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Explorations in Economic History 43 (2006) 280–308

Explorations in
Economic History

www.elsevier.com/locate/eeh

International comparison in historical perspective: Reconstructing the 1934–1936 Benchmark purchasing power parity for Japan, Korea, and Taiwan

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Received 29 February 2004
Available online 25 April 2005

Abstract

This article provides the first expenditure-based estimate of purchasing power parity (PPP) converters for 1934–1936 Japan, Korea, and Taiwan. We match all together 70–80 types of goods and services for private consumption, government expenditure and investment using three levels of weights derived from various expenditure surveys. We find that the 1934–1936 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 1934–1936 Korea and Taiwan overall GDE average

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price levels of 0.87 and 0.86 that of Japan, respectively. Our new benchmark estimate is an improvement over existing converters based either on exchange rates or the 1990 backward projection method, which is 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 for these three economies.

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Keywords: Purchasing power parity; International comparison; Convergence; Index number bias; Backward projection

1. Introduction

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 Japanese colonial era using detailed statistics compiled by the Japanese colonial administrations. 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, based on the official one to one exchange rate, 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; 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 expenditure PPP for Japan, Taiwan, and Korea in 1934–1936. For private consumption, we conduct a three way bi-lateral matching of 50–60 types of goods and services, with three-level consumption expenditure weights derived from detailed household budget surveys. For private investment and government expenditure, we match over 20 types of goods and services for these three economies. We find that the 1934–1936 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 1934–1936 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 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 series.

The rest of the paper is divided into three main sections followed by a conclusion. Section 2 provides a detailed explanation of our PPP estimation procedure and results. Section 3 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 4 gives a brief application of our PPP estimates to an overview of long-term structural change, ethnic income distribution, and the historical convergence for these three economies in the past century.

2. The 1934–1936 Benchmark PPP

Japan's colonial acquisitions of Taiwan and Korea were the spoils of two military victories, the Sino-Japanese War of 1894–1895 and the Russo-Japanese War of 1904–1905, which also marked the 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 China paved the way for her conversion to the gold standard in 1899. The victory of the 1905 Russo-Japanese War marked the beginning of Japan's incorporation of 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.²

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.³ 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.⁴ The 3-year average of 1934–1936, chosen as our PPP benchmark, falls in the high stage of Japanese colonialism. More importantly, 1934–1936 is also a period of relative economic and price stability, interposed between the severe deflation leading to Japan’s banning of gold exports in 1931–1932 and the late 1930s economic dislocation brought about by the outbreak of the Sino-Japanese War.

Our study makes full use of the relatively rich and high-quality statistical data (by pre-war standards) compiled by the Japanese government and its colonial administration that employed comparable 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.⁵ Given the above, we believe our study is differentiated from some other similar pioneering studies which had to compromise with a narrow set of commodity prices and simplifying assumptions of expenditure weights due to the data constraint for most non-industrialized countries in the pre-War period (Bassino and van der Eng, 2002; Nakagawa, 2000; Van Zanden, 2003). Our study is thus closer to the methodology used

² 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).

³ Free trade was largely realized between Japan and Taiwan in the 1920s and 1930s. But tariff rates and taxable trade items between Japan and Korea were reduced over several stages and only completely abolished by 1941 to ensure fiscal revenue for the cash-strapped Japanese colonial administration in Korea. See Yamamoto, 2000, pp. 69–72.

⁴ Applying gravity model to detailed trade data from 1896 to 1940, Huang and Xu (1997) analyzed the historical process of Taiwan being steadily but effectively absorbed into the Japanese colonial economic structure. They show that Japan’s increasing dominance in Taiwan’s total external trade since 1896, was accompanied by a corresponding retreat of other traditional trading partners such as mainland China and European powers. 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.

⁵ 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.

by several rounds of the ICP studies for the post-WWII benchmark period (Heston and Summers, 1993; Maddison, 1995).

2.1. The 1934–1936 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.⁶ 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.

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 include the service sector such as utilities (domestic lighting and heating cost), housing and medical expenses (proxied by wages of construction workers, price of cement, and annual salaries of doctors). Our PPP is computed by a three way bi-lateral comparison of absolute prices with Japan serving as the numaire country. For n numbers of goods and services, Japan's (sub- or super-scripted as J) price level relative to that of country i , ($i = \text{Korea, Taiwan}$) is calculated as follows:

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

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.

The detailed price matching, consumption weights as well as data sources and methodologies are explained in Appendix A along with three data tables. First and second tables of Appendix A show that the average consumer price levels of 1934–1936, Korea and Taiwan are 0.86 and 0.84 times that of Japan, respectively. Third table of Appendix A, 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

⁶ 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 Taipei, Keelung, Ilan, Hsinchu, Taichung, Changhua, Tainan, Chiai, Kaohsiung, Pingtung, Taitung, Hualien, and Makung. Our urban-based PPP estimate could possibly bias downward our PPP adjusted real per-capita income for Korea considering its larger agrarian and self-sufficient sector. 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.

Table 1
Aggregate rural and urban expenditure weights in 1934–1936

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

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 Appendix A. The rural share of population in Taiwan and Korea are 52 and 75%, respectively, calculated from M&U volume, pp. 235, 237, 263, and 268.

