The Role of Education in the Economic Catch-Up: Comparative Growth Experience from Japan, Korea, Taiwan, and the United States*

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Summary

East Asia in the postwar period achieved a miraculous success in economic catching-up by technology-borrowing from the West. Many intuitive arguments hint that the rich endowment in education in East Asia was critical for its miraculous success. However, empirical studies on the macroeconomic role of education for East Asian countries have been so limited so far that researchers in economics are still uncertain about even basic questions such as whether and how education contributed to the East Asian Economic Miracle. This paucity of the empirical analyses can be attributable to the lack of detailed dataset for education stock. This paper presents nearly-100-year-long annual estimates of education stock for Japan, Korea, Taiwan and the US, which the author newly estimated. The data in this paper provide detailed information such as average years of schooling by age groups, by gender, by levels of education, and by types of education. Based on this dataset, this paper investigates similarities and differences in the pattern of educational development among those four countries. In order to describe the characteristics of the East Asian Miracle, this paper invents a new terminology of 'military-style heavy industrialization.' This word refers to the situation in which a mass of homogeneously not very highly educated (so-so educated) people collaborate methodically in factories (instead of military camps). This paper argues that Japan, Korea and Taiwan succeeded in forming uniform societies, which were suited for 'military-style heavy industrialization.' This paper also presents the following four working hypotheses, which should be further examined with more information in future studies: (1) the accumulation of education precedes industrialization, (2) the screening effect of education helped Japan, Korea and Taiwan to endure the heavy burden of the long "maternity" period of educational investments, (3) tertiary education is less important than secondary education in the midst of rapid heavy industrialization, and (4) prewar Japan's heavy investments in vocational education bore fruit in the postwar high economic growth.

1. Introduction

Education is often idealized. Both academicians and non-academicians frequently express their support for education. The expansion of education is often regarded as the key factor for promoting economic development in developing countries.

The international organizations are also devoted to educational aid for developing countries. For example, the World Bank promotes education in developing countries as a measure of poverty reduction under the slogan of "education for all." This slogan sounds commendable enough to press everybody to support the World Bank's idea.

However, there is no clear empirical evidence on the macroeconomic role of education. Some studies such as Barro and Lee (1993) present that education accelerates economic growth. However, others such as Eastery (2001), Prechitt and Bils (2001) and Mark and Klenow (2000) shed skeptical views on the macroeconomic role of education. In fact, while developing countries succeeded in increasing school enrollments, the income gap between the rich and poor countries has been widening throughout the postwar period. This fact implies that education should not be regarded as a panacea for economic development.

The paucity of the long-term dataset on education stock has stymied the empirical analyses on the macroeconomic role of education. Economists often use the datasets of Barro and Lee (2000), Nehru, Swanson and Dubey (1995) and Kim and Lau (1995). While these datasets provide useful information, there remains much room for improvement as Godo and Douangngeune (2005) points out.

The author constructed a nearly-100-year-long dataset of education stock for Japan, Korea, Taiwan and the US (Godo, 2005; Godo and Fukami 2005).[1][2] This dataset includes detailed information like average number of years of schooling per person (abbreviated as henceforth '*average schooling*') by gender, by age group, and by types and levels of education (i.e., primary, secondary, tertiary and vocational). The US has led the world economy since the late 19th century[3]. Japan was the first nonwestern

[1] The earlier versions of the author's are available at Godo and Hayami (1999), Godo (2001), and Yamauchi and Godo (2004).

[2] 'Korea' in this paper refers to Korea as whole (all the Korean Peninsula) until its independence from Japan (1945) and to the Republic of Korea (South Korea) thereafter.

[3] The US has been at the top of the world economy since around 1890 (Maddison, 1995)

nation that succeeded in economic catching-up with the advanced nations[4]. Taiwan and Korea also achieved miraculous economic successes in only 15-20 years after Japan. Thus, these four countries comprise a perfect combination to analyze the relationship between education and economic development.

Using the author's dataset, this paper examines the East Asian Miracle from the view point of human capital. In order to describe the characteristics of the Miracle, this paper invents a new terminology of 'military-style heavy industrialization.' This word refers to the situation where a mass of homogeneously not very highly educated people (so-so educated) young people collaborate methodically in factories.

This paper finds both similarities and differences among the experiences of these three Asian countries. One of the most important similarities is the big time-lag between educational and economic catching-up, which is consistent with the threshold hypothesis presented by Lau, Jamison, Liu and Rivikin's (1993).

The next section outlines the author's methodology of estimating education stock. Section 3 briefly reviews Japan, Korea and Taiwan's economic catching-up processes. Based on the author's dataset, Sections 4, 5 and 6 examine the macroeconomic role of education in Japan, Korea and Taiwan respectively. Section 7 discusses the implication of the time-lag between educational and economic catching-up that this paper commonly finds for these three countries. Section 8 presents the implication of Japan, Korea and Taiwan's experiences for today's developing countries.

2. Measuring the Average Level of Education

Average schooling can be calculated by accumulating the total enrollment of corresponding years and ages after adjusting for changes in the population due to immigration and mortality. For reasons of simplicity, this paper assumes there are no differences in education level between immigrants and domestic citizens and no correlation between school career and mortality. Then, let:

$AS_{m\text{-}n,\,t}$= Average number of years of schooling in year t for persons of age from m to n years in year t;
$N_{w,t}$= Total enrollment of persons of age w years in year t; and
$G_{w,t}$ = Total number of persons of age w years in year t.

[4] It is a popular view among researchers that after the Meiji restoration of 1868 Japan needed 20-30 years to complete its 'transition' from a feudal to modern state. For example, see Ito (1992: p.16)

Then, the *average schooling* in year t for persons age from m to n years, $AS_{m\text{-}n,t}$, is defined as follows:

$$AS_{m-n,t} = \frac{\sum_{u=m}^{n}\sum_{w=0}^{u-1}\left(\frac{G_{u,t}}{G_{w,t+w-m}}\right)N_{w,t+w-m}}{\sum_{u=m}^{n}G_{u,t}}$$

Average schooling for the working-age (age 15 -64) population can be calculated for the case of m=15 and n=64. By taking the data of enrollment by levels of education (primary, secondary and tertiary), *average schooling* can be estimated by levels of education too. The problem is that the classification of levels of education differs according to time and country. This paper employs the definition of the US Department of Education: the primary level, the secondary level, and tertiary level correspond to grades 1-8, grades 9-12, and beyond grade 12 respectively. Likewise, *average schooling* of vocational education can also be estimated as shown in Section 3.

Table 1 summarizes the estimation results of *average schooling* in the working-age population and enrollment ratio for the schooling-age (age 6-20) population. While Japan, Korea and Taiwan fell behind the US significantly in the prewar period, the gap diminished rapidly in the postwar period. While there remain gaps of 2 to 3 years among those four countries as of 2000, there are almost no differences in enrollment ratio. Thus, the gap in *average schooling* in the working-age population will converge to the same level future.

Figure 1 shows the gender gaps of education measured by the female/male ratio of *average schooling*. No significant gender gap ever existed in the US at least for the period of this paper's analysis. In contrast, Japan, Korea, and Taiwan had large gender gaps in the early period. These gaps rapidly closed over a century of modern economic growth. As a result, female's *average schooling* is now almost par with male's in all four countries.

Figure 2 shows how the gender gap in Japan, Korea, and Taiwan decreased according to the increase of education level overall. Korea's path is amazingly close to Japan's path. Taiwan's path is also close to Japan's and Korea's. Taiwan's path is higher than Japan's and Korea's after 1970, which means that Taiwan's educational development was less biased in favor of males.

