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**International Comparison in Historical Perspective:  
Reconstructing the 1934-36 Benchmark  
Purchasing Power Parity for Japan, Korea and Taiwan**

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This article provides the first expenditure approach estimate of purchasing power parity (PPP) converters for 1934-36 Japan, Korea and Taiwan. We matched all together 70 to 80 types of goods and services for private consumption, government expenditure and investment using three levels of weights derived from actual expenditure surveys. We find that the 1934-6 average prices of Korea for private consumption, investment and government expenditure were about 0.86, 0.89 and 0.98 times that of Japan respectively; and for Taiwan 0.84, 0.87 and 0.95 respectively. This gives the 1934-6 Korea and Taiwan overall GDE average price levels of 0.87 and 0.86 respectively that of Japan. Our new benchmark estimate is an improvement over existing converters based either on exchange rates or the 1990 backward projection method, which was embedded with index number biases. It provides a vital link for a long-term overview of structural change, ethnic income distribution and the historical convergence or divergence for these three economies in the past century.

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### **Abstract:**

This article provides the first expenditure approach estimate of purchasing power parity (PPP) converters for 1934-36 Japan, Korea and Taiwan. We matched all together 70 to 80 types of goods and services for private consumption, government expenditure and investment using three levels of weights derived from actual expenditure surveys. We find that the 1934-6 average prices of Korea for private consumption, investment and government expenditure were about 0.86, 0.89 and 0.98 times that of Japan respectively; and for Taiwan 0.84, 0.87 and 0.95 respectively. This gives the 1934-6 Korea and Taiwan overall GDE average price levels of 0.87 and 0.86 respectively that of Japan. Our new benchmark estimate represents an improvement over existing converters based either on exchange rates or the 1990 backward projection method, which was embedded with index number biases. It provides a vital link for a long-term overview of structural change, ethnic income distribution and the historical convergence or divergence for these three economies in the past century.

The rejuvenation of growth theories and the rise of the “new” growth theories in the past decade have revolutionized our intellectual thinking on issues of long-term economic development. Central to the empirical works of this burgeoning theoretical literature is the compilation of historical national accounts data in purchasing power parity (PPP) terms, exemplified by the masterly scholarship of the Penn World Table group and Angus Maddison.

While the debate on whether global economies are converging or diverging over time is still on-going, the miraculous rise of Japan, Korea and Taiwan from the aftermath of WWII has been undoubtedly a source of inspiration for the convergence school, as well as other aspiring developing economies. The past two decades have also seen a flourishing of scholarly works on the role of historical factors - particularly their shared colonial heritage in the pre-WWII period - in the long-term economic development of these three economies. An important milestone in this literature is the systematic reconstruction of times series macroeconomic indicators of Korea and Taiwan in the pre-WWII period using detailed statistics compiled by the Japanese government and its colonial administrations in Taiwan and Korea. This culminated in the publication of the statistical volume compiled by Mizoguchi and Umemura (hereafter referred to as M&U) and

published in 1988, which provided annual estimates of GDP and its various components for Taiwan and Korea in the colonial period.

The GDP series of these three economies in the M&U volume is based on the official one to one exchange rate, which shows the Taiwanese and Korean per capita GDP at about 60% and 40% respectively of the Japanese level in the 1930s. It has long been revealed by the purchasing power parity (PPP) doctrine that exchange rate conversion of international per capita income, which fails to incorporate relative price level differences in the non-tradable sector, tends to systematically underestimate the real per capita income level of the lower income countries (in this case Taiwan and Korea) (Balassa 1964, Samuelson, 1964, Bhagwati, 1984).

The GDP series in the M&U volume also formed the basis of Angus Maddison's national accounts series for the colonial period. To arrive at globally comparable series, Maddison consistently used the 1990 benchmark PPP to project backward using domestic real GDP growth rates. Surprisingly, the Maddison backcast series based on the original M&U data, gives the Taiwanese and Korean per capita GDP at 63% and 70% of the Japanese level around 1935 respectively, reversing the per-capita income ranking in the M&U volume.

As a resolution to this jarring discrepancy, this paper launches a full-fledged pre-War expenditure PPP for Japan, Taiwan and Korea in 1934-36. For private consumption, we conducted a three way bi-lateral matching of 50 to 60 types of goods and services, with three-level consumption expenditure weights derived from detailed household budget surveys. For private investment and government expenditure, we matched over 20 types of goods and services for these three economies. We find that the 1934-6 average prices of Korea for private consumption, investment and government expenditure were about 0.86, 0.89 and 0.98 times of that of Japan respectively; and for Taiwan 0.84, 0.87 and 0.95 respectively. This gives the 1934-6 Korea and Taiwan an overall GDE average price levels at about 87% and 86% of the level of Japan respectively. Under Japanese colonialism, all these three economies issued currencies denoted as yen, convertible within the empire at the 1:1 exchange rate. This alternatively meant

that, in our case, one Japanese yen was equivalent to 0.87 Korean yen and 0.86 Taiwanese yen in PPP terms, which would translate the 1935 Korean and Taiwanese per capita income into about 43% and 78% of the Japanese level respectively.

This pre-war PPP estimate confirms the PPP doctrine that exchange rate conversion would under-estimate the real per-capita income of the relatively under-developed countries, Taiwan and Korea in our case. It also shows that the Maddison back-projected series, while under-estimating the per-capita income of Taiwan, exaggerated the pre-war Korean per-capita income. Clearly, there are serious index number issues embedded in the backward projection method that ignores long-term relative shifts in a country's terms of trade and economic structure as well as possible errors in the real GDP volume index.

Our 1934-36 PPP benchmark provides a vital link through which we can examine issues of long-term growth trends for these three economies. In this paper, we supplement our statistical exercise with a historical and quantitative analysis of economic changes between the mid-1930s and 1990. The rest of the paper is divided into three main sections followed by a conclusion. The first section provides a detailed explanation of our PPP estimation procedure and results. The second section offers a preliminary analysis and some conjectures on the sources of the biases inherent in pre-War exchange rate conversion and the 1990 benchmark backward projection method. Section III is a brief application our PPP estimates to the overview of long-term overview of structural change, ethnic income distribution and the historical convergence or divergence for these three economies in the past century.

### **I. The 1934-6 Benchmark PPP**

Japan's colonial acquisitions of Taiwan and Korea were the spoils of two military victories, the Sino-Japanese War of 1894-5 and the Russo-Japanese War of 1904-5. These victories also marked important turning points for Japan's evolving monetary integration with the global economy. The massive war indemnities that Japan managed to extract from the defeated Qing paved the way for her conversion to the gold standard in 1899. Through the victory of the 1905

Russo-Japanese War, Japan began a process of bringing these two formerly silver based Taiwan and Korea colonies into the gold exchange regime. 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.<sup>1</sup>

Concurrent with Japan’s monetary integration was a process towards trade integration within the colonial empire. By the 1930s, the three economies under the colonial empire became closer to a free trade bloc protected by a common external tariff.<sup>2</sup> The objective of the Japanese colonial economic policy had been to convert Korea and Taiwan into peripheries supplying agricultural commodities such as rice, sugar and industrial raw materials to the industrialized metropolis, Japan, in exchange for her manufactured products.<sup>3</sup>

The three-year average of 1934-36, chosen as our PPP benchmark, reflects the high stage of Japanese colonialism. More importantly, 1934-36 is also a period of relative economic and price stability, interposed between the severe deflation leading to Japan’s banning of gold exports in 1931-32 and the late 1930s economic dislocation brought about by the outbreak of the Sino-Japanese War. For this reason and the fact that most Taiwanese and Korean household budget

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<sup>1</sup> By the mid-1930s, a “yen currency block” came into formation with China’s Manchuria falling under the Japanese colonial sphere (Yamamoto 2000, pp.84-93).

<sup>2</sup> Free trade was largely realized between Japan and Taiwan in the 1920s and 30s. But tariff rates and items to be taxed between Japan and Korea were reduced over several stages and only completely abolished in 1941 in order to ensure fiscal revenue for the cash-strapped Japanese colonial administration in Korea. See Yamamoto 2000, pp. 69-72.

