S based on *Historical Statistics,* Part I, p. 283 for 1947. Shares of raw materials and labor for construction investment for U.S from ibid, p. 282; Japan from Fukao et al (2004).

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 Cost	0.24	0.45	0.07	0.07	0.07	0.07
Material Costs				0.69	0.63	0.66
Food	0.03	0.02	0.53			
Textiles	0.03	0.01	0.51			
Wood products	0.03	0.06	0.40			
Medical cost	0.14	0.06	0.37			
Chemical Products	0.11	0.09	1.33			
Metals & machinery	0.06	0.02	0.88			
Construction	0.08	0.24	0.48			
Transportation and communication	0.21	0.04	0.54			
coal	0.02	0.01	0.89			
electricity	0.05	0.01	0.96			
Total	1.01	1.00		0.54	0.38	0.45

Source Notes:

1. Labor cost is based on Japanese government employee salaries from Emi and Shionoya (1966), pp. 222-3. Labor cost for U.S is from *Historical Statistics,* Part II, pp. 1100-1. Chemical products, metals & machinery, transportation communication from Pilat (1994), pp. 24 &24. The rest is from Appendix table II.
2. Weight for Labor and Material Costs for Japan is based on Emi and Shionoya (1966), pp.31-2; weight for U.S is based on *Historical Statistics,* pp. 282-3 (share of material cost is assumed to be equal to share of total intermediate inputs in government purchases, value added is assumed to be equal to labor cost. The U.S shares used are for the 1950s and 60s). The item weights under material cost for Japan is based on Fukao et al (2004), Table 5; item weights for U.S also based on the same input-output table in *Historical Statistics,* pp. 282-3.

Table 7. Price Levels of East Asia Relative to the U.S (1934-36)

	Expenditure Weight				Price Level (Fisher Average, U.S.=1)		
	Taiwan	Korea	Japan	U.S	Taiwan	Korea	Japan
Consumption	0.73	0.84	0.70	0.77	0.46	0.50	0.54
Private Investment	0.20	0.11	0.18	0.11	0.64	0.66	0.68
Government Expenditure	0.07	0.05	0.12	0.12	0.39	0.40	0.45
GDP	1.00	1.00	1.00	1.00	0.48	0.51	0.56

Source Note:

In the case of Taiwan and Korea, the relative price level for each expenditure category (five consumption categories, private investment, and government expenditure) is calculated multiplying the Fisher average price level of these countries in comparison to Japan by the Fisher average price level of Japan in comparison to the U.S. The price levels for total GDP of Taiwan, Korea and Japan relative to the U.S. are calculated as Fisher averages based on each country's expenditure weights and U.S. expenditure weights for five consumption categories, private investment and government expenditure. Price levels and weights for Korea and Taiwan are based on Fukao et al. (2004).

Table 8. 1934-36 East Asian per Capita GDPs in 1934-36 U.S. Dollars (Number in Parentheses Are per Capita Incomes Relative to the U.S)

	US	Japan	Taiwan	Korea	China
1. Exchange rate converted estimate	574.7	79.4 (13.8%)	50.7 (8.8%)	29.9 (5.2%)	20.7 (3.6%)
2. Relative GDP Price Levels	1	0.559	0.479	0.509	0.422
3. PPP Adjusted Estimate = 1/2	574.7	142.0 (24.7%)	105.8 (18.4%)	58.8 (10.2%)	49.2 (8.6%)

Source notes:

1. GDP for China from Liu and Yeh, p. 68, Table 10; for Japan from Ohkawa and Shinohara (1979), Taiwan and Korea from Mizoguchi and Umemura (1988); U.S from the *Historical Statistics of the U.S* (the Bicentennial Edition (1975). Maddison estimate from Maddison (2003, p.182).
2. 1934-36 exchanges rates: 1 US$ = 3.33 yen, 1 Chinese yuan = 1.1 yen.

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

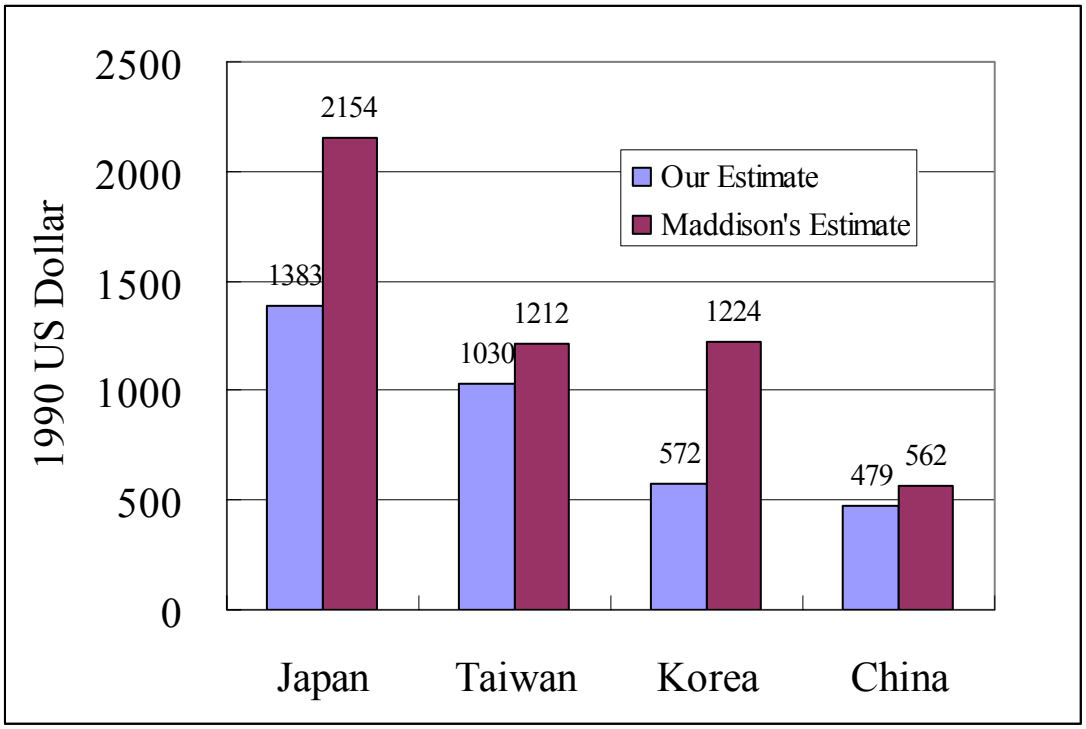

Table 9. Relative GDP Price Levels and Relative GDP per capita (U.S = 100)

	Relative GDP Price Levels	Relative GDP per capita	Sources
1934-36	56	25	This Study
1939	60.7*	27	Pilat 1994, p.24.
1952	52**	18	Watanabe and Komiya 1958
1970	68	59	Kravis et al. 1982, p.13 & 21
1973	95	64	Kravis et al. 1982, p.13 & 21
1975	90	68	Kravis et al. 1982, p.13 & 21

* The Watanabe and Komiya study did not calculate relative per capita GDP for 1952. We recalculate it with the exchange rate 1$= 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, p. F10-30).