It seems reasonable to hypothesize that certain Confucian ideologies and traditions in Japan, Korea and Taiwan may have confined women to a subordinate role,

which deprived them of the opportunity to receive higher education in the earlier period. However, it is also very likely that economic reason mattered more than religious or cultural reasons. Factories of the heavy industry require heavy manual labor, in particular in the early period of industrialization. Thus, it may be reasonable for those countries to have used the limited resources for males' education first. Obviously, more investigation is necessary about the reason for the gender gap. However, it is beyond the scope of this paper's analysis.

3. Overview of the process of economic catching-up

Before looking at details of the autor's dataset, it is useful to have a quick review of the East Asian success story, as shown in Figures 3 and 4 and Table 2.

Figure 3 shows the convergence of per-capita GDP among those four countries. In the prewar period, Japan, Korea and Taiwan fell far behind the US. However, those three countries accomplished marvelous economic achievements in the postwar period. The speed of catching-up is particularly high for 1950-70 in Japan, for 1965-95 in Korea and for 1960-90 in Taiwan. These periods are regarded as the East Asian 'miracle.'

Figure 4 views economic convergence from a different angle. This scatter diagram takes the inverse of physical capital productivity for vertical axis and the inverse of labor productivity for the horizontal axis, which plots unit isoquants of conventional macro production function. Thus, Figure 4 shows the change of macroeconomic efficiency and physical capital-labor ratio[5]. As can be seen, both macroeconomic efficiency and the combination of conventional inputs of the three Asian countries have also been converging to the US's level rapidly in the postwar period.[6]

Table 2 shows the change of the industrial structure and demography in the three Asian countries. The right section of Table 2 indicates that the miraculous periods coincide with the periods of the expansion of manufacturing sector. Interestingly, the expansion of manufacturing sector also coincides with expansion of percentage in younger working-age (age 15-39) people in the total population (the left section of Table 2). In sum, Table 2 provides a simple but persuasive story on the East

[5] The direction of south-west in Figure 4 means higher macroeconomic efficiency. The direction of north-west (or south-east) means more labor-saving (or labor-intensive) and capital-intensive (or capital-saving).

[6] Exception is the 1990s in Japan. In spite of increase in the physical capital – labor ratio, Japan had almost zero percent economic growth during the 1990s.

Asian Miracle: the Miracle was caused by the increase of factory production that relied on profusely abundant supplies of young workers.

4. Japan's catching-up with the US

To observe the relationship between educational and economic catching-up, we employ the framework of macro production function. A standard macro production function with human capital is defined as follows:

$$y = f(k, h),$$

where y = per-capita GDP; k = physical capital-labor ratio; and h = *average schooling*.

Assuming that the US is the frontier of the world economy, this paper uses two indicators for the degree of economic catching-up and one indicator for the degree of educational catching-up. Namely, this paper uses the Japan/US ratio in per-capita GDP and that in physical capital-labor ratio as indicators of economic catching-up. In Likewise, this paper uses the Japan/US ratio in *average schooling* as an indicator of educational catching-up.

Figure 5 traces the changes of these economic and educational indicators since the late 19th century. As can be seen, there is a sharp contrast between the prewar and the postwar periods. In the prewar period, Japan's per-capita GDP stagnated at 20 to 30 % of the US's level[7]. Japan's physical capital-labor ratio remained less than 10 % of the US's level throughout the prewar period. Those findings demonstrate that Japan did not start economic catching-up in the prewar period. Simultaneously, however, the educational indicator reveals that Japan had already started its educational catching-up with the US as early as the late 19th century and steadily narrowed the gap from the US throughout the prewar period.

In contrast to the prewar period, Japan experienced rapid economic catching-up in the postwar period. Since the end of the Pacific War, the Japan/US ratio in per-capita GDP and that in physical capital-labor ratio increased sharply in tandem[8]. It is well-known that aggressive investments in physical capital propelled the economy in the Japanese high growth era. Strong effective demand caused by aggressive

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[7] The ratio increased by nearly 10 % in the 1930s. But this period should be seen as unusual because the US was in the aftermath of Black Thursday and Japan enjoyed a short-lived economic boom brought on by the military expansion in the Chinese Continent.

[8] It should be noted that physical capital-labor ratio is a stock term while per-capita GDP is a flow term. Physical capital investments (flow data) surged almost simultaneously as per-capita GDP did.

physical capital formation created rapid GDP growth, and this rapid GDP growth stimulated further investments in physical capital. This virtuous cycle is known by the famous key phrase of 'an investment produces another investment.'

Japan's educational catching-up sped down in the postwar period. This slow down is not surprising because the Japan/US ratio had already reached nearly 70 % at the beginning of the postwar period. Around 1990, Japan almost caught up with the US both in education and in economy.

Figure 5 also describes Japan's economic doldrums in the 1990s. In this period, while Japan increased its physical capital-labor ratio faster than the US, Japan's income gap against the US widened. Japan seems to have been chasing the dream of the high economic growth era even in the 1990s when the virtuous cycle of 'an investment raises another investment' no longer functioned[9].

Many researchers attribute East Asian Miracle for the rich endowment of education stock[10]. The postwar part of Figure 5 supports this popular view. As human and physical capitals are complementary, Japan's high education level in the early postwar period guaranteed high return to physical capital investments. This high return triggered the virtuous cycle of 'an investment raises another investment.'

However, the prewar part of Figure 5 raises a tough question: why did Japan not achieve economic catching-up in the prewar period? A nearly-60-year-long time-lag exists between the starting point of educational catching-up and that of economic catching-up. How to understand this time-lag is an immense question for researchers.

One possible answer can be found in the threshold hypothesis presented by Lau, Jamison, Liu and Rivikin (1993). They argue that education will be full-fledged only after education stock in the nation surpasses a certain critical level.

If the threshold hypothesis is the case, why does such a threshold exist? In order to investigate this issue further, this paper proposes a new idea of 'military-style heavy industrialization.' This word refers to the situation in which a mass of homogeneous laborers with a so-so level of education work together methodically at factories (instead of military camps). The scale economy functions in the heavy industry. In addition, developing countries do not need to invent new production

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[9] It is also interesting the all three indicators in Figure 5 took almost the same level (around 85 %) as of 1990. Japan may have finished the phase of catching-up around 1990. However, Japan seems to have failed to find a new system which is suitable for the post catching-up period. This may be a major reason for the long economic slump since 1990.

[10] For example, see World Bank (1993), Asian Development Bank (2001), and Hayami and Godo (2005).

technologies by themselves because the advanced technologies already exist in developed countries. Thus, 'military-style' should be regarded as a quick way for a developing country to implant the heavy industry by borrowing technology from the advanced nations. In the case of 'military-style heavy industrialization,' it is obvious that the economic catching-up does not start unless a homogeneous education extends to a certain majority of population. This paper considers that the East Asian Economic Miracle was 'military-style heavy industrialization.'

The Japan/US gap by levels of education in Figure 6 displays interesting features about Japan's educational catching-up. The catching-up of primary education comes first. The second is secondary education, and tertiary education is the last. This sequence looks natural. However, the movement of the Japan/US ratio in tertiary education is remarkable. This ratio increased sharply from the mid-1920s to the early 1940s. This is triggered by the University Order of 1915 whereby the government allowed establishment of private universities (before that, nine of the Imperial Universities were the only universities the government authorized). The surge of university graduates coincides with the period of Japan's heavy industrialization and military expansion to Manchuria. In these years, demands for technocrats and bureaucrats (for managing the colonial regimes) expanded. Thus, the hike in Japan/US ratio in tertiary education matched these surging demands.