<sup>3</sup> Applying gravity model to detailed trade data from 1896 to 1940, the statistical study by Huang and Xu (1997) carefully documented this historical process of Taiwan being steadily but effectively absorbed into the Japanese colonial structure. They show that firstly Japan’s increasing dominance in Taiwan’s total external trade since 1896, accompanied by a corresponding retreat of other traditional trading partners such as mainland China and European powers. Secondly, while Taiwan’s trade with mainland China and other countries as well as imports from Japan were relatively diversified in product variety, its exports to Japan were heavily concentrated in a narrow range of agricultural commodities.

and rural surveys with consumption expenditure information are only available after 1930, Mizoguchi also used this benchmark period for his construction of the consumer price index.

In our study, we make full use of the unusually rich and high-quality statistical data (by pre-war standards) compiled by the Japanese government and its colonial administration that employed reasonably consistent standards, terminologies and methodologies for their statistical system within the empire. We also benefited from the wealth of information and worksheets accumulated under the Long Term Economics Statistics Project (LTES) initiated by Professor Kazushi Ohkawa at Hitotsubashi University, which produced long-term nominal and real GDP series for Japan and was later extended to colonial Taiwan and Korea by Mizoguchi and others.<sup>4</sup> Retracing the steps they used to construct GDP and the consumer price index provides us a shortcut to an otherwise extremely cumbersome PPP computation. Given the above, we believe our study is differentiated from some other similar pioneering studies which had to compromise with the narrow set of commodity prices used and simplifying assumptions of expenditure weights due to the data constraint for most non-industrialized countries in the pre-War period (Jan Luiten van Zanden 2002, Bassino and van der Eng 2002, Nakagawa 2000). Our study is thus closer to the methodology used by several rounds of the ICP studies for the post-WWII benchmark period (Heston and Summers 1993 and Maddison 1995).

#### *The 1934-36 Consumption PPP*

For our consumption PPP estimation, we collected absolute prices for items included in consumers' expenditure for major cities of different regions within these three countries. We treated each country's price as the simple average of the prices of these major cities. For Japan, the cities included are Tokyo, Osaka, Kyoto, Nagoya, Yokohama and Kobe. For Korea, they are Seoul, Mokpo, Taegu, Pusan, Pyongyang, Shinuiju, Wonsan and Chongjin. The Taiwan cities are

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<sup>4</sup> For Japan, there are the 14 volume series LTES publications in Japanese. For the English version, see the abridged one volume by Kazushi Ohkawa and Miyoei Shinohara.

Taipei, Keelung, Ilan, Hsinchu, Taichung, Changhua, Tainan, Chiai, Kaohsiung, Pingtung, Taitung, Hualien, and Makung.<sup>5</sup>

We then derive the consumption expenditure weights at three levels of aggregation (upper, medium and lower). Table 1 presents the aggregated five-item upper level rural and urban expenditure weights for these three countries.

Insert Table 1

To compute PPP, we use our database of absolute prices that matched altogether 61 types of goods and services for Japan-Korea, 58 for Japan-Taiwan and 41 for Taiwan-Korea. Our database also included the service sector such as utilities (domestic lighting and heating cost). Data on housing and medical expenses are difficult to obtain, thus we follow Mizoguchi (1971, 1975) and use residential construction cost (e.g. wage of construction workers, price of cement and so on) and annual salaries of doctors.

Using the matched prices and the detailed three level consumption weights, we carry out a standard PPP computation of a three way bi-lateral comparison of absolute prices with Japan serving as the numeraire country. For  $n$  numbers of goods and services, Japan's (sub- or superscripted as  $J$ ) price level relative to that of country  $i$ , ( $i =$  Korea, Taiwan) is calculated as

$$\text{follows: } P_{i,J}^J = \frac{\sum p_n^i q_n^J}{\sum p_n^J q_n^J} = \frac{\sum \frac{p_n^i}{p_n^J} p_n^J q_n^J}{\sum p_n^J q_n^J} = \sum \frac{p_n^i}{p_n^J} \omega_n^J .$$

The formule using  $i$  country's consumption weights is:

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<sup>5</sup> Since our PPP estimate is based on urban prices, we do not exclude the possibility that, considering the more agrarian and self-sufficient economies of Korea, urban-rural price differentials are likely to be larger than in the other two economies, thus possibly biasing downward our PPP adjusted real per-capita income for Korea. This problem is partly alleviated by our inclusion of 10 cities in Korea. The extent of the bias can only be ascertained when more rural price data become available.



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

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.<sup>6</sup>

The detailed price matching, consumption weights as well as data sources and methodologies are explained in Appendix A along with three data tables A-1, A-2 and A-3. Tables A-1 and A-2 show that the average consumer price levels of 1934-6, Korea and Taiwan are 0.86 and 0.84 times that of Japan respectively. Table A-3, which gives a direct bi-lateral price matching of Korea and Taiwan, shows the Korea price level at 1.03 times that of Taiwan, confirming the three-country transitivity conditions for relative price levels. The summary information of relative price levels is in Table 2.<sup>7</sup>

Insert Table 2

#### The PPP for Investment and Government Expenditure

For estimating PPP for investment and government expenditure, we use similar methodology - multiple levels of weights and the fisher average – as in our consumption PPP calculation. For items and their weights, we follow Mizoguchi (1975) for Taiwan and Korea and match them with the comparable categories in the *LTES* volumes on Capital Formation and Government Expenditure (vols. 4 and 7) for Japan. For prices related specifically to the investment and government sectors, we utilize several industrial and factory surveys conducted

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<sup>6</sup> The summation sign is summed across the  $n$  types of goods and services.

<sup>7</sup> Note that our consumption PPP price database reveals Taiwan as having relatively the lowest price level in food and agricultural products. This may be partly attributable to Taiwan's more favorable factor and natural resources endowments as well as her relative geographic remoteness from Japan and Korea, which are located next to each other. For example, freight rates of rice shipments from Osaka-Kobe to Taiwanese ports around 1940 were about 30 to 50 percent higher than they were to major Korean ports (The rates were 0.85 yen and 0.88 yen per tan respectively between Osaka, Kobe of Japan and Keelung and Kaosiung of Taiwan, but 1.4 yen and 1.66 yen per koku (1 koku = 2.5 tan = 150 kgs between the Japanese ports and Pusan and In'chon in Korea) (Okazaki 1942, pp. 465 and 494).

by the ministries of the three governments. Prices for other items are retrieved from our price database for consumption PPP in the Appendix tables.

Table 3 gives the average relative price levels of the investment for these three economies, which are also disaggregated into equipment and construction categories. For equipment investment, average price levels in Taiwan and Korea are actually higher than that of Japan – at about 1.64 and 1.55 times respectively, confirming the predominance of Japanese direct capital investment in these two colonies, particularly in modern machinery and transportation (Yamamoto 2000, chap. 6). Price levels for construction investment in Taiwan and Korea that relied more on local materials and labor are at about 74 and 79 percent of the Japanese level respectively. Overall, the average price levels of private investment in Taiwan and Korea are fairly close to that of Japan, at 95 and 98 percent the level of Japan respectively.

Insert Table 3

Table 4 presents the relative price levels for government expenditure further disaggregated into two broad categories of labor and materials costs. It shows that the average labor costs in the government expenditure of Taiwan and Korea - calculated as the total labor costs divided by the number of government staff - are actually 46 and 18 percent higher than in Japan respectively. Clearly, the high wages and shares commanded by the Japanese staffs in the colonial governments were making the Japanese colonial administration very costly to the two territories. In contrast, price levels for the material costs in Taiwan and Korea relative to that of Japan are roughly comparable to those in our consumption PPP. Overall, relative price levels for government expenditure in Taiwan and Korea are 0.87 and 0.89 times that of Japan respectively.

Insert Table 4

Table 5 summarizes our PPP calculation for consumption, investment and government expenditure. Using the respective weights of these three sectors, we derive the overall relative

price levels for GDE for Taiwan and Korea at 0.86 and 0.87 times that Japan for our 1934-36 benchmark period.