Table 2
Relative consumption price levels by sectors (1934–1936: Japan = 1)

Sectors	Korea	Taiwan
Total	0.86	0.84
Tradables	0.93	0.88
Food	0.94	0.87
Other tradables	0.91	0.89
Non-tradables	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 formula. 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%, respectively. For Japan–Korea comparison, Japanese and Korean weights used for the same three categories are 41, 21, 38 and 66, 17, 17%, respectively.

three-country transitivity conditions for relative price levels. The summary information of relative price levels is in Table 2.

2.2. 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 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.

Table 3
Relative price levels for investment

	Weights			Absolute price level with fisher average (Japan = 1)	
	Taiwan	Korea	Japan	Taiwan/Japan	Korea/Japan
Equipment	0.17	0.30	0.54	1.64	1.55
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
Construction	0.83	0.70	0.46	0.74	0.79
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
Total	1	1	1	0.95	0.98

Sources. Weights for Taiwan and Korea from Mizoguchi (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 Office of Taiwan (Relevant issues), *Shigen Chosa rei*, Governor Office of Korea (1938), *Kousan Touke*, and Ministry of Industry and Commerce, *Kouyou Toukei* for Taiwan, Korea, and Japan respectively. Other prices can be found in the first table of Appendix A.

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, Chapter 6). Price levels for construction investment in Taiwan and Korea that relied more on local materials and labor are at about 74 and 79% 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% the level of Japan, respectively.

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% higher than in Japan, respectively. Clearly, the high wages and shares commanded by the Japanese staffs in the colonial governments represented a costly burden 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.

Using the weights of consumption, investment, and government expenditure, Table 5 summarizes the overall relative price levels for GDE for Taiwan and Korea which stand at 0.86 and 0.87 times that of Japan, respectively, for our 1934–1936 benchmark period.

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
Total	1	1	1	0.87	0.89

Sources. The weights for Taiwan and Korea are from Mizoguchi (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. Mizoguchi (1975) only has weight for oil which we use for sulfuric acid. Prices for chemical and metal products are from Governor Office of Taiwan (Relevant issues), *Shigen Chosa rei*, Governor Office of Korea (1938), *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 the first table of Appendix A.

3. PPP converters, exchange rate, and the 1990 backward projection

3.1. 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% to 43 and 78% 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.

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 Mizoguchi 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 1934–1936 benchmark PPP estimate.

3.2. 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 pre-War GDP data used in Maddison's 1990 backward projected real series largely come from Ohkawa and Shinohara (1979) for Japan and M&U (1988) for Korea and Taiwan, we can derive the implicit GDP deflator in the Maddison back-projected series using the following calculation formula in the case of Korea relative to Japan at a period:

$$\begin{aligned}
 & \text{Korean Price Level/} \text{Japanese Price Level} \\
 &= [(\text{nominal Korean per-capita GDP}) \\
 & \quad / (\text{Maddison's real Korean per-capita GDP})] \\
 & \div [(\text{nominal Japanese per-capita GDP}) \\
 & \quad / (\text{Maddison's real Japanese per-capita GDP})].
 \end{aligned}$$

Appendix B provides a 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 and the 1990 back projected real series. Columns 7 and 8 of Table 7 are the derived GDP deflator from Maddison's

Table 7
Per-capita GDP and comparative price levels

	Per-capita GDP (GDE)						Maddison's implicit GDP De flator		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				
Cols.	1	2	3	4	5	6	7	8	9	10
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 \(1995\)](#).

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 Fig. 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.

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 Eq. (B.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 (or effects from changes in economic structures). We show that an improvement (or deterioration) of a country's Laspeyres terms of trade between 1934–1936 and 1990 could cause the 1990 back-projected estimate to over-estimate (or under-estimate) that country's 1934–1936 per-capita GDP relative to its 1934–1936 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

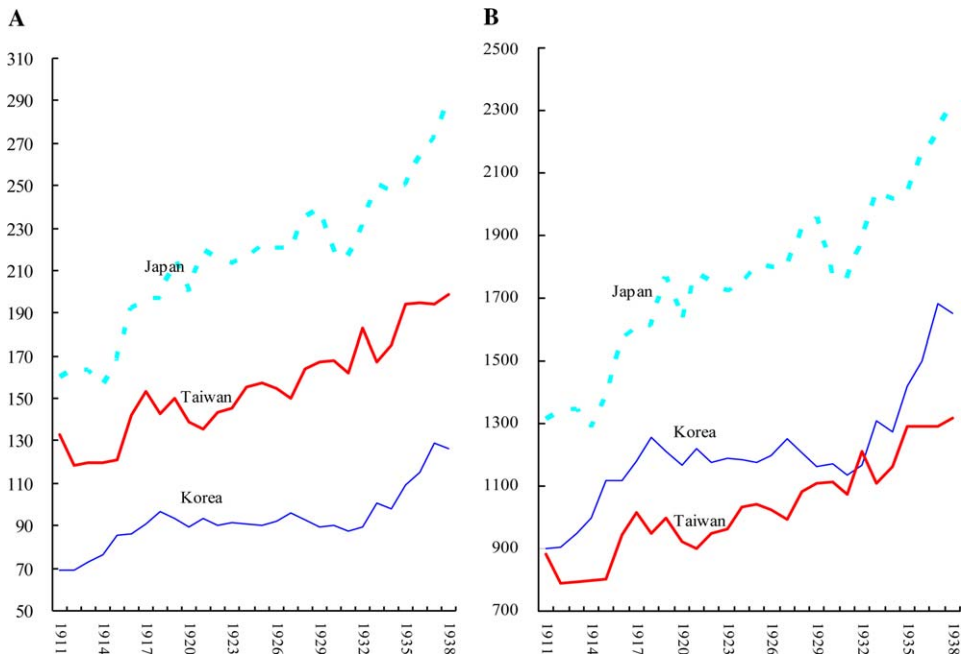


Fig. 1. (A) Real per-capita GDP based on our expenditure PPP (in 1934–1936 Japanese yen). (B) Maddison's real per-capita GDP (1990 Geary–Khamis dollars). *Note.* See the text.

study. Below we provide some preliminary examination or conjectures on the sources of discrepancy in the back-projected estimates.