An even more impressive feature is that the Japan /US ratio in tertiary education remained constant from the 1950s to the 1980s. It means that the catching-up in tertiary education stagnated as long as 40 years. This contradicts with the common view such as that of Kohama and Watanabe (1996) that the expansion of tertiary education promoted postwar Japan's economic miracle. This common view should be re-examined carefully in two senses. First, simple comparison of the number of annual graduates from university in the prewar period with that in the postwar period may not be informative because almost all the nations on the globe (including even the countries that showed poor economic performance in the postwar period) increased their graduates after the Second World War. Thus, it is overly simplistic to attribute postwar Japan's economic success to the increase in the number of university graduates. Second, researchers should pay more attention to the fact that advanced countries, in particular the US, have heavily invested in tertiary education since the 1940s. The US government provided scholarships to ex-servicemen and sponsored science research (partly with the intension of military use) in universities. The civil right movements in the early postwar period also opened up more opportunity of tertiary education for girls and African Americans.

In fact, Japanese business leaders in the early postwar period often opposed to expansion of the tertiary education[11]. Japan, a late-comer to industrialization, had been the labor-abundant society till around 1960. The business leaders wanted low-wage blue-collar workers rather than high-wage highly educated workers. In addition, the secondary education received priority in the government's educational expenditures because the enrollment in lower secondary schools surged ahead. This surge came from the extension of the compulsory education from 6 to 9 years in 1947 and the baby-boom in the early 1950s.

Even after the 1960s, the government continued its restrictive policy on expansion of tertiary education till around 1990. This is mainly because the government feared that expansion of tertiary education would result in the deterioration of quality of tertiary education (although many researchers are skeptical about whether this restrictive policy was effective in maintaining the quality of education)[12].

Japan's tertiary education policy changed around 1990 from suppression to expansion. The government allowed more flexibility for universities in setting enrollment quota and curricula. As a result, as Figure 6 shows, Japan's catching-up in tertiary education restarted around 1990.

The author's dataset (2005) gives comprehensive information on Japan's vocational education, too. The definition of vocational education differs according to researchers. This paper defines vocational education as 'post-compulsory education at the schools (or courses) that provide mainly vocational training.' The post-secondary education is not included in vocational education in this paper[13]. Figure 7 shows the historical change in enrollment of vocational education (flow data). The government employed Vocational Education Order in 1897, and various types of vocational schools have been established since then. One of the most popular vocational schools in the prewar period was Vocational Supplementary School (VSS). Accepting graduates from elementary school, VSS provided reviews of elementary education and practical knowledge for farming, manufacturing and merchandising. While most of VSS started

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[11] See Kaneko and Kobayashi (1996: pp141-145).

[12] Many Japanese universities were established in the large cities which had suffered from overpopulation during the high growth era. Thus, alleviation of congestion in the large cities was another reason for the suppression of tertiary education.

[13] This paper's definition of vocational education is same as Godo and Hayami (1999). Godo and Hayami (1999) provide the concrete list of vocational education.

on local people's initiative, the government gradually increased its commitments to VSS. According to the regime shift towards wartime, the government reformed VSS to Adult School. Adult School provided a mixture of military and vocational training for youngsters who were not promoted middle school after graduation from elementary school. The expansion of Adult School resulted in the sharp increase in vocational school enrollment in the 1920s and 30s in Figure 7.

In 1947, the Japanese education system was reformed. The new system employed the so-called '6-3-3' system. Three years at junior high schools were added to the six years of education at elementary schools to form the new compulsory education system. The upper secondary education was unified into 3-year-long senior high schools. There are two types of senior high school. One is vocational high school and the other is general high school. Most of prewar Japan's vocational schools, including Adult School, were abolished in 1947. Vocational high education has been provided mostly in vocational high school in the postwar period[14]. Gender discrimination in schooling opportunities was also eliminated. This system has remained essentially unchanged until today.

Because of the abolishment of Adult School in 1947, the enrollment of vocational education dropped sharply from 1945 to 50. According to the increase in vocational high schools, the enrollment of vocational education increased from 1950 to 1968. After that, the enrollment gradually decreased throughout the 1970s. Interestingly, the enrollment was kept almost constant in the 1980s, and went on a downward trend again in the 1990s.

The stock data of vocational education provides insightful features on the postwar Japan's miraculous economic growth (Figure 8). *Average schooling* of vocational education for the entire working-age population had been at a plateau during the high growth era (from the early postwar period to around 1970). This implies that vocational education stock had a significant contribution on postwar Japan's miraculous economic growth. Education researchers often criticize prewar Japan's military training in Adult School. It must be true that military training is far from the ideal of education. This paper neither rationalizes nor advocates for military training. Instead, this paper wants to state an objective view that who had received military and vocational education in Adult School in the prewar period bore the destiny of the

[14] Technical College, another type of vocational school, was established in 1962. For the postwar period, only vocational high school and technical college are counted as vocational education in this paper.

Japanese economy in the high growth era.

Figure 8 also provides *average schooling* of vocational education for younger workers (aged 15-39) and elder workers (aged 40-64) separately. As can be seen, vocational education stock in younger generation exceeds that in elder generation till 1960, and the pattern changed inverse since then. 1960 coincides the year where Japanese economy turned from labor abundant economy to labor shortage economy[15]. Thus, Figure 7 tells a plausible story: The labor-intensive industries led Japanese economy based on young workers who had received rich vocational training till around 1960. After that, with the leadership of veteran workers and middle- and top-managers who had vocational knowledge and experience, Japanese manufacturers remodeled themselves to produce higher value added products[16].

5. Korea's catching-up with the US

As is the case of Japan, this paper takes the Korea/US ratios for economic and economic indicators in Figures 9 and 10. These figures exhibit interesting similarities between Japan and Korea. First, educational catching-up precedes economic catching up. Second, the order of educational catching-up by level is also same as Japan's case: primary level is the first, the secondary level is the second, and the tertiary level is the third. Third, catching-up in tertiary education stagnated in the 1970s, when Korea sped up its heavy industrialization. In fact, the regime of President Pak Chong-hui (1961-79) severely controlled the number of enrollment in universities[17]. Instead, the regime was devoted in expansion of primary and secondary education under the slogan of 'eradication of the illiterate.' As is the case of Japan's early prewar period, President Pak Chong-hui considered that low-wage blue-collar workers were more useful for Korea's industrialization than high-wage high-educated workers.

In spite of these similarities between the two countries, Korea achieved the educational catching-up in a shorter period than Japan had done. In Japan, the economic catching-up started in the middle of the 1950s. Thus, it was nearly 60 years after Japan had started educational catching-up in the late 19th century. The Japan/US ratios in *average schooling*, per-capita GDP and physical capital-labor ratio in the middle of the 1950s were 0.7, 0.3 and 0.2 respectively. In Korea, the economic

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[15] Minami (2002).

[16] Panasonic, Sony and Honda are good examples.

[17] See, McGinn, Snodgrass, Kim, Kim and Kim (1980) and Kim (2000).

catching-up started in the middle of the 1960s. It was nearly 30 years (half of Japan's case) after Korea had started its educational catching-up with the US around the 1930s. The Korea/US ratios in *average schooling*, per-capita GDP and physical capital-labor ratio in the middle of 1950 were 0.3, 0.1 and 0.05 respectively, which are much lower than Japan's starting points. Korea's stagnation of catching-up of tertiary education (nearly 10 years) is much shorter than Japan's (nearly 40 years), too.