Insert Table 5

## II. PPP Converters, Exchange Rate and the 1990 Backward Projection

### PPP vs. Exchange Rate

Using the information from Table 5, we now present our benchmark PPP adjusted per capita GDP of these three economies alongside the exchange rate converted estimates in Table 6. In comparison with the exchange rate conversion, our PPP converter raised the Korean and Taiwanese per capita income in 1935 from 38 and 66 percent to 43 and 78 percent that of the Japanese level respectively. In view of the predominant share of consumption in GDE, the lower level consumer price levels in Taiwan and Korea relative to that of Japan is the most important factor accounting for this downward exchange rate bias. Furthermore, in the consumption category as shown in Table 2, the average price levels for the non-tradable sector in Korea and Taiwan relative to that of Japan - 0.71 and 0.78 respectively - was much lower than those for the tradable goods. This result, with Taiwan and Korea being regarded as under-developed relative to Japan for this period, corroborates the theoretical predictions of the productivity and factor proportion differential models.<sup>8</sup>

Insert Table 6

### PPP vs. the 1990 Backward Projection

How does our current price benchmark PPP result compare with Maddison's 1990 back-projected PPP estimate. As the original GDP data used in Maddison's 1990 backward projected real series largely came from the LTES series, Ohkawa and Shinohara (1979) for Japan and M&U (1988) for Korea and Taiwan, here we can derive the implicit GDP deflator in the Maddison

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<sup>8</sup> For an earlier study based on consumption PPP only, see Yuan and Fukao, 2002.

back-projected series. The calculation formula for Korea relative to Japan at period  $t$  is as follows:

Korean Price Level / Japanese Price Level

$$= [(\text{nominal Korean per-capita GDP}) / (\text{Maddison's real Korean per capita GDP})] \div [(\text{nominal Japanese per-capita GDP}) / (\text{Maddison's real Japanese per capita GDP})].$$

Appendix B provides a more rigorous and formal presentation for the calculation of the above implicit GDP deflator. Table 7 lists the original LTES's estimated 1911-1938 nominal series of per capita GDP in yen for the three countries (Ohkawa and Shinohara 1979 for Japan and M&U 1988 for Taiwan and Korea) and the 1990 back projected real series. Columns 7 and 8 of Table 7 are the derived GDP deflator from Maddison's back-projected series for Korea and Taiwan. In striking contrast to our PPP study which gives both Korea and Taiwan price levels at about 85% of the Japanese level, the Maddison series shows a Korean price level (or GDP deflator) about half that of the Japanese level but that of Taiwan at similar or even higher levels than in Japan for the selected years of 1915-1935. The consequence of these contrasting comparative price levels on their respective per-capita GDP estimates are captured by Figure 1 which presents a confrontation of our estimates vs. Maddison's using the information in Table 6 and columns 9 and 10 of Table 7.

Insert Table 7 and Figure 1

The 1990 backward projected series that ranked the pre-War Korean per capita income higher than that of Taiwan runs counter to well-recognized historical studies and other related statistical findings. It is commonly known that backward projection suffers index number bias. In Appendix B, particularly equation (1), we use our implicit GDP deflator equation to mathematically decompose this index number bias into two components: the terms of trade and Gerschenkron effects. More specifically, we show that an improvement (or deterioration) of a country's Laspeyres terms of trade between 1934-36 and 1990 could cause the 1990 back-projected estimate to over-estimate (or under-estimate) that country's 1934-36 per capita GDP

relative to its 1934-36 period benchmark PPP estimate. For Gerschenkron effects, we show that it tends to be larger for economies experiencing greater structural and relative price changes during the period under study. Whether or not this effect over- or under-estimates a country's 1934-36 per capita income depends on if there is a positive or negative correlation between the changes in the relative prices and quantities of the corresponding sectors. Below we provide some preliminary examination or conjectures on the sources of discrepancy in the back-projected estimates.

*Some Conjectures on the Sources of Biases in Backward Projection*

PPP studies have been most extensively carried out for the OECD countries in the Post-War period under the ICP. The same, however, cannot be said of Korea and Taiwan. Although ICP has included Korea since 1970, it has never covered Taiwan. For his 1990 benchmark GDP for Korea, Maddison (1995) adopted the 1980 ICP (round 4) result updated using real GDP volume index. His 1990 PPP for Taiwan came from the 1993 Supplement to Summers and Heston's "The Penn World Table (PWT 5.5), which, in turn, took it from Yotopoulos and Lin (1993), an independent PPP study (Maddison 1995, pp.166-7).

How consistent are Korea and Taiwan's 1990 benchmark PPP estimates upon which the back projection is based? According to Maddison (1995), the Korean per capita GDP was 87% of the Taiwanese level in 1990, but became roughly equal by the 1960s and then slightly exceeded the Taiwanese level in 1953 and 1955 (p.205). In the latest version of Penn World Tables (6.1), Korean per capita GDP already equaled to that of Taiwan by 1961, and became on average 20% higher throughout the 1950s. These estimates which give a higher relative levels of Korea over that of Taiwan in the 1950s and 60s, are clearly problematic in view of the enormous devastation of the Korean War on the 1950s Korean economy and the initially lower relative level of Korea per capita income in the colonial period. Thus, there exists a real possibility that backward projection bias may have started in the Post-War era.

There have been no consistent GDP series for Korea and Taiwan between 1938 and 1953 due to the War, the subsequent political upheavals, and in the case of Korea, the split of national territories. Maddison's War period GDP series for this period came from a host of disparate estimates, some of which were combined with various assumptions. As it turns out, His Korean per capita GDP figure in 1938, back-projected from the 1950s by the War period GDP series, became 25% higher than that of Taiwan. Thus, it is conceivable that Maddison's anomalously high Korean per capita GDP (relative to Taiwan) in the colonial period could be the dual consequence of an already upward-biased 1950s Korean level being further exaggerated by backward projection based on the problematic War period GDP series.<sup>9</sup>

To reconstruct the War period GDP series is clearly beyond the scope of this paper. However, some conjectures on the backward projection bias in the Post-War period in the context of our theoretical framework regarding the Gerschenkron and terms of trade effects can be made.

Although we do not have data to test directly the Gerschenkron effects, it can be surmised that as the post-War GDP indices for Korea and Taiwan were linked series, the Gerschenkron effects can be somewhat mitigated at the switch of benchmark years. We do have Post-War terms of trade data for both these economies. However, the data series show ambiguous results: both Taiwan and Korean terms of trade indices, all expressed relative to that of Japan, remain roughly unchanged between 1963 and 1990. Mizoguchi (1975, chapter 2) also constructed 1934-36 benchmark pre-War terms of trade indices for Taiwan and Korea (relative to Japan) and linked with the Post-War period. His linked series shows the Taiwan terms of trade improved slightly

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<sup>9</sup> For details and sources of Maddison's data on Taiwan and Korea, see Maddison 1995, p.146. In a separate study using fixed ratios of exchange rates between the colonial and the Post-War currencies, Mizoguchi and Noguchi (1996) directly linked Korea and Taiwan's colonial GDP with their Post-War GDP series in 1934-36 prices. Their series, though themselves not free from the usual exchange rate biases, do give a consistently lower (and thus plausible) Korean per capita GDP relative to that of Taiwan for the entire post-War period (1996, Tables 3C, 3R, 9C and 9R).

over Korea during this period, a result in contradiction to our theoretical predictions.<sup>10</sup> Clearly, the quality of these terms of trade data is far from ideal for our purpose here. We hope future research with more extensive data-compilation could shed further light on this important issue based on our 1934-36 benchmark PPP result.

### **III. From Colonial Empire to Economic Miracles: a PPP Perspective**

Our 1930s PPP benchmark a vital link for a long-term overview of economic transformation in these three economies, which saw a leap from the high stage of Japanese colonialism to the pinnacle of the East Asian miracle between 1935 and 1990. While in 1935, the external trade (imports plus exports) to GDP ratio in Korea and Taiwan already reached 58 and 70 percent, they increased to 76 and 80 percent respectively in 1990.<sup>11</sup> However, the change was far more structural than quantitative. In 1935, 90 and 76 percent of total exports from Taiwan and Korea respectively consisted of a narrow range of agricultural and primary products. In 1990 more than 90 percent of these two countries' exports were industrial products ranging from labor-intensive textile goods to high-tech and machinery products. For Japan, a similar but less drastic transformation occurred with primary and agricultural exports reduced from 13 percent in 1935 to less than 0.6 percent in 1990 (M&U Tables 61 and 64, Yamazawa and Yamamoto Tables 3 and 4, Statistical Year Books of Japan).