3.3. *Conjectures on the sources of biases in backward projection*

There have been extensive rounds of PPP studies 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.166–167).

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 equaled to that of Taiwan already by 1961, and became on average 20% higher throughout the 1950s (Heston et al., 2002). These estimates which give a higher relative levels of Korea over that of Taiwan in the 1950s and 1960s, 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, 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.⁷

To reconstruct the War period GDP series is 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

⁷ For details of Maddison's war-time 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 1934–1936 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).

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 may be mitigated by the switch of benchmark years. We do have Post-War terms of trade data for both these three 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 1934–1936 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 over Korea during this period, a result in contradiction to our theoretical predictions.⁸ 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.

4. From colonial empire to economic miracles: a PPP perspective

The period between 1935 and 1990 saw a leap from the high stage of Japanese colonialism to the pinnacle of the East Asian miracle. While in 1935, the external trade (imports plus exports) to GDP ratio in Korea and Taiwan already reached 58 and 70%, they increased to 76 and 80%, respectively, in 1990.⁹ However, the change was far more structural than quantitative. In 1935, 90 and 76% of total exports from Taiwan and Korea, respectively, consisted of a narrow range of agricultural and primary products. In 1990 more than 90% 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% in 1935 to less than 0.6% in 1990 (M&U Tables 61 and 64, Yamazawa and Yamamoto (1979) 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% of their exports in 1990, while in 1935, this share for US was negligible, with the exception of Japan which saw the US taking about 17% 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 Fig. 2.

⁸ 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.

⁹ 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% in 1935 to 18% 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.

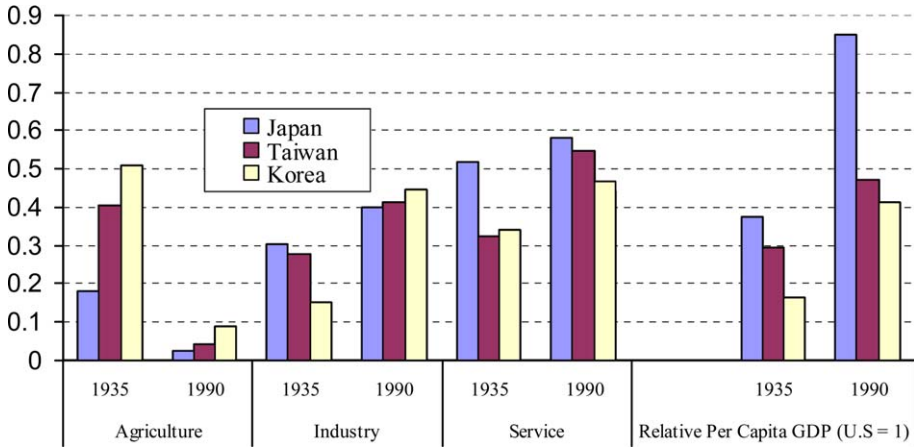


Fig. 2. Sectoral GDP shares and relative per-capita GDP (US = 1) of Japan, Taiwan, and Korea in 1935 and 1990. Sources. 1935 sectoral shares data from M&U, Tables 3, 5, and 7. 1990 sectoral shares data for Japan and Korea are from Pilat, 1994, pp. 279 and 297. The 1935 PPP per-capita data is from this study. To link with the US, we used data from Maddison, 1995. Korea for 1990 is for South Korea only.

Interestingly, Fig. 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.¹⁰ 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 (Maddison, 1990, p. 363). These Japanese residents had 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. 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 price level in Table 2, would be roughly 40% higher than their compatriots of the same occupation living in Japan in 1937.

A tentative estimate by Mitsuhiro Kimura shows that Japanese residents who were 5.1 and 2.7% of the total population of Taiwan and Korea respectively in the mid-1930s, had 26 and 22% shares, respectively, in their total national incomes.¹¹

¹⁰ In fact, Taiwan’s per-capita income relative to Japan actually declined from 78% in 1935 to 55% in 1990. Per-capita income in South Korea did catch up slightly with that of Japan, rising from 43% in 1935 to 48% in 1990. 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.

¹¹ Population share figures from M&U, Table 23 on p. 256. National income share figures are the average of 1930 and 1940 from Kimura, 1998, pp. 30–31.

Table 8

Per-capita 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, September and 1938, August) compiled by the Statistical Bureau of the Japanese Interior Ministry. Taiwan is from *Kakei Chousa Houkoku*, November 1937 and October 1938. There are 1601 families surveyed in Japan, 390 Taiwanese families and 355 Japanese residents' families surveyed in Taiwan.