Thus, it should be legitimate to argue that Korea's catching-up has a shorter "runway" and a higher rate of "climb" than Japan's. Korea's economic development has often been described as "compressed version of Japan's.[18]" This paper's analyses show that Korea's educational development is also described as "compressed version of Japan's."

Why did Korea achieve educational and economic development in a shorter period than Japan? This may be attributable to the "advantage of backwardness" as Gerschenkron (1962) argues. Another possibility is the development of the IT industry in the postwar period. More investigation is obviously necessary, but it is beyond the scope of this paper's analysis

6. Taiwan's catching-up with the US

Figure 11 and 12 show the Taiwan/US ratios in educational and economic indicators. The biggest difference from Japan and Korea is that the Taiwan/US ratio in per-capita GDP exceeded that in *average schooling* in the prewar period (Figure 11). Japan and Korea did not have such a period. This phenomenon should be attributable to the fact that the agricultural industry (in particular sugar production) led the Taiwanese economy in the prewar period. Taiwan's agricultural GDP grew almost parallel to the Taiwan's overall GDP from 1915 to 30 (Mizoguchi and Umemura 1988). This makes a sharp contrast with Korea's and Japan's cases where the share of agriculture in GDP decreased significantly in the same period. Many economists assert that education is less important in agriculture than in modern industries[19]. This may be the reason why prewar Taiwan's per-capita GDP was so high compared with its educational level.

In the postwar period, when the leading industry in Taiwan changed from the

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[18] See Watanabe (1992).

[19] For example, see Lockheed, Jamison and Lau (1980), Yang (1998), Otsuka and Place (2001) and Fafchamps and Quisumbing (1999).

agricultural sector to the manufacturing sector, Taiwan's educational catching-up preceded its economic catching-up just as in the cases of Japan and Korea. Still, the gap between educational catching-up and economic catching-up was smaller in Taiwan compared with Japan and Korea. Namely, Japan and Korea experienced some periods when the Japan/US (or Korea/US) ratio in *average schooling* recorded over 30 percent point higher than that in per-capita GDP (Figures 5 and 9), but Taiwan has never experienced such period (Figure 11).

It should be noted that, compared with Japan and Korea, postwar Taiwan's industrialization did not heavily rely on the process industries (such as shipbuilding and iron and steel refinery that need huge amount of physical capital). Instead, medium- and small-size enterprises led Taiwan's industrialization. Thus, Taiwan's industrialization less relied on physical capital stock than Japan's and Korea's. This results in the fact that the Taiwan/US ratio in per-capita GDP constantly exceeds that in physical capital-labor ratio in Figure 11.

Another of Taiwan's unique points is that secondary education and tertiary education caught up with the US at almost the same speed. There was no stagnation in catching-up in tertiary education. This is a big difference from Japan's and Korea's experiences.

Above observations indicate that Taiwan's experience of catching-up is smoother than Japan's and Korea's in the following three senses: 1), gender gap diminished faster in Taiwan (as was mentioned in Section 2, 2), the gap between educational and economic catching-up was smaller in Taiwan, and 3), Taiwan had no stagnation in catching-up in tertiary education.

While Korea and Taiwan experienced high economic growth in similar periods by borrowing advanced technologies from the US and Japan, why do these two countries differ in the pattern of educational catching-up? This paper's understanding is that this difference in educational catching-up comes from the difference of the type of economic entities which bore the task of technology-borrowing. In Korea, huge conglomerates, called *chaebol,* introduced advanced technologies from the West (including Japan), and in Taiwan, medium- and small-size entrepreneurs did it. Taiwanese entrepreneurs were so light-footed that they started their businesses with technologies within easy reach. So, the technologies of Korean firms had more scale economy than those of Taiwanese firms. Thus, demands of Korean firms for a mass of homogenous, so-so educated workers was much stronger than those of Taiwanese firms. Since Taiwan relied less on the process industries that require heavy manual labor, Taiwan's educational development was less biased in favor of males.

7. Implications of the time-lag between educational and economic catching-up

The analyses in the previous sections find that educational catching-up preceded economic catching-up in the three East Asian countries. This finding implies that it took a seriously long period for a late-comer country to start up industrialization. Even if a country invests in education today, it will take time to increase in educational stock. In addition, there is the time-lag between educational and economic catching-up. Such a long "maternity" period may not be affordable for today's developing countries, which are often exposed to the crises of the regime.

This time-lag raises another question about those three countries' experience: why had Japan, Korea and Taiwan invested heavily in education before their economic catching-up started? One of the reasons should be attributable to the governments' initiative. The political leaders in those three countries emphasized the importance of education from the very early stages of development. In Japan, the government after the Meiji Restoration encouraged and persuaded (even with intimidation by police force) children to attend schools as a measure of reigning over the country. The promotion of Adult School (as was mentioned in Section 3) is another example of the forcible expansion of education for ordinary families. The Government -General of Korea extended schooling as a part of the assimilation policy in the 1930s. President Pak Chong-hui also stated "the annihilation of illiteracy" as the top national target. The National Party in Taiwan also emphasized education in order to assimilate Taiwanese with Chinese.

However, more important is people's spontaneity. Many researchers observe ordinary families' enthusiasm of sending their children to schools even before the beginning of their economic catching-up. In Meiji Japan, as was mentioned in Section 3, VSS developed nationwide spontaneously. Many ordinary families welcomed the government's encouragement for Adult School because it meant more chances of education. Kimura (1988) asserts that postwar Korea's explosive increase in enrollment should be attributable more to the ordinary families' enthusiasm for getting education than to the government's initiative. McGinn, Snodgrass, Kim , Kim, and Kim (1980) also find that Koreans were surprisingly eager for education even in the chaotic 1950s (in the wake of the Pacific War and the Korean War). Abe and Abe (1971) report that demands for education in Taiwan surged rapidly beyond the control and expectation of the Taiwanese government in the early postwar period.

Why were people in those three countries so ardent in education even without

sufficient macroeconomic fruits? This paper's understanding is that the 'screening effect' functioned. The Meiji Restoration shuffled the Japanese society entirely. The Korean and Taiwanese societies experienced the upheaval by Japanese colonialization and the Pacific War, followed by civil wars. Thus, the new elite strata were about to be formed in those countries. All the children in ordinary families had a chance to join new elites if they had a better education career than others. Conversely, people received a big pressure not to fall behind others in school career. Thus, the private return to school was high even before the beginning of economic catching-up. This is exactly the case of the 'screening effect.' Usually, researchers use the term of 'screening effect' as a negative meaning. However, in Japan, Korea and Taiwan, the 'screening effect' helped their societies to endure the heavy burden of the long "maternity" period of educational investments.

8 Conclusion

This paper asserted that the East Asian economic successes can be characterized as 'military-style heavy industrialization.' Roughly speaking, their society was rich in so-so educated, homogeneous laborers during the miraculous economic growth periods. These laborers worked together methodically at factories (instead of military camps).

Japan, Korea and Taiwan succeeded in forming uniform societies, which were suited for 'military-style heavy industrialization,' through long-range educational investments. The screening effect helped those countries to endure the long 'maternity' period between educational and economic catching-up. The well-timed suppression of the opportunities of tertiary education by the Japanese and Korean governments was effective in achieving their rapid heavy industrialization. The heavy investments in vocational education in prewar Japan bore fruit in the postwar high growth era.