Similarly by 1990, the geographic locus of trading for Taiwan and Korea greatly diversified compared with the colonial era dominated by the share of Japan. The United States emerged as the largest importer for all three economies, absorbing over 30 percent of their exports in 1990, while in 1935, this share for U.S was negligible, with the exception of Japan which saw the U.S

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<sup>10</sup> The Korea (South Korea) and Taiwan post-War terms of trade data is from IMF database (IFS-CD) and *Taiwan Statistical Data Book* respectively, both linked at the year 1965.

<sup>11</sup> For trade data, see the trade matrix in Yamamoto 1989, p.244. The GDE data is from M&U, p.232 and p. 236. All are in current price of 1935. For Japan, this ratio actually declined from 27 percent in 1935 to 18 percent in 1990 largely because of the greatly expanded size of the Japanese economy by 1990. Data calculated from relevant issues of Statistical Year Books of these three economies.

taking about 17 percent of her goods (mostly textile products). Structural changes of such a magnitude in external trade also exerted transformational effects on their overall economic structure, as captured in Figure 2.

Insert Figure 2

Interestingly, figure 2 shows that, despite the enormous economic transformation, the ordinal ranking of the PPP per capita income for these three economies is identical between the benchmark years. In fact, Taiwan's per capita income relative to Japan actually declined from 78 percent in 1935 to 55 percent in 1990. Per capita income in South Korea did catch up slightly with that of Japan, rising from 43 percent in 1935 to 48 percent in 1990.<sup>12</sup>

However, in the 1930s, a large number of Japanese residents – far larger in comparison with Westerners staying in their Asian colonies – lived in Korea and Taiwan.<sup>13</sup> These Japanese residents enjoyed much higher average per-capita income partly due to their disproportionate over-representation in skilled and management occupations. But even controlling for occupation, large gaps in per capita incomes persisted between the Japanese residents and the native population.

This point is supported by information culled from the urban household budget survey in Taiwan, used in our PPP study for expenditure weights. Table 8 shows that controlling for occupation, urban per capita household income of Taiwanese residents was only 52% of that of the Japanese residents in Taiwan. In fact, the per capita income and expenditure of Japanese residents living in Taiwan, if adjusting for our consumption PPP, would be roughly 40% higher than their compatriots of the same occupation living in Japan in 1937.

Insert Table 8

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<sup>12</sup> The 1990 GDP per capita data is from Maddison, 1995. Korea for 1990 is for South Korea only. Considering that the colonial Korea included the then relatively more developed Northern part, South Korea's catch up with Japan from 1935 to 1990 would be larger if we incorporate the territorial change.

<sup>13</sup> For comparative studies of Western and Japanese residents living in their colonial territories, see Maddison, 1990, p.363.



A tentative estimate by Mitsuhiro Kimura shows that, with the shares of Japanese residents in the total population of Taiwan and Korea equal to 5.1 and 2.7 percent respectively around the mid-1930s, their income shares (the averages of 1930 and 1940) in total Taiwan and Korea's national income are 26 and 22 percent respectively (Kimura 1998, pp.30-1).<sup>14</sup> This would give per capita GDP of native Taiwanese and Koreans (excluding the Japanese residents) at 75 and 78 per cent of the average national per capita GDP (including the Japanese residents). Thus, the native Taiwanese and Korea per capita income (excluding the Japanese residents), in PPP terms, are now 59 and 34 percent of the per capita income of Japan in 1935, lower than the 78 and 43 percentage figures which included the per-capita income of the Japanese residents. Thus, by ethnicity standards, the per capita income gap between Taiwanese and Japanese is roughly comparable between 1935 and 1990, but significantly narrowed between Koreans and Japanese.

But the East Asian miracle story is more of a tale of convergence towards the global leading economies, than their keeping-up with each other. A U.S based comparison would show that the Japanese per capita income surged from 37 percent in 1935 to 85 percent of the U.S level in 1990, while these ratios for Taiwan and Korea rose from 30 and 16 percent to 47 and 41 percent respectively during this period. Taking account of the ethnic income distribution would imply that the income of the population of Taiwan and Korea had actually started only at 22 and 13 percent respectively, of the U.S level in 1935 (also see figure 2).<sup>15</sup> Thus, the Post-War period marked a huge catch-up for the average citizens of all these three economies on a global scale.

### **Conclusion**

Our study provides a set of pre-War benchmark conversion standards for comparison of income, consumption, investment, government expenditure as well as other monetary indicators of these three economies in the pre-WWII period for Japan, Taiwan and Korea, a standard that is

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<sup>14</sup> Population share figures from M&U, Table 23 on p. 256.

superior to both the exchange rate conversion and backward projection, each dogged by its inherent biases.

Our pre-War PPP confirms that the exchange rate conversion consistently under-estimated Taiwan and Korea's per capita income relative to that of Japan as predicted by the factor proportion and productivity differential models. Furthermore, our PPP result reveals the substantial exaggeration of Korea's pre-War per capita GDP given by the 1990 backward projection method. Our preliminary analysis offers some conjectures that both the backward projection biases in the Post-War period and problematic War-period GDP series may account for this erroneous result. It is hoped that this exercise, though preliminary, could point the way to future studies on this important issue.

We believe our pre-War PPP benchmark could provide a solid footing on which the long-term issues of economic convergence or divergence in these three regions can be analyzed. This study aims to lay the foundation of a framework, which not only insists on a historical view where post-War economic growth should be tied with pre-War economic conditions, but also an integrated East Asian framework under which neither the one and a half century of modern economic growth in Japan, nor the post-War economic miracles of Taiwan and Korea should be studied independently from each other. Our future research plans to extend our 1930s PPP benchmark to China and other Asian countries.

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<sup>15</sup> The U.S. GDP per capita GDP data for 1990 and also the linking of 1935 Japanese GDP per capita with the 1935 US GDP per capita figure are from Maddison, 1995.

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**Table 1. Aggregate Rural and Urban Expenditure Weights in 1934-36**

	Japan			Taiwan			Korea		
	Urban	Rural	<b>National</b>	Urban	Rural	<b>National</b>	Urban	Rural	<b>National</b>
Food	35.99	46.57	<b>40.9</b>	45.24	50.49	<b>47.99</b>	51.11	70.7	<b>65.82</b>
Lighting and Heating	4.91	4.6	<b>4.8</b>	4.91	6.69	<b>5.84</b>	6.95	10.68	<b>9.75</b>
Clothing and Bedding	11.91	9.3	<b>10.71</b>	9.72	4.27	<b>6.87</b>	7.97	6.88	<b>7.15</b>
Housing Expenses	17.05	3.29	<b>10.73</b>	12.75	3.04	<b>7.67</b>	14.13	2.73	<b>5.57</b>
Mis. Expenses	30.14	36.19	<b>32.92</b>	27.38	35.51	<b>31.63</b>	19.84	9.01	<b>11.71</b>

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. 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 2. Relative Consumption Price Levels by Sectors (1934-36 Japan =1)**

Sectors	Korea	Taiwan
Total	<b>0.86</b>	<b>0.84</b>
Tradables:	0.93	0.88
Food	0.94	0.87
Other Tradables	0.91	0.89
Non-tradable:	0.71	0.78

Notes: 1. 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.

Tradable goods for Taiwan: food, firewood, charcoal, coke, cotton, muslin, cotton flannel, cement, tatami mats, kneaded tiles, cedarboard, soap, writing paper, Minogami paper.

2. Relative price levels in the above three categories are calculated using the Fisher formule. For Japan-Taiwan comparison, Japanese and Taiwanese weights used for the categories of food, other tradables and non-tradables are 41, 19, 40 and 48, 19, 37 percent respectively. For Japan-Korea comparison, Japanese and Korean weights used for the same three categories are 41, 21, 38 and 66, 17, 17 percent respectively.