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

Thus, if we exclude the income share of Japanese residents, the native Taiwanese and Korea per-capita income in PPP terms would be only 59 and 34% of the per-capita income of Japan in 1935. By the criteria of ethnicity, the per-capita income gap between Taiwanese and Japanese is roughly comparable between 1935 and 1990, but significantly narrowed between Koreans and Japanese.

More importantly, the East Asian miracle is more of a tale of convergence towards the global leading economies, than their keeping-up with each other. The Japanese per-capita income surged from 37% of that of the US in 1935 to 85% of the US level in 1990. Similarly, if we exclude the income share of Japanese residents in the colonial period, the Taiwanese and Korea per-capita incomes rose from 22 and 13% of that of the U.S to 47 and 41%, respectively, in 1990 (also see Fig. 2). In this regard, the Post-War period marks a huge catch-up for the average citizens of all these three economies on a global scale.

5. 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 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 underestimated 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. Our future research plans to extend our 1930s PPP benchmark to China and also link with the U.S.

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. It helps lay the foundation of an integrated historical framework that links the one and a half century of modern economic growth in Japan with the Post-War economic miracles of Taiwan and Korea.

Appendix A. Data source

Due to space constraint, this appendix only lists the main data source for prices and expenditure weights. For detailed information, we refer our readers to our Hitotsubashi Hi-Stat Discussion Paper Series No. 66 of the same title which can be found at: <http://hi-stat.ier.hit-u.ac.jp/>. Sources in Japanese language can also be found in Yuan, Tangjuan and Fukao, Kyoji (2002) “1930 Nendai ni Okeru Nihon, Chosan, Taiwan kan no Koubai Ryoku Heika” *Keizai Kenkyuu* (The Economic Review) Vol. 53, 2002.

Main sources for price data:

Japan: relevant issues of *Nihon Teikoku Toukei Nenkan* (Statistical Annals of the Japanese Empire) and *Bukka Toukei Hyou* (Statistical Tables of Prices) by Sho-ukou Daijin Kanbou Toukeika (Government Statistics Department of the [Ministry of Commerce and Industry](#), 1938).

Korea: relevant issues of the *Statistical Annals of the Korea Government-General* published by Chousen Soutokufu ([Governor Office of Korea](#), 1938).

Taiwan: 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 Shokusan-kyoku.

Expenditure weights:

Japan: upper level weights are from 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 for the relevant years. Lower level weights from vol. 6, Private Consumption Expenditure of *LTES*.

Taiwan and Korea: we largely follow [Mizoguchi \(1971\)](#). As there is no urban household budget survey in colonial Korea, we use weights from *The 1961 Household Expenditure Survey Report*, conducted by the Economic Planning Council of the Republic of Korea in 1962. This is justified on two grounds. First, the urban expenditure share is only 25% of the total share of our expenditure weight. The

rural expenditure share, which constitutes 75% share in our expenditure share, is derived from the 1930s agricultural household surveys. Second, various sources such as Maddison (1995, p. 204–205) and Mizoguchi and Nojima (1996, pp. 30–37, 40–45) indicate that Korea in the 1930s and South Korea in the 1960s are probably at similar stages of development: the per-capita GDPs and sectoral and expenditure composition of total GDPs between these two periods are roughly comparable. Somewhat indirect but more illustrative is the case of Taiwan: a large scale consumption survey of 3000 families in urban Taiwan in 1966 revealed a consumption share almost identical to the similar surveys carried out in the 1937 (see *Report on the Survey of Family Income & Expenditure in Taiwan* by the Statistics Office of the Republic of China in 1966).

Appendix A.1. Korean price level relative to Japan (1934–1936: Japan = 1)

Commodities	Japanese weight			Korean weight			Units	Prices			Korean price level		
	U	M	L	U	M	L		Korea	Japan	Korea/ Japan	Korean weight	Japanese weight	Average
Total											0.86	0.87	0.86
<i>Food</i>	41.3			65.8							0.88	1.00	0.94
Grain		39.7	100.0		54.0	100.0	Unit				0.85	0.86	0.86
Rice			89.1			77.6	1 kg	20.80	23.80	0.88			
Wheat flour			5.6			20.3	1 kg	18.30	23.00	0.80			
Soybean			3.1			1.5	1 kg	15.70	22.90	0.69			
Azuki			2.2			0.6	1 kg	18.00	21.30	0.85			
Meat		2.7	100.0		7.1	100.0					0.79	0.81	0.80
Beef			63.9			60.2	100 g	11.00	12.80	0.86			
Pork			26.8			30.7	100 g	9.70	14.00	0.69			
Chicken			9.4			9.1	100 g	15.60	20.80	0.75			
Fish		8.3	100.0		9.9	100.0					1.26	1.30	1.28
Yellowtail 1			34.9			18.9	100 monme	27.00	21.50	1.26			
Mackerel 1			34.9			18.9	100 monme	16.00	11.30	1.42			
Dried bonito			30.1			62.1	100 monme	35.10	28.80	1.22			
Milk and eggs		2.5	100.0		2.5	100.0					1.15	1.14	1.15
Milk			23.0			16.5	1 go	8.00	7.80	1.03			
Eggs			77.0			83.5	1 kg	73.30	62.20	1.18			
Ingredients		8.5	100.0		4.5	100.0					1.05	1.13	1.09
Soy sauce			40.7			29.9	1 ½	36.20	26.90	1.35			
Miso			25.3			9.1	1 kg	19.60	21.80	0.90			
Salt			3.5			24.0	1 kin	6.00	7.00	0.86			
Sugar			30.5			37.0	1 kg	39.40	37.30	1.06			
Vegetables and fruits		9.2	100.0		13.9	100.0					0.91	1.19	1.04
Onion 1			18.4			7.3	100 monme	5.00	3.90	1.28			
Burdock 1			18.4			10.6	1 kg	16.00	12.00	1.33			
Sweet potato 1			23.7			10.6	1 kg	13.30	8.00	1.66			
Potato 1			2.8			10.6	1 kg	10.70	8.00	1.34			
Other dried vegetables			18.4			34.8	16.00	22.70	0.70				
Apple 1			18.4			26.1	1 piece	4.00	5.00	0.80			