In today's developing countries, expansion of secondary and higher education tends to receive higher priority than achievement of universal education[20]. This is different from the pattern of educational development in Japan Korea and Taiwan where catching-up in primary education preceded catching-up in secondary and tertiary education.

All the findings of this paper must be informative for today's developing

[20] For example, see Szirmai (2005: p.238) and Tan (1999: pp.55-60).

countries, which aim to follow the East Asian success stories. However, obviously, the situation of developing countries in the 21st century is different from the East Asian countries in the 20th century. First, in contrast to the single ethnic societies such as Japan, Korea and Taiwan, many of today's developing countries suffer seriously from the multi-ethnicity problems. Since curricula of elementary and secondary education are closely related to lifestyle, simple expansion of education without due consideration of ethnicity may provoke the conflicts between the governments and local citizens. As this paper argued in Section 7, Japan, Korea and Taiwan succeeded in forming a mass of homogeneous laborers that is suitable for heavy industrialization. However, in multi-ethnic countries, such strategy may not work. Second, in the 21st century, heavy industrialization may not be synonymous with economic development as was in the 20th century. Importantly, secondary industry has been reducing its percentage in the World GDP since the middle of 1970s (World Bank, 2005). The non-manufacturing sectors such as the IT industries may lead the economy of developing countries in the 21st centuries. If so, 'military-style heavy industrialization' may not be an appropriate development strategy for today's developing countries.

Still, it should be legitimate to assert that clarifying the characteristics of the 20th century style economic development is important for all the academicians and non-academicians who are concerned with the development policies in today's developing countries. The author's dataset, on which this paper relied, will be published soon from the website of the FASID[21]. Using this dataset as a 'public good,' various empirical analyses should be made in the near future[22].

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[21] The author is constructing long-term educational stock data for Thailand and the Philippines, too. Those will be also published from the website of the FASID.

[22] Yamauchi and Godo (2005) provides an example of econometric analyses based on the author's dataset.

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Table 1 Human capital accumulation through educational investments in USA, Japan, Korea and Taiwan

	Enrollment ratio[a] (%)				*Average schooling*[b] (yrs/psn)			
	USA	Japan	Korea[c]	Taiwan	USA	Japan	Korea[c]	Taiwan
1890	40	26	n.a.	n.a.	6.5	1.3	n.a.	n.a.
1900	40	38	n.a.	4	7.2	2.0	n.a.	0.4
1910	62	43	8[d]	6	7.7	3.3	n.a.	0.5
1920	68	51	11	14	8.3	4.3	0.6	0.6
1930	73	58	16	18	9.1	5.6	0.8	1.0
1940	74	62	38	34	9.8	6.5	1.1	1.6
1950	78	70	n.a.	32	10.5	7.6	n.a.	2.5
1960	85	75	56	57	11.3	8.7	3.3	3.6
1970	87	78	68	65	12.0	9.8	4.8	5.1
1980	85	87	77	73	12.8	10.7	6.9	7.3
1990	87	85	80	81	13.5	11.5	9.0	9.1
2000	89	87	89	86	14.0	12.3	10.5	10.9

a. For persons age 6-20 years.
b. Average number of years of schooling per person in the working-age population (persons age 15-64 years).
c. Korea before 1945 means all the Korean Peninsula. Korea thereafter means the Repiblic of Korea (South Korea).
d. 1912 value.

Source: Godo (2005), Godo and Fukami (2005).

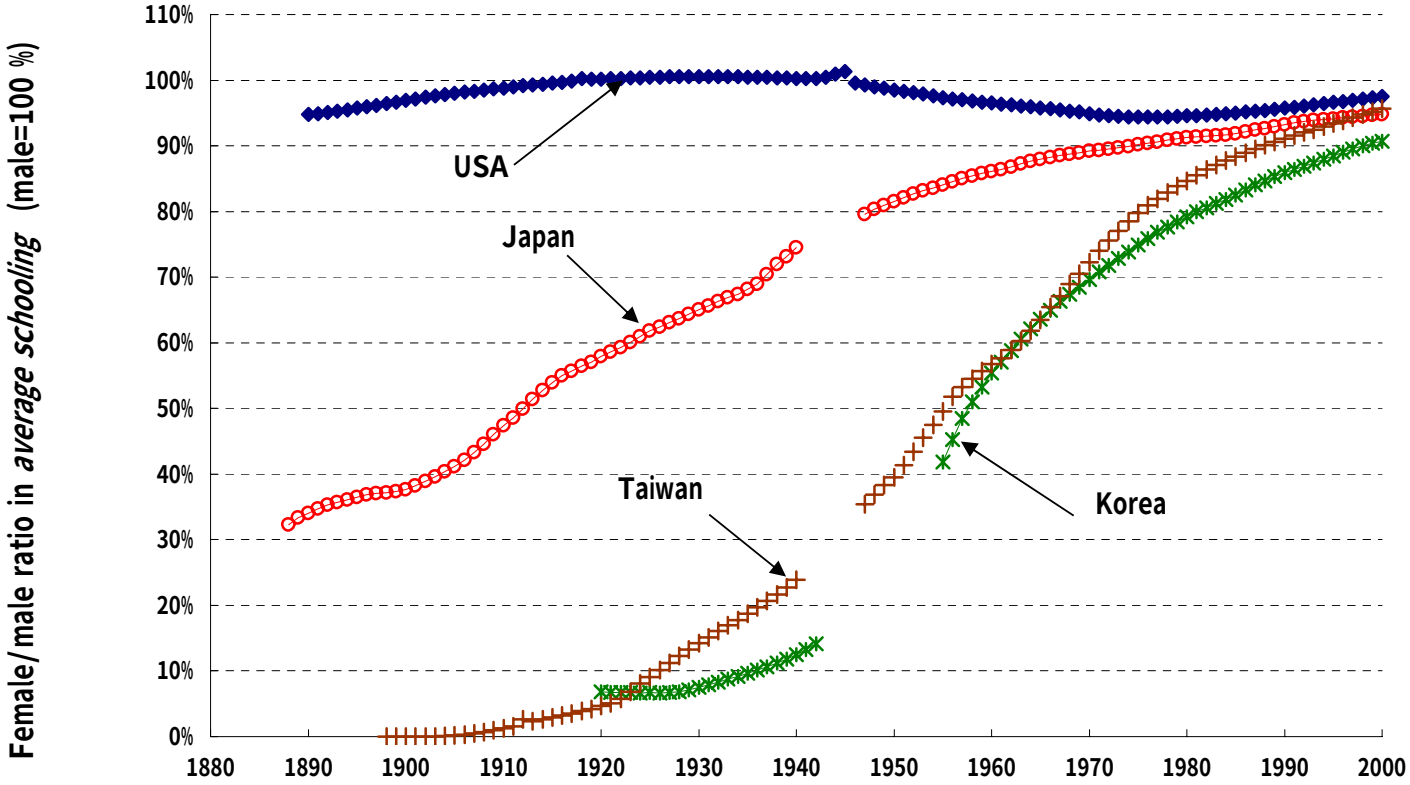
Table 2 The percentage of population aged 15-39 in the total population and the Percentage of manufactring sector in the total laborforce in Japan, Korea and Taiwan

	Percentage of population aged 15-34 in the total population			Percentage of manufacturing sector[a] in the total laborforce		
	Japan	Korea[b]	Taiwan	Japan	Korea[b]	Taiwan
1910	38.1	40.3	43.9	14.0	1.2[c]	7.8[d]
1920	37.5	38.7	39.7	18.3	1.7	8.8
1930	38.3	37.9	39.0	17.1	1.9	9.8
1940	38.1	38.2	37.3	22.5	4.2	10.9
1950	39.3	n.a.	40.7	n.a.	7.0	13.9[e]
1955	40.2	34.0	38.4	20.7	7.6	15.1
1960	42.2	36.7	37.5	25.0	8.2	17.1
1965	44.8	36.9[f]	37.7	27.9	10.4	18.5
1970	43.8	37.7	38.4	29.2	14.3	22.5
1975	40.6	40.9	41.3	28.0	19.1	28.6
1980	38.6	43.1	43.4	26.5	22.5	33.7
1985	37.0	45.3	45.0	26.7	24.4	34.1
1990	35.3	47.4	45.2	25.3	27.6	32.3
1995	34.4	46.4	44.4	22.4	23.6	27.2
2000	33.6	47.2	42.6	20.6	20.2	28.1

a.Includes mining.
b.Korea refers to all the Korean Peninsula until its interdependence from Japan (in 1945) and the Republic of Kora (South Korea) thereafter.
c.1911 value.
d.1908 value.
e.1951 value.
f.1966 value.