**Table 3 Relative Price Levels for Investment**

	Weights			Absolute Price Level with Fisher Average (Japan=1)	
	Taiwan	Korea	Japan	Taiwan/Japan	Korean/Japan
<b>Equipment</b>	<b>0.17</b>	<b>0.30</b>	<b>0.54</b>	<b>1.64</b>	<b>1.55</b>
Machinery (steam powered)	0.69	0.72	0.68	2.16	1.83
Vehicles (both passenger and freight)	0.25	0.22	0.04	0.42	0.91
Ships (non-iron only)	0.01	0.02	0.08	1.31	0.96
Others (tools and materials)	0.05	0.04	0.21	0.71	0.49
<b>Construction</b>	<b>0.83</b>	<b>0.70</b>	<b>0.46</b>	<b>0.74</b>	<b>0.79</b>
Lumbers (furniture)	0.18	0.18	0.34	0.79	0.98
Bricks	0.15	0.13	0.00	0.64	0.78
Metal (pig iron)	0.18	0.18	0.09	0.71	0.49
Wages (construction workers)	0.50	0.52	0.57	0.77	0.83
<b>Total</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>0.95</b>	<b>0.98</b>

Sources: Weights for Taiwan and Korea from Mizouguchi (1975). Weights for Japan are from Emi (1971). Wages used for construction investment is separated from other constructions using the ratio of residential and non-residential construction. Prices for machinery, vehicles, ships and metals are from Governor Offices of Taiwan, *Shigen Chosa rei*, Governor Office of Korea, *Kousan Touke*, and Ministry of Industry and Commerce, *Kouyou Toukei* for Taiwan, Korea and Japan respectively. Other prices can be found in Appendix Table A.



**Table 4 Average Relative Price Levels for Government Expenditure by Sectors**

		Weights			Absolute Price Level with Fisher Average (Japan=1)	
		Taiwan	Korea	Japan	Taiwan/Japan	Korea/Japan
Labor Cost		0.32	0.23	0.24	1.46	1.18
Material Costs		0.68	0.78	0.76	0.70	0.81
	Food products		0.04		0.82	0.88
	Textiles goods		0.04		0.88	0.89
	Wood products		0.04		0.79	1.12
	Paper goods		0.04		1.00	0.68
	Medical Costs		0.19		0.79	0.85
	Chemical (sulfuric acid)		0.11		0.88	0.96
	Metal and machinery (pig iron)		0.08		0.71	0.49
	Construction and repair (bricks)		0.10		0.64	0.78
	Travel Expenses		0.16		0.38	0.74
	Communication		0.11		0.52	0.84
	Coal		0.03		0.74	0.84
	Electricity		0.07		0.94	0.88
<b>Total</b>		<b>1</b>	<b>1</b>	<b>1</b>	<b>0.87</b>	<b>0.89</b>

Sources: The weights for Taiwan and Korea are from Mizouguchi (1975) and the Japanese weight (the middle level) is from Emi and Shionoya (1966). We assume the lower level weights for these three regions to be same. Mizouguchi (1975) only has weight for oil which we use for sulfuric acid.

Prices for chemical and metal products are from Governor Offices of Taiwan, *Shigen Chosa rei*, Governor Office of Korea, *Kousan Touke*, and Ministry of Industry and Commerce, *Kouyou Toukei* for Taiwan, Korea and Japan respectively. Prices for all other goods are the same used in Appendix Table A.

**Table 5. PPP Price Levels for GDE by Sectors (Number in parentheses are sectoral shares)**

	Taiwan			Korea		
	Consumption	Government Expenditure	Investment	Consumption	Government Expenditure	Investment
Average Sectoral Price Levels relative to Japan (Japan =1)	0.84 (73%)	0.87 (7%)	0.95 (20%)	0.86 (84%)	0.89 (5%)	0.98 (11%)
Average Relative Price Levels of GDE (Japan = 1)	0.86			0.87		

Sources: GDE composition from Mizouguchi and Umemura (1988).

**Table 6. Real Per-capita GDP (GDE) of Korea and Taiwan Relative to Japan (Japan =1)**

	Exchange Rate Converted Estimate		PPP Adjusted Estimate	
	Korea	Taiwan	Korea	Taiwan
1915	0.37	0.62	0.51	0.77
1920	0.38	0.64	0.45	0.73
1925	0.34	0.54	0.44	0.77
1930	0.31	0.61	0.43	0.82
1935	0.38	0.66	0.43	0.78

Sources : Data for Japan are from Ohkawa and Shinohara (1979), Korea and Taiwan from Mizoguchi and Nojima (1996). For years before 1935, the PPP adjusted real GDP per capita estimates are obtained by extrapolating backward our 1934-36 benchmark PPP estimate.

**Table 7 Per Capita GDP and Comparative Price Levels**

	Per Capita GDP ( GDE)						Maddison's Implicit GDP Deflator		Maddison Per Capita GDP estimate (Japan=1)	
	Japan		Korea		Taiwan		Korea/Japan =(3/4)/(1/2)	Taiwan/Japan =(5/6)/(1/2)	Korea	Taiwan
	LTES	Maddison	M&U	Maddison	M&U	Maddison				
<i>Cols.</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>
1915	96.29	1375	35.51	1116	59.47	804	0.45	1.06	0.81	0.58
1920	276.26	1631	103.97	1167	175.69	921	0.53	1.13	0.72	0.56
1925	288.67	1814	96.85	1175	156.37	1041	0.52	0.94	0.65	0.57
1930	226.39	1780	69.39	1173	138.57	1112	0.47	0.98	0.66	0.62
1935	248.78	2040	94.23	1420	163.71	1291	0.54	1.04	0.7	0.63

Sources: the nominal GDP series are in yen; Japan, the LTES series from Ohkawa and Shinohara (1979), The M&U series for Korea and Taiwan are from M&U (1988). The Maddison series are real GDP figures in 1990 Geary-Khamis dollars from Maddison (1995). Maddison's series are largely based on M&U nominal series with per-capita GDP computed from the Maddison population data.

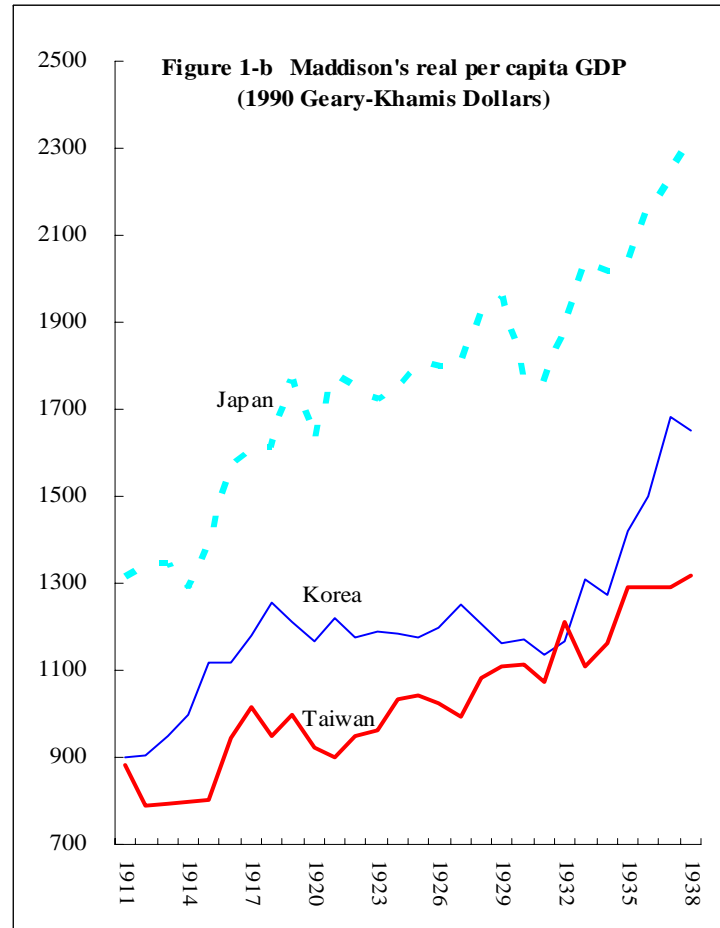
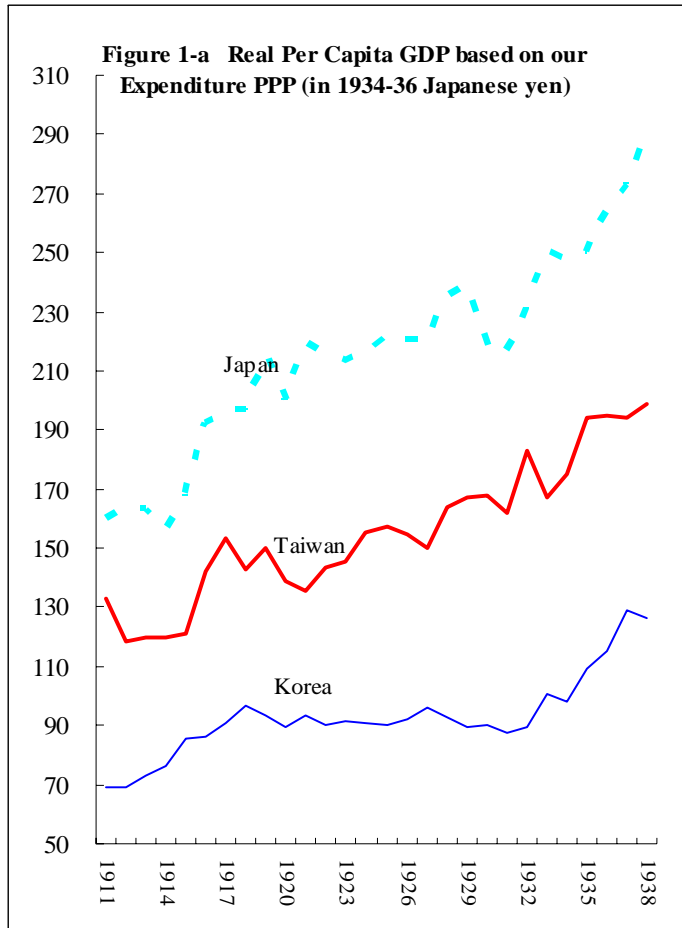