(continued on next page)

Appendix A.1 (continued)

Commodities	Japanese weight			Korean weight			Units	Prices			Korean price level		
	U	M	L	U	M	L		Korea	Japan	Korea/ Japan	Korean weight	Japanese weight	Average
Processed food		19.1	100.0		1.4	100.0					0.95	1.04	0.99
Daikon			50.0			50.0	100 monme	9.00	6.70	1.34			
Nara pickles			50.0			50.0	100 monme	21.00	28.70	0.73			
Alcohol		4.8	100.0		1.5	100.0					1.10	1.09	1.10
Sake			74.2			96.3	1 L	94.50	85.40	1.11			
Beer			25.8			3.7	1 bottle	34.70	33.40	1.04			
Tea and drinks		1.2	100.0		0.5	100.0					0.94	0.97	0.96
Cider			50.0			50.0	1 bottle	19.00	17.00	1.12			
Tea			50.0			50.0	100 g	15.20	18.60	0.82			
Tobacco													
Tobacco		3.9	100.0		5.5	100.0		10.00	15.00	0.67	0.67	0.67	0.67
<i>Lighting and electricity</i>	4.8			9.8							0.83	0.81	0.82
Fuel expenses		52.4	100.0		78.3	100.0					0.82	0.75	0.78
Coal			11.8			78.5	10 kg	22.80	27.20	0.84			
Firewood			38.8			14.8	10 kg	16.90	26.60	0.64			
Charcoal			40.8			3.9	10 kg	53.90	80.80	0.67			
Oil			8.6			2.9	10 kg	36.00	36.90	0.98			
Electricity													
Electricity		47.6	100.0		21.7	100.0	1 kwh	14.00	16.00	0.88	0.88	0.88	0.88
<i>Clothing and bedding</i>	10.6			7.2							0.89	1.00	0.94
Cloth		33.3	100.0		19.7	100.0					1.13	1.16	1.14
Cotton			50.0			50.0	1 kg	100.70	103.30	0.97			
Bleached cloth 1			50.0			50.0	1 roll	82.00	61.00	1.34			
Wages for processing		33.5			62.7	100.0					0.80	0.80	0.80
Tailor			50.0			50.0	Daily	1.50	1.80	0.82			
Shoemaker			50.0			50.0	Daily	1.40	1.80	0.78			
Personal items		33.2			17.7	100.0					1.02	1.03	1.03
Socks 1			20.0			20.0	1 pair	22.60	23.00	0.98			
Underwear 1			20.0			20.0	1 piece	94.00	88.00	1.07			

Shoe 1		20.0		20.0	1 pair	769.00	804.00	0.96			
Umbrella 1		20.0		20.0	1 piece	112.00	100.00	1.12			
Western umbrella 1		20.0		20.0	1 piece	178.00	176.00	1.01			
<i>Housing expenses</i>	10.2		5.6						0.90	0.85	0.88
Wages	48.6	100.0	14.3	100.0					0.83	0.84	0.84
Carpenter		33.4		33.4	Daily	1.80	2.00	0.91			
Plasterer		33.3		33.3	Daily	2.00	2.20	0.91			
Tiler		33.3		33.3	Daily	1.70	2.40	0.71			
Construction materials	48.6	100.0	57.2	100.0					0.84	0.85	0.85
Cement		50.0		50.0	100 kg	2.10	2.30	0.91			
Kneaded tiles		50.0		50.0	1000 pieces	19.00	24.30	0.78			
Furniture and miscellaneous	2.7	100.0	28.5	100.0					1.12	1.14	1.13
Tea cup 1		50.0		50.0	1 piece	26.00	20.00	1.30			
Furniture maker		50.0		50.0	Daily	1.70	1.80	0.98			
<i>Miscellaneous expenses</i>	33.2		11.7						0.72	0.69	0.71
Transport and communication	6.2	100.0	13.4	100.0					0.84	1.58	1.15
Train 2		79.3		21.3	1 kg	3.30	1.80	1.82			
Ricksaw wage		1.3		73.9	Daily	2.00	2.70	0.74			
Postcard		19.4		4.8	1 piece	10.00	15.00	0.67			
Health and hygiene	23.2	100.0	37.3	100.0					0.85	0.89	0.87
Doctor salaries		28.0		25.6	Annual	544.00	633.00	0.86			
Health pills		28.0		25.6	300 pills	150.00	160.00	0.94			
Barber wages		21.6		26.5	Daily	1.30	2.00	0.66			
Soap		22.4		22.2	1 piece	10.00	9.30	1.08			
Education	11.3	100.0	45.0	100.0					0.63	0.82	0.72
Textbook and tuition		36.5		81.5	Monthly	40.70	66.70	0.61			
Writing paper		10.6		11.7	10 pieces	5.00	7.40	0.68			
Newspapers		52.9		6.8	1 issue	5.00	5.00	1.00			
Entertainment											
Movies 1	59.3	100.0	4.3	100.0	Once	15.00	30.00	0.50	0.50	0.50	0.50