Source: For Japan, Godo (2005), Government of Japan (various issues).
For Korea, Godo (2005), Pyo (2001), Bank of Korea (various issues).
For Taiwan, Godo and Fukami (2005), Moon (2002), Director-General of Budget, Accounting and Statistics(various issues).

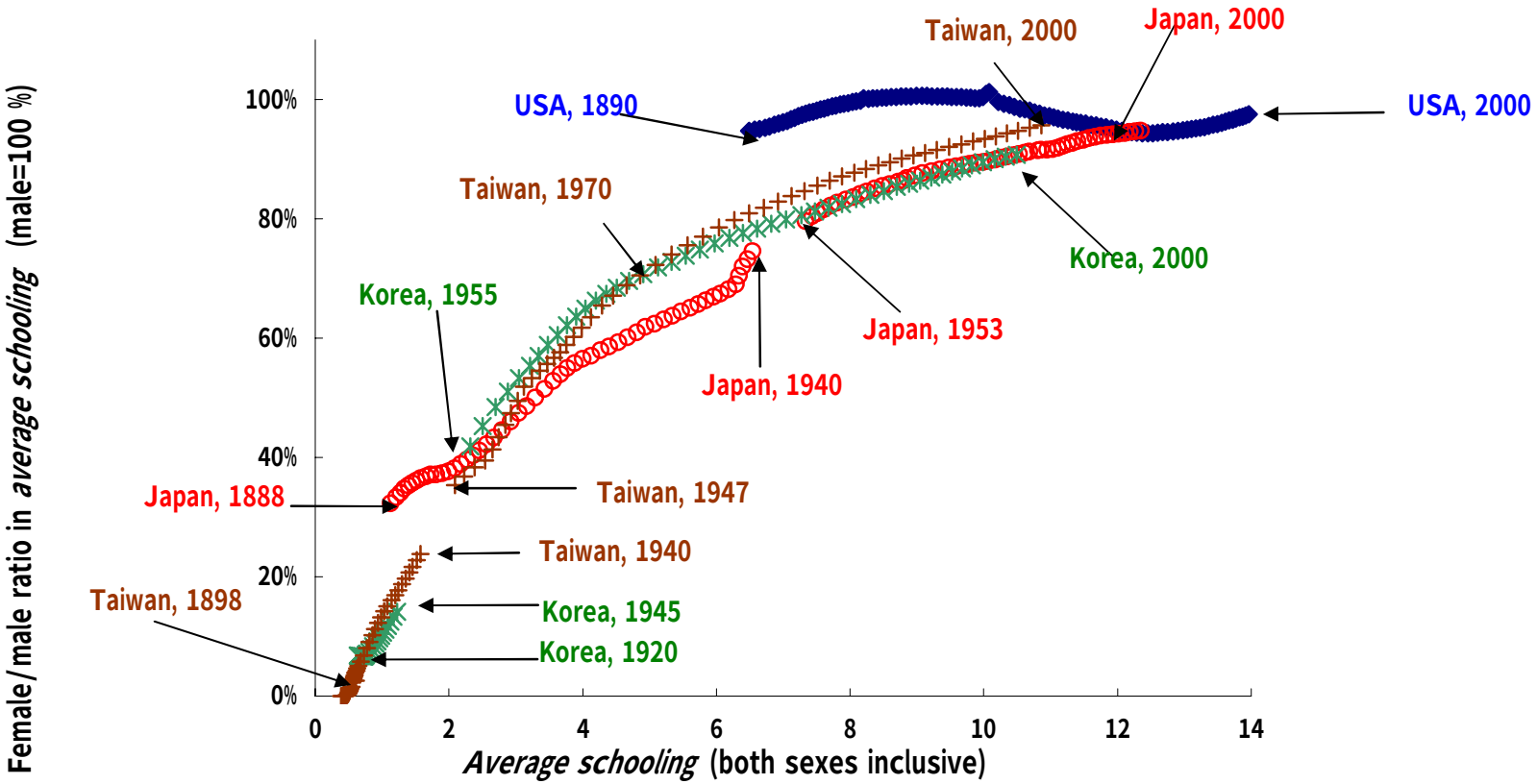
Figure 1 Changes in the female/male ratio in *average schooling*[a], Taiwan (1898-1940, 1947-200), Korea[b] (1920-1945, 1955-2000), Japan (1888-1940, 1953-2000) and the USA (1890-1990)



a. Average number of years of schooling per person in the working-age population (persons age 15-64 years).
b. Korea refers to the whole Korea (all the Korean Peninsula) until its interdependence from Japan (in 1945) and the Republic of Kora (South Korea) thereafter.

Source: Godo (2005), Godo and Fukami (2005)