**Table 8. Per Capital Income and Expenditure in Urban Households in 1937 yen  
(unadjusted for Purchasing Power Parity)**

	Japan		Taiwan			
	Income	Expenditure	Japanese Residents		Taiwanese	
			Income	Expenditure	Income	Expenditure
Total	287	246	333	289	172	157
Salaried worker	319	276	408	350	223	184
Laborer	270	229	292	256	145	143

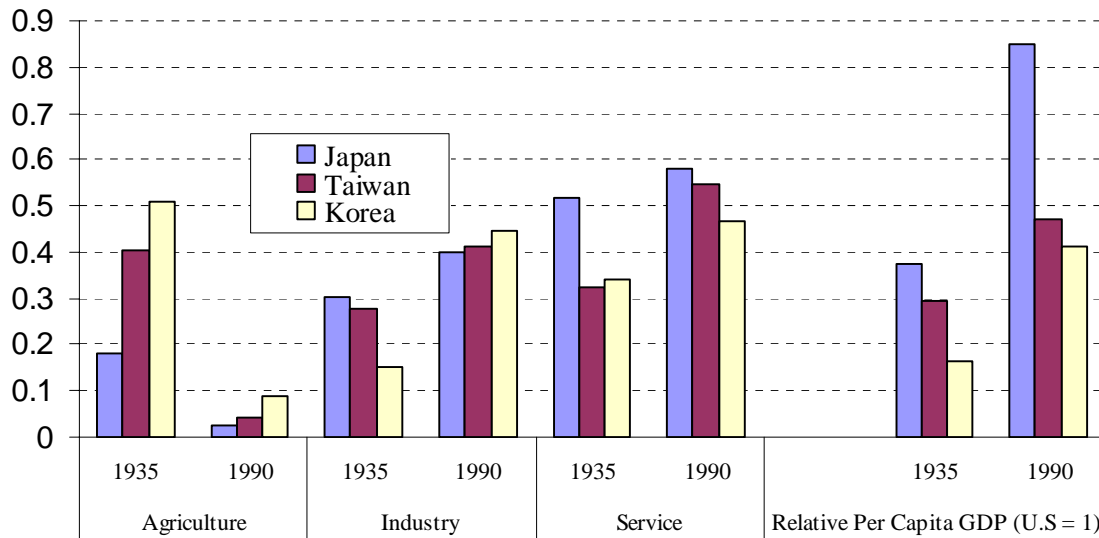
Sources: Japan is from *Kakei Chousa* (1937, Sept. and 1938, August) compiled by the Statistical Bureau of the Japanese Interior Ministry. Taiwan is from *Kakei Chousa Houkoku*, Nov. 1937 and Oct. 1938. There are 1601 families surveyed in Japan, 390 Taiwanese families and 355 Japanese residents' families surveyed in Taiwan. For details, also see Appendix A.

Notes: The salaried workers include teachers, bankers and civil servants while the laborers include industrial and transportation workers. For all three categories, I have consistently applied the Japanese occupational weights in the Japan sample.



Note: See the text.

**Figure 2. Sectoral GDP Shares and Relative Per Capita GDP (US=1) of Japan, Taiwan and Korea in 1935 and 1990**



Sources: 1935 sectoral shares data from M&U, Tables 3, 5 and 7. 1990 sectoral shares data for Japan and Korea are from Dirk Pilat, 1994, p. 279 and 297. The 1935 PPP per capita data is based on this paper. To link with the U.S, we used data from Maddison, 1995. Korea for 1990 is for South Korea only.



## Appendix A: Data Source

### Price Data:

Japan: Among the three countries, price data on Japan are the best and used as a benchmark for comparison. We relied mostly on the relevant issues of *Nihon Teikoku Toukei Nenkan* (Statistical Annals of the Japanese Empire) and *Bukka Toukei Hyou* (Statistical Tables of Prices) by Shoukou Daijin Kanbou Toukeika (Government Statistics Department of the Ministry of Commerce and Industry). In addition, we also used the relevant issues of *Tokyo Bukka Oyobi Chingin Toukei* (Tokyo Price and Wage Statistics) by Tokyo Shoukou Kaigisho (Tokyo Council of Commerce and Industry), *Senzen Kijun Shouhi Suijun---Tokyo Sanshutu Houhou (1)*, *Toukei Shiryou Dai 78 Go* (Pre-War Standard Consumption Level – Method of Calculation for Tokyo (1), Statistical Materials No. 78) by Keizai Shingichou Chousabu Toukeika (Statistical Survey Department of the Economic Council) (1953), and *Shouwa 11 Nendo Tokyo Shi Toshi Koutuu Toukei Shiryou Dai 2 Kai* (1936 Tokyo Metropolitan Transportation Statistics No.2) by Tokyo Shi Denki Kyoku (Tokyo Electricity Bureau), (1936).

Korea: We used various issues of the *Statistical Annals of the Korea Government-General* published by Chousen Soutokufu. The number of available product prices in 1935 was smaller than after 1936. To match with products for Japan, we often have to use individual year prices instead of the three-year averages. *Chousen Shouhin Torihiki Binran* (A Guide for Korean Products) issued by Chousen Soutokufu Shoukou Shoureikan (1937) contained rich price information for 1936. We also acquired some price data from newspapers, *Chousen Nippou*, and *Chuuou Nippou*.

Taiwan: Available retail prices are not as plentiful. In various cases, we used wholesale prices to match with wholesale prices in Japan and Korea. The price data are mostly from relevant issues of *Taiwan Soutokufu Toukei Shou* (Statistics of the Taiwan Government-General) published by Taiwan Shoutoku Kanbou Chousabu (later renamed as Keikakubu) and *Taiwan Shoukou Toukei* (Statistics of Taiwan Commerce and Industry) published by Taiwan Soutokufu Shokusankyoku, and *Taiwan Sheng 51 Nian Tongji Tiyao* (51 Years of Statistical Summary of Taiwan Province) compiled by the new Chinese Komingdang government in 1946 (Taiwan Sheng Xingzeng Zhangguan Kongsu). Classification of commodities among these publications is also roughly comparable. For service sectors such as expenses for housing, medical care, education, transportation and entertainment, we gathered prices from *Denki Tuushin Youran* (A Summary of Electrical, Transportation and Communication Utilities) by Taiwan Soutokufu Koutuukyoku (various yearly issues), *Taiwan Shakai Jigyuu Youran* (A Summary Guide to

Taiwan Social Facilities), *Nichinichi Shinbun* (Everyday News) published by Taiwan Soutokufu Bunkyoukyoku (1935). We also used the following materials from *The Series on Chinese Local Gazette*, No. 160 of “Taiwan Annai,” No.183 of “Rakuen Taiwan no Sugata,” and No.190 of “Yakushin Taiwan Taikan.” This Local Gazette Series was originally published before the War, reprinted in 1985 by Taipei Cengwen Publishing Ltd.