Source. See the explanation in the Appendix. *Notes.* Items marked with 1 are the regional average of consumer prices in 1936. Items marked with 2 are the average of Tokyo and Seoul in 1936. All other prices are the 1934–1936 regional averages of consumer prices. “U,” “M,” and “L” denote the Upper, Medium, and Lower Level of expenditure weights.

Appendix A.2. Taiwanese price level relative to Japan (1934–1936: Japan = 1)

Commodities	Japanese weight			Taiwanese weight			Unit	Prices			Taiwanese price level		
	U	M	L	U	M	L		Taiwan	Japan	Taiwan/ Japan	Taiwanese weight	Japanese weight	Average
Total											0.79	0.89	0.84
<i>Food</i>	4.13			48.0							0.82	0.89	0.87
Rice		33.2	93.3		39.0	96.7	1 kg	21.20	23.80	0.89			
Wheat flour		33.2	6.7		39.0	3.3	1 kg	25.50	21.00	1.21			
Fish			8.3		11.9						0.72	0.74	0.73
Mackerel 3		8.3	33.3		11.9	33.3	100 kg	11.30	16.35	0.69			
Tuna 3		8.3	33.3		11.9	33.3	100 kg	31.00	50.27	0.62			
Dried bonito		8.3	33.4		11.9	33.4	100 g	26.45	28.78	0.92			
Meat		2.7			17.0						0.60	0.70	0.65
Pork		2.7	26.8		17.0	79.3	100 g	7.61	14.00	0.54			
Beef		2.7	63.9		17.0	4.2	100 g	9.24	12.83	0.72			
Chicken		2.7	9.4		17.0	16.5	100 g	20.93	20.78	1.01			
Eggs		2.0			2.8						1.16	1.17	1.17
Chicken eggs		2.0	82.9		2.8	82.9	1 kg	75.70	62.20	1.01			
Duck eggs		2.0	17.1		2.8	17.1	1 kg	59.40	62.20	0.95			
Milk		0.6			0.7						1.27	1.27	1.27
Milk		0.6	100.0		0.7	100.0	1 bottle	9.90	7.80	1.27			
Vegetables and soybeans		11.0			9.7						1.02	0.93	0.97
Soybeans		11.0	11.2		9.7	23.9	1 kg	21.13	22.30	0.95			
Potato		11.0	2.3		9.7	4.4	1 kg	14.31	6.83	2.09			
Radish 4		11.0	28.8		9.7	23.9	100 kg (yen)	23.0	3.01	0.76			
Burdock 4		11.0	28.8		9.7	23.9	100 kg (yen)	3.80	7.60	0.50			
Onion 4		11.0	28.8		9.7	23.9	100 kg (yen)	6.00	6.43	0.93			
Sweet potato		11.0	19.9		9.7	13.0	1 kg	5.10	7.30	0.70			
Ingredients		8.5			8.8						0.90	0.94	0.92
Sugar		8.5	12.2		8.8	14.5	1 kg	36.90	37.35	0.99			
Miso		8.5	18.8		8.8	11.5	1 kg	16.27	21.78	0.75			
Soy sauce		8.5	28.7		8.8	33.7	1 L	36.30	26.94	1.35			
Peanut oil		8.5	40.4		8.8	40.4	1 kg	44.72	62.42	0.72			

Processed food	23.8		6.1						0.77	0.90	0.83
Dried salty fish	23.8	33.3	6.1	33.3	1 kg	27.60	53.67	0.50			
Dried squid	23.8	33.3	6.1	33.3	1 kg	95.30	113.11	0.84			
Daikon	23.8	33.4	6.1	33.4	100 momme	9.10	6.70	1.36			
Drinks	1.2		0.9						0.98	0.98	0.98
Tea	1.2	100.0	0.9	100.0		18.15	18.61	0.98			
Alcohol	8.7		3.2		100 g				1.16	1.16	1.16
Sake	8.7	74.2	3.2	77.7	1 L	189.00	155.35	1.22			
Beer	8.7	25.8	3.2	22.3	1 bottle (633 cc)	33.00	33.40	0.99			
	8.7		3.2								
<i>Lighting and heating</i>	4.8		5.8						0.77	0.82	0.79
Electricity	47.6		24.7						0.94	0.94	0.94
Electricity	47.6	100.0	24.7	100.0	1 kwh	15.00	16.00	0.94			
Fuel	52.4		75.3						0.73	0.71	0.72
Firewood	52.4	42.3	75.3	20.9	10 kg	42.04	80.83	0.52			
Charcoal	52.4	44.6	75.3	44.3	10 kg	23.43	26.56	0.88			
Coke	52.4	12.9	75.3	34.8	10 kg	25.30	34.30	0.74			
	52.4		75.3								
<i>Clothing and bedding</i>	10.6		6.9						0.88	1.01	0.94
Clothing	66.5		56.9						1.11	1.15	1.13
Cotton	66.5	33.4	56.9	33.4	1 tan	83.00	62.00	1.34			
Muslin	66.5	33.3	56.9	33.3	1 m	61.60	70.70	0.87			
Cotton flannel	66.5	33.3	56.9	33.3	1 m	27.80	22.30	1.25			
Wages	33.5								0.70	0.71	0.70
Tailors (western style)	33.5	33.3	43.1	33.3	Daily	1.31	1.79	0.73			
Shoemaker	33.5	33.3	43.1	33.3		10.3	1.80	0.57			
Tailors (Taiwanese style)	33.5	33.4	43.1	33.4	Daily	1.00	1.20	0.83			
	33.5		43.1								
<i>Housing expenses</i>	10.2		7.7						0.72	0.75	
Construction wages	48.6		28.6						0.77	0.78	0.78
Carpenter	48.6	33.3	28.6	33.3	Daily	1.78	1.95	0.91			
Bricklayer	48.6	33.4	28.6	33.4	Daily	1.72	2.38	0.72			
Plasterer	48.6	33.3	28.6	33.3	Daily	1.72	2.44	0.70			