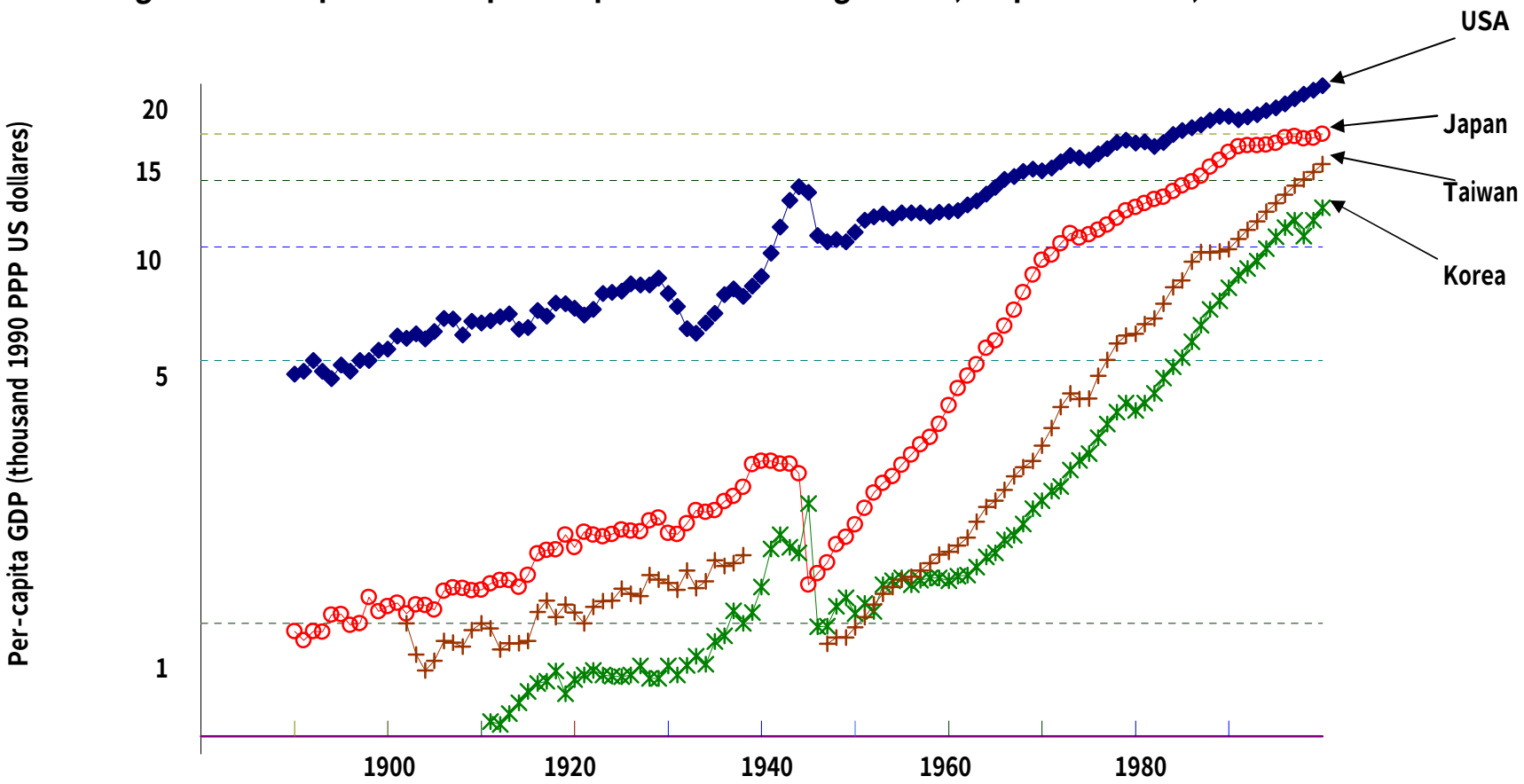
Figure 2 Changes in combination of *average schooling*[a] and the female/male ratio in *average schooling*[a] **Taiwan** (1898-1940, 1947-2000), **Korea**[b] (1920-45, 1955-2000), **Japan** (1888-1940, 1953-2000) and the **USA** (1890-2000)



a. Average number of years of schooling per person in the working-age population (persons age 15-64 years).
b. Korea refers to the whole Korea (all the Korean Peninsula) until its interdependence from Japan (in 1945) and the Republic of Kora (South Korea) thereafter.

Source: Godo (2005), Godo and Fukami (2005).

Figure 3 Comparison of per-capita GDP among Korea, Japan Taiwan, and USA

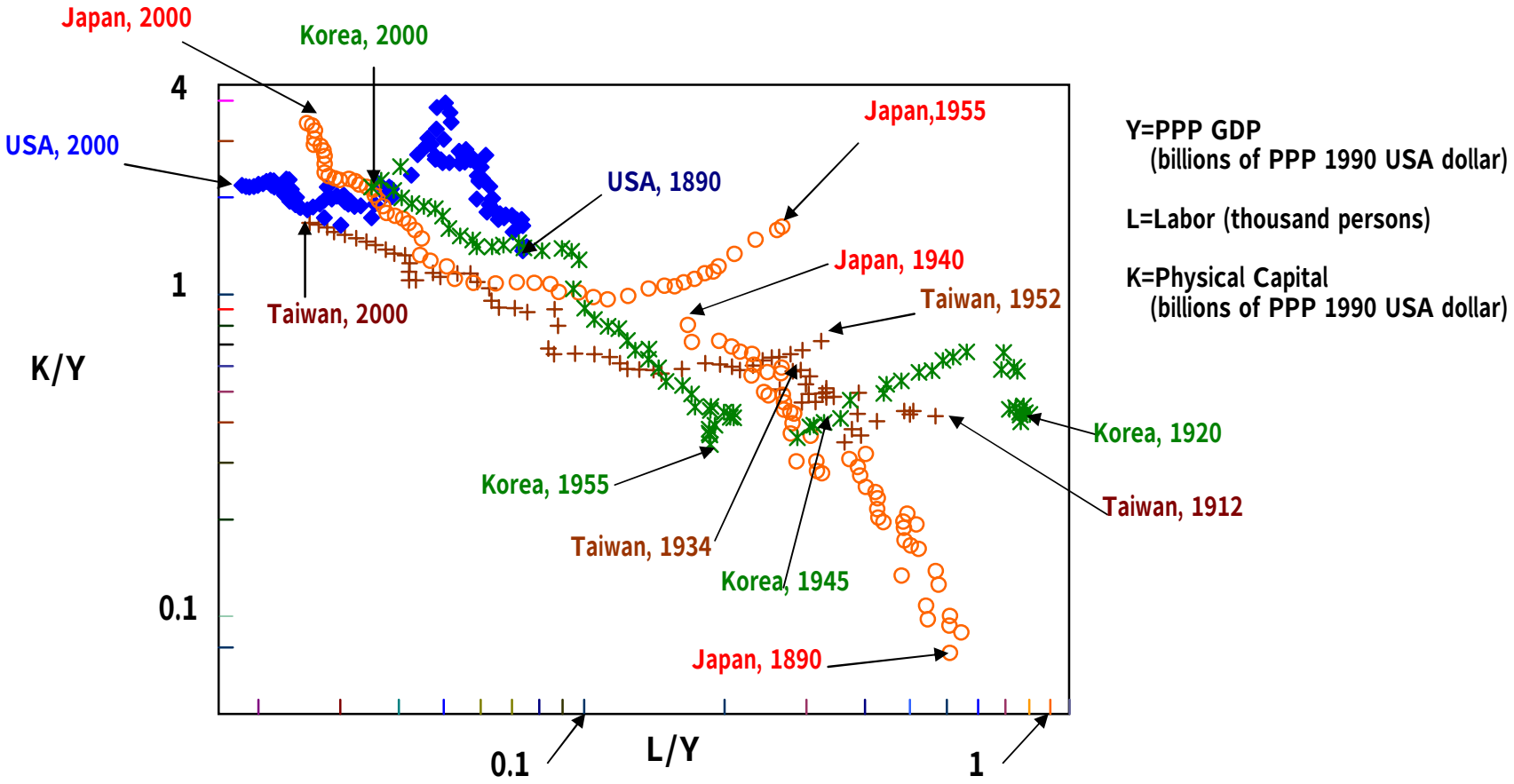


a. Korea refers to the whole Korea (all the Korean Peninsula) until its interdependence from Japan (in 1945) and the Republic of Kora (South Korea) thereafter.

Source: Godo (2005), Godo and Fukami (2005).