#### Expenditure Weights:

Consumption expenditure weights vary by levels of aggregation according to the source of data. We use three levels of weights, the upper (the most aggregated 5 levels), the medium and the lower level, denoted as “U, M, and L” respectively in the Appendix tables. These weights are based on a combination of household budget surveys conducted for cities and rural areas.

Japan: the Japanese upper level weights are the weighted averages of expenditure shares derived from the relevant yearly series of the urban based *Household Expenditure Survey* (Kakei Chousa) published by the Statistical Bureau of the Japanese Interior Ministry, and the rural based *Agricultural Household Economic Survey* (Nouka Keizai Chousa) published by the Economic Recovery Department of the Ministry of Agriculture and Forestry. The weights are assigned according to the actual shares of urban and rural households within Japan. The same methodology applies to both Korea and Taiwan. For the lower level weights we use the result of vol.6, Private Consumption Expenditure of *LTES*. To match with Korea and Taiwan, we constructed the medium level weight from the 113 products used in this volume.

For weights on Taiwan and Korea, we largely follow Mizoguchi (1971):

Korea: As there is no urban household budget survey, we constructed the urban expenditure weights using the *The 1961 Household Expenditure Survey Report*, conducted by the Economic Planning Council of the Republic of Korea in 1962. There are three farm household budget surveys conducted in 1930, 1932-33, and 1937-39. The 1930 survey, [Report on Farm Household Economy], conducted by the Korean Agricultural Association and published in 1932-3, includes several separate volumes for different regions. The two other surveys are the 1932-33 and 1937-39 *Nouka Keizai Gaikyou Chousa* (Surveys on Economic Conditions of Agricultural Households for Self, part-self-and-part-tenancy and Tenancy cultivators) published in 1940 by the Agricultural Recovery Department of the Ministry of Agriculture and Forestry of the Korean Governor-General (Chousen Soutokufu Nourinkyoku Nourin Shinkouka). Although the sample size of the 1937–39 survey was fairly large, detailed information on consumption weights were missing. Mizoguchi (1971) opted for the 1930 survey.

Taiwan: The Economic Planning Committee of the Taiwan Governor General (Taiwan Soutokufu Kanbou Kikakubu) conducted surveys for urban working households in Nov. 1937 and Oct. 1938, which were published as *Kakei Chousa Houkoku* (Household Expenditure Survey) in 1940. This survey, which sampled 355 families of Japanese migrants and 390 Taiwanese families in urban Taiwan could certainly be considered as fairly large scale by the standard of the time. Unfortunately, there are only expenditure weights at the medium level. For lower level weights, we relied on the 1954-55 urban household budget survey in *Zhonghua Minguo Taiwan Shenn Xinci Jieji Jiaji Tiaoca* published by the Statistics Department of the Taiwan Provincial Government in 1955.

For rural areas, there were two agricultural household surveys in 1918-21 and 1931-33. For the five category upper level weights, we used the 1931-33 survey *Taiwan Nouka Keizai Chousa Houkoku, No. 1 and 2*, also listed as No. 30 and 32 of *Nougyou Kihon Chousasho*, released by Taiwan Soutokufu Shokusankyoku in 1933. For the medium and lower weights, we follow Mizoguchi to apply the result obtained from the urban surveys.





### A-3 Korean Price Level Relative to Taiwan (1934-36 : Japan=1)

Commodities	Taiwan Weight			Korean Weight			Unit	Prices			Korean Price Level (Taiwan=)		
	U	M	L	U	M	L		Korea	Taiwan	Korea/Taiwan	Korea weights	Taiwan weights	Average
Total											0.98	1.09	1.03
<b>Food</b>	<b>48.0</b>			<b>65.8</b>							<b>0.98</b>	<b>1.07</b>	<b>1.02</b>
Grain		39.0	96.7		52.9						<b>0.90</b>	<b>0.97</b>	<b>0.94</b>
			3.3				79.2	1Kg	20.84	21.20	0.98		
							20.8	100 momme	18.50	26.70	0.69		
Fish		14.9			9.9						<b>1.33</b>	<b>1.33</b>	<b>1.33</b>
							100.0	100g	35.11	26.45	1.33		
Meat		17.0	100.0		7.1						<b>1.15</b>	<b>1.18</b>	<b>1.17</b>
			4.2				60.2	100g	11.02	9.24	1.19		
			79.3				30.7	100g	9.69	7.61	1.27		
			16.5				9.1	100g	15.56	20.93	0.74		
Milk and Eggs		3.5			2.5						<b>1.03</b>	<b>1.03</b>	<b>1.03</b>
			20.4				16.5	1bottle	8.00	9.90	0.81		
			79.6				83.5	1Kg	73.33	67.50	1.09		
Ingredient		8.8			4.5						<b>1.05</b>	<b>1.05</b>	<b>1.05</b>
			56.6				39.3	1liter	36.22	36.60	0.99		
			19.2				12.0	1Kg	19.56	16.27	1.20		
			24.2				48.7	1Kg	39.44	36.90	1.07		
Vegetables and others		9.5			15.0						<b>1.15</b>	<b>1.04</b>	<b>1.09</b>
			43.6				9.7	1Kg	15.74	21.13	0.75		
			30.8				12.9	100 momme	5.00	2.01	2.49		
			10.3				12.9	100 momme	4.00	6.12	0.65		
			15.4				42.6	100 momme	7.00	8.10	0.86		
Processed food		3.0			1.4						<b>0.99</b>	<b>0.99</b>	<b>0.99</b>
			100.0				100.0	100 momme	9.00	9.11	0.99		
Alcohol		3.2			1.5						<b>0.86</b>	<b>0.90</b>	<b>0.88</b>
			77.7				96.3	1liter	162.00	189.00	0.86		
			22.3				3.7	1bottle	34.70	33.00	1.05		
Drinks		0.9			6.0						<b>0.84</b>	<b>0.84</b>	<b>0.84</b>
			100.0				100.0	100g	15.22	18.15	0.84		
<b>Lighting and Electricity</b>	<b>5.8</b>			<b>9.8</b>							<b>0.89</b>	<b>0.91</b>	<b>0.90</b>
Electricity		24.7			21.7						<b>0.93</b>	<b>0.93</b>	<b>0.93</b>
			100.0				100.0	1KWH	14.00	15.00	0.93		
Fuel		75.3			78.3						<b>0.88</b>	<b>0.90</b>	<b>0.89</b>
			34.8				80.8	10 Kg	22.78	25.30	0.90		
			20.9				4.0	10 Kg	53.93	42.04	1.28		
			44.3				15.2	10 Kg	16.89	23.43	0.72		
<b>Clothing and Bedding</b>	<b>6.9</b>			<b>7.2</b>							<b>1.23</b>	<b>1.29</b>	<b>1.26</b>
Clothing		56.9			37.4						<b>1.25</b>	<b>1.34</b>	<b>1.29</b>
			50.0				50.0	1Tan	82.00	83.00	0.99		
			50.0				50.0	1ft.	17.00	10.10	1.68		
Wage for processing		43.1			62.7						<b>1.22</b>	<b>1.23</b>	<b>1.22</b>
			50.0				50.0	Daily (Yen)	1.43	1.31	1.09		
			50.0				50.0	Daily (Yen)	1.41	1.03	1.37		
<b>Housing Expenses</b>	<b>7.7</b>			<b>5.6</b>							<b>1.02</b>	<b>1.03</b>	<b>1.02</b>
Construction wages		28.6			14.3						<b>1.00</b>	<b>1.00</b>	<b>1.00</b>
			50.0				50.0	Daily (yen)	1.78	1.78	1.00		
			50.0				50.0	Daily (yen)	1.73	1.72	1.01		
Construction materials		58.1			57.2						<b>0.93</b>	<b>1.00</b>	<b>0.96</b>
			50.0				50.0	100Kg(yen)	2.10	2.83	0.74		
			50.0				50.0	1000 pieces (yen)	19.00	15.16	1.25		
Mis.		13.3			28.5						<b>1.25</b>	<b>1.25</b>	<b>1.25</b>
							100.0	Daily (yen)	1.73	1.39	1.24		
<b>Mis. Expenses</b>	<b>31.6</b>			<b>11.7</b>							<b>0.94</b>	<b>1.12</b>	<b>1.02</b>
Transportation and Communication		12.7			13.4						<b>1.86</b>	<b>2.14</b>	<b>2.00</b>
			47.7				21.3	1km	3.28	1.33	2.47		
			47.7				73.9	Daily (yen)	1.97	1.01	1.95		
			4.6				4.8	1piece	10.00	15.00	0.67		
Health and Hygiene		47.9			37.3						<b>1.09</b>	<b>1.09</b>	<b>1.09</b>
			19.0				22.2	1piece	10.00	10.00	1.00		
			19.0				26.5	daily	131.00	93.00	1.41		
			62.0				51.3	Annual (yen)	544.00	536.70	1.01		
Stationaries		23.8			41.9						<b>0.72</b>	<b>0.72</b>	<b>0.72</b>
			83.1				87.4	(yen)	40.67	55.88	0.73		
			16.9				12.6	1quire	5.00	7.43	0.67		
Entertainment		15.7			7.4						<b>1.00</b>	<b>1.00</b>	<b>1.00</b>
			100.0				100.0	1 issue	5.00	5.00	1.00		