(continued on next page)

Appendix A.2 (continued)

Commodities	Japanese weight			Taiwanese weight			Unit	Prices			Taiwanese price level								
	U	M	L	U	M	L		Taiwan	Japan	Taiwan/ Japan	Taiwanese weight	Japanese weight	Average						
Construction materials		48.6				58.1													
Cement 3		48.6	13.5			58.1	13.5	(yen)	4.80	4.15	11.6				0.68	0.71			0.70
Tatami mats 3		48.6	13.5			58.1	13.5	10 pieces	732.00	977.00	0.75								
Kneaded bricks 3		48.6	13.5			58.1	13.5	1000 pieces	15.16	23.66	0.64								
Cedarboard 3		48.6	59.7			58.1	59.7	1 tsubo	1.40	2.26	0.62								
Miscellaneous		2.7				13.3			1.80	2.50				0.79	0.79				0.79
Wage of furniture maker		2.7	100.0			13.3	100.0		1.39	1.76	0.79								
						13.3													
<i>Miscellaneous expenses</i>	33.2					31.6								0.76	0.87				0.82
Communication		6.2				12.7								0.52	0.82				0.65
Car 2		6.2	39.7			12.7	23.9	1 km	1.33	1.58	0.84								
Rail staff		6.2	39.7			12.7	23.9	Monthly (yen)	43.02	60.25	0.71								
Ricksaw wage		6.2	1.3			12.7	47.7	Daily (yen)	1.01	2.67	0.38								
Postcard		6.2	19.4			12.7	4.6	1 piece	1.50	1.50	1.00								
Health and hygiene		23.2				47.9								0.79	0.83				0.81
Soap		23.2	22.4			47.9	19.0	1 piece	10.00	9.30	1.08								
Public bath		23.2	10.8			47.9	9.5	1 time	3.00	5.00	0.60								
Wage of barber		23.2	10.8			47.9	9.5	Daily (yen)	0.93	1.97	0.47								
Salary of doctors		23.2	56.0			47.9	62.0	Annual	536.70	633.00	0.85								
		23.2				47.9													
Stationeries		0.6				4.0								1.00	1.00				1.00
Writing paper		0.6	50.0			4.0	50.0	20 pieces (1 quire)	7.43	7.40	1.00								
Minogami paper		0.6	50.0			19.7	50.0	50 pieces (1 quire)	41.27	41.50	0.99								
Education		10.7				19.7								0.81	0.81				0.81
Teacher salary		10.7	100.0			19.7	100.0	Monthly	53.54	65.91	0.81								
Education		59.3				15.7								0.89	0.90				0.89
Newspapers		59.3	50.0			15.7	50.0	1 issue	5.00	5.00	1.00								
Magazines		59.3	50.0			15.7	50.0	1 issue	40.0	50.0	0.80								

Notes: "2" is the consumer price for Tokyo and Taipei, "3" is the regional average retail price for 1934–1936, "4" is the retail price of Tokyo and Taipei. All others are regional average consumer prices.

Appendix A.3. Korean price level relative to Taiwan (1934–1936: Japan = 1)

Commodities	Taiwan weight			Korean weight			Unit	Prices			Korea price level		
	U	M	L	U	M	L		Korea	Taiwan	Korea/ Taiwan	Korea weights	Taiwan weights	Average
Total											0.98	1.09	1.03
<i>Food</i>	48.0			65.8							0.98	1.07	1.02
Grain		39.0			52.9						0.90	0.97	0.94
Rice			96.7			79.2	1 kg	20.84	21.20	0.98			
Wheat flour			3.3			20.8	100 momme	18.50	26.70	0.69			
Fish		14.9			9.9						1.33	1.33	1.33
Dried bonito			100.0		100.0	100 g		35.11	26.45	1.33			
Meat		17.0			7.1						1.15	1.18	1.17
Beef			4.2		60.2	100 g		11.02	9.24	1.19			
Pork			79.3		60.2	100 g		11.02	9.24	1.19			
Chicken			16.5		9.1	100 g		15.56	20.93	0.74			
Milks and eggs		3.5			2.5						1.03	1.03	1.03
Milk			20.4		16.5	1 bottle		8.00	9.90	0.81			
Chicken eggs			79.6		83.5	1 kg		73.33	67.50	1.09			
Ingredient		8.8			4.5						1.05	1.05	1.05
Soyasauce			56.6		39.3	1 L		36.22	36.60	0.99			
Miso			19.2		12.0	1 kg		19.56	16.27	1.20			
Sugar			24.2		48.7	1 kg		39.44	36.90	1.07			
Vegetables and others		9.5			15.0						1.15	1.04	1.09
Soyabeans 1			43.6		9.7	1 kg		15.74	21.13	0.75			
			30.8		12.9	100 momme		5.00	2.01	2.49			
Potato 1			10.3		12.9	100 momme		4.00	6.12	0.65			
Onion 1			15.4		42.6	100 momme		7.00	8.10	0.86			
Processed food		3.0			1.4						0.99	0.99	0.99
Daikon			100.0		100.0	100 momme		9.00	9.11	0.99			
Alcohol		3.2			1.5						0.86	0.90	0.88
Sake			77.7		96.3	1 L		162.00	189.00	0.86			
Beer			22.3		3.7	1 bottle		34.70	33.00	1.05			