Notes: see notes to Appendix A-1 and A-2.

## Appendix B. Decomposition of Index Number Bias from 1990 Backward Projection

We denote  $PL_i^C(t)$  as the ratio of country  $i$ 's exchange rate converted per capita income over its Geary-Khamis international price measured per capita income in year  $t$ :

$$PL_i^C(t) = \xi^i(t) \frac{\sum p_n^i(t)e_n^i(t)}{\sum p_n^G(t)e_n^i(t)},$$

where

$\xi_i(t)$ : nominal exchange rate of country  $i$ 's currency to US \$ at time  $t$ .

$p_n^i(t)$ : country  $i$ 's price of the  $n$ th good or service at time  $t$ ,  $n = 1, 2, \dots, N$ ;

$p_n^G(t)$ : the Geary-Khamis (GK) international price of the  $n$ th good or service of country  $i$  in year  $t$ ;

$e_n^i(t)$ : country  $i$ 's real per capita value-added of  $n$ th good or service at time  $t$ .

We then define country  $i$ 's PPP adjusted or GK price  $PL_i^E(t,90)$  for Korea and Taiwan as follows ( $i =$  Korea, Taiwan):

$$PL_i^E(t,90) = \xi_i \sum p_n^i(t)e_n^i(t) \div \frac{\sum p_n^i(t)e_n^i(t)}{\sum p_n^i(t)e_n^i(90)} \sum p_n^G(90)e_n^i(90),$$

where  $\xi$ ,  $p_n^i(t)$ ,  $e_n^i(t)$  are the same as defined earlier. The (90) is used to denote benchmark year 1990.

We use the superscript  $E$  for  $PL_i^E$  to denote the extrapolated price level to distinguish from the current price level which used the superscript  $C$ .

Note that the numerator of  $PL_i^E(t,90)$  is just Korea or Taiwan's current price per capita GDP converted to U.S. \$ at the nominal exchange rate of time  $t$ . The denominator is Maddison's 1990 benchmark back projected Korea or Taiwan real per capita GDP at time  $t$  expressed in GK dollars, which is the product of its 1990 GK benchmarked per capita GDP and its real GDP growth rates in their domestic national accounts between time  $t$  and 1990.

Following Hestons and Summers (1993), we define the ratio of country  $i$ 's benchmark PPP over its exchange rate as country  $i$ 's current price comparative price levels (here with Japan being the benchmark

country) by:  $CPL_{i,J}^C(t) = \frac{PL_i^C(t)}{PL_J^C(t)}$ . (Since exchange rates in our mid-1930s benchmark studies are 1:1,

the  $P_{i,J}$  used in Table 2 is equivalent to  $CPL_{i,J}^C$ ).

Again with Japan being the benchmark country in our study, Korea and Taiwan's implicit GDP deflators relative to the Japanese price should be  $CPL_{i,J}^E(t,90) = PL_i^E(t,90)/PL_J^E(t,90)$ , which is the formal version of the calculation for columns 7 and 8 in Table 4.

The Comparative Price Ratio defined by Hestons and Summers (1993) is just equivalent to:

$$\frac{CPL_{i,J}^C(t)}{CPL_{i,J}^E(t,90)} = \frac{PL_i^C(t)/PL_J^C(t)}{PL_i^E(t,90)/PL_J^E(t,90)}.$$

For ease of decomposition, we would like to focus on the  $i$  country by using the ratio:  $Z_i(t,90) = PL_i^C(t)/PL_i^E(t,90)$ , written as follows:

$$Z_i(t,90) = \frac{\sum p_n^i(t)e_n^i(t)}{\sum p_n^i(t)e_n^i(90)} \sum p_n^G(90)e_n^i(90) \div \sum p_n^G(t)e_n^i(t).$$

The numerator of  $Z_i(t,90)$  is the Maddison style  $t$  period's 1990 benchmark back projected per capita GDP and the denominator,  $\sum p_n^G(t)e_n^i(t)$ , is the direct  $t$  year benchmark based per capita GDP estimate

in GK price. Therefore, we can consider  $Z_i(t,90)$  as a measure of the extrapolation bias. For purposes of interpretation, we transform the  $Z_i(t,90)$  equation as follows:

$$Z_i(t,90) = \frac{\sum p_n^G(90)e_n^i(t)}{\sum p_n^G(t)e_n^i(t)} \times \frac{\sum p_n^G(90)e_n^i(90)/\sum p_n^G(90)e_n^i(t)}{\sum p_n^i(t)e_n^i(90)/\sum p_n^i(t)e_n^i(t)} \quad (1).$$

Equation (1) decomposes the source of Maddison's deviation from the current price benchmark estimation into two components. The first item of the equation is country  $i$ 's Laspeyres price index in GK international price between time  $t$  and 1990 using its  $t$  period quantity weight. For a relatively open and price-taking economy, this price index can be approximated by that country's Laspeyres terms of trade (export price index divided by its import price index) from  $t$  to 1990. Thus, an improvement (or deterioration) of country  $i$ 's Laspeyres terms of trade between  $t$  and 1990 could cause the 1990 back projected estimate to over-estimate (or under-estimate) country  $i$ 's  $t$  period per capita GDP relative to its  $t$  period benchmark PPP estimate.

The second term of equation (1) is the ratio of a Paache quantity index (using the 1990 GK price weight) over a Laspeyres quantity index (with the weight of the  $t$  period domestic price). This ratio, which measures the discrepancy between real growth rates using the later period price weights and base period weights 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 under-estimates a country's  $t$  period per capita income depends on if there is a positive or negative correlation between the changes in the relative prices and quantities of the corresponding sectors.

The Gerschenkron effect arises from the use of later and base price weights both of the same country. In our case, the later price weights are the Geary Khamis international price of 1990. We are thus assuming the discrepancies in real growth rates using 1990 GK price and 1990 domestic price are relatively small, far smaller than using domestic later and base price weights. For a discussion of the Gerschenkron effect, see Edward Ames and John Carlson (1968).

For our tri-partite comparison, which can be written as:  $Z_i(t,90) \div Z_j(t,90) = CPL_{i,j}^C(t) \div CPL_{i,j}^E(t,90)$ , we only need to re-interpret both the terms of trade and Gerschenkron effects in Korea and Taiwan relative to those of Japan.