(continued on next page)

Appendix A.3 (continued)

Commodities	Taiwan weight			Korean weight			Unit	Prices			Korea price level		
	U	M	L	U	M	L		Korea	Taiwan	Korea/ Taiwan	Korea weights	Taiwan weights	Average
Drinks		0.9			6.0						0.84	0.84	0.84
Tea			100.0			100.0	100 g	15.22	18.15	0.84			
<i>Lighting and electricity</i>	5.8			9.8							0.89	0.91	0.90
Electricity		24.7			21.7						0.93	0.93	0.93
Electricity			100.0			100.0	1 kwh	14.00	15.00	0.93			
Fuel		75.3			78.3						0.88	0.90	0.89
Coal			34.8			80.8	10 kg	22.78	25.30	0.90			
Charcoal			20.9			4.0	10 kg	53.93	42.04	1.28			
Firewood			44.3			15.2	10 kg	16.89	23.43	0.72			
<i>Clothing and bedding</i>	6.9			7.2							1.23	1.29	1.26
Clothing		56.9			37.4						1.25	1.34	1.29
Bleached													
Cotton			50.0			50.0	1 Tan	82.00	83.00	0.99			
Cotton flannel			50.0			50.0	1 ft	17.00	10.10	1.68			
Wage for processing		43.1			62.7						1.22	1.23	1.22
Tailor			50.0			50.0	Daily (yen)	1.43	1.31	1.09			
Western Shoe maker			50.0			50.0	Daily (yen)	1.41	1.03	1.37			
<i>Housing expenses</i>	7.7			5.6							1.02	1.03	1.02
Construction wages		28.6			14.3						1.00	1.00	1.00
Carpenter			50.0			50.0	Daily (yen)	1.78	1.78	1.00			
Bricklayer			50.0			50.0	Daily (yen)	1.73	1.72	1.01			

Construction materials	58.1		57.2						0.93	1.00	0.96
Cement 4		50.0		50.0	100 kg (yen)	2.10	2.83	0.74			
Kneaded tiles 4		50.0		50.0	1000 pieces (yen)	19.00	15.16	1.25			
Miscellaneous	13.3		28.5						1.25	1.25	1.25
Wage of furniture maker		100.0		100.0	Daily (yen)	1.73	1.39	1.24			
<i>Miscellaneous expenses</i>	31.6		11.7						0.94	1.12	1.02
Transport and communication	12.7		13.4						1.86	2.14	2.00
Car 2		47.7		21.3	1 km	3.28	1.33	2.47			
Ricksaw wage		47.7		73.9	Daily (yen)	1.97	1.01	1.95			
Postcard		4.6		4.8	1 piece	10.00	15.00	0.67			
Health and hygiene	47.9		37.3						1.09	1.09	1.09
Soap		19.0		22.2	1 piece	10.00	10.00	1.00			
Barber		19.0		26.5	Daily	131.00	93.00	1.41			
Doctor salary		62.0		51.3	Annual (yen)	544.00	536.70	1.01			
Stationaries	23.8		41.9						0.72	0.72	0.72
Textbook fees		83.1		87.4	(yen)	40.67	55.88	0.73			
Writing paper		16.9		12.6	1 quire	5.00	7.43	0.67			
Entertainment	15.7		7.4						1.00	1.00	1.00
Newspapers		100.0		100.0	1 issue	5.00	5.00	1.00			

Notes. See notes of first and second table.

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, $\xi_i(t)$ is the nominal exchange rate of country i 's currency to US \$ at time t ; $p_n^i(t)$ is the country i 's price of the n th good or service at time t , $n = 1, 2, \dots, N$; $p_n^G(t)$ is the the Geary–Khamis (GK) international price of the n th good or service of country i in year t ; $e_n^i(t)$ is the 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 ($i = \text{Korea, Taiwan}$):

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

where ξ_i , $p_n^i(t)$, $e_n^i(t)$ 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 US \$ 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.

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

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

The numerator of $Z_i(t, 90)$ is the Maddison style t period's 1990 benchmark back-projected per-capita GDP. 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:

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

The above equation 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 Eq. (B.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 measures the discrepancy between real growth rates using the later period and base period price weights. This is close to what is broadly known as the Gerschenkron effect. (Usually, 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.) 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.

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