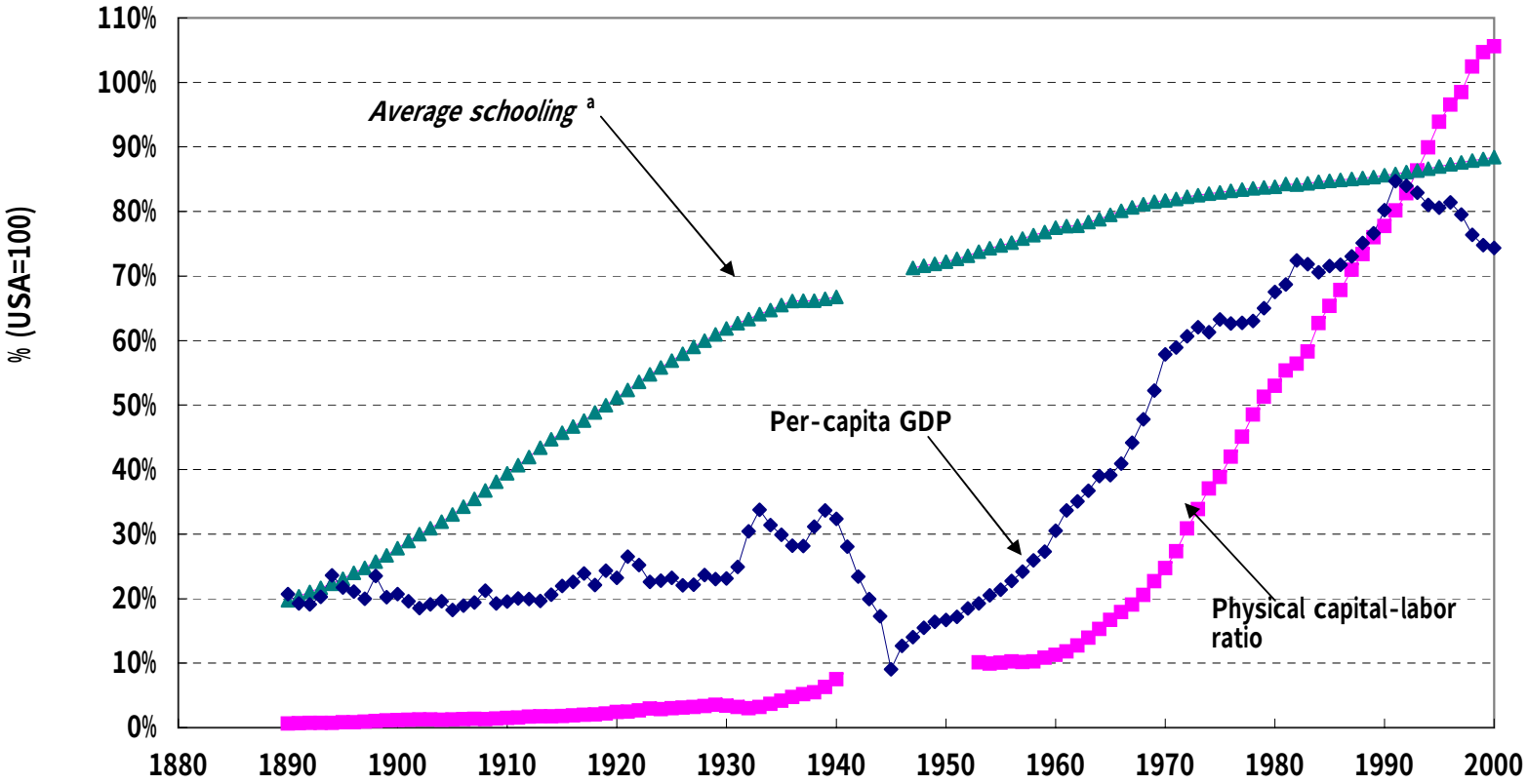
Figure 4 Labor input per GDP versus physical capital per GDP

USA (1890-2000), **Japan** (1890-1940、1948-2000)、**Korea** (1920-45、1955-2000)、**Taiwan** (1912-34, 1952-2000)



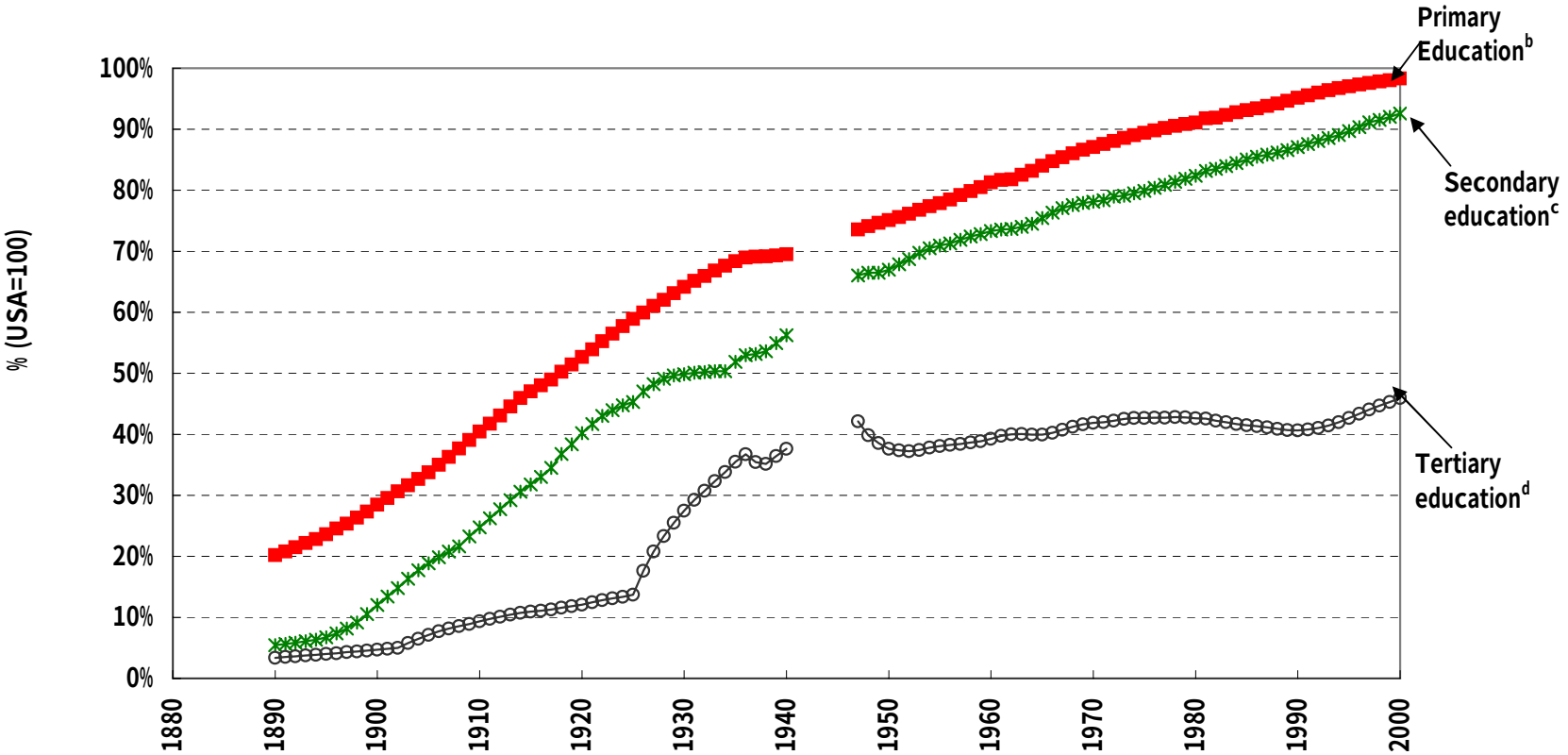
Source: Godo (2005), Godo and Fukami (2005).

Figure 5. The Japan/USA ratios in *average schooling* [a], per-capita GDP and physical capital-labor ratio



a. Average number of years of schooling per person in the total working-age population..
b. Labor is measured by total employment. Physical capital is measured by gross nonresidential non-military physical capital stock at the beginning of year. GDP is measured in PPP 1990 USA dollars.
Source; Godo (2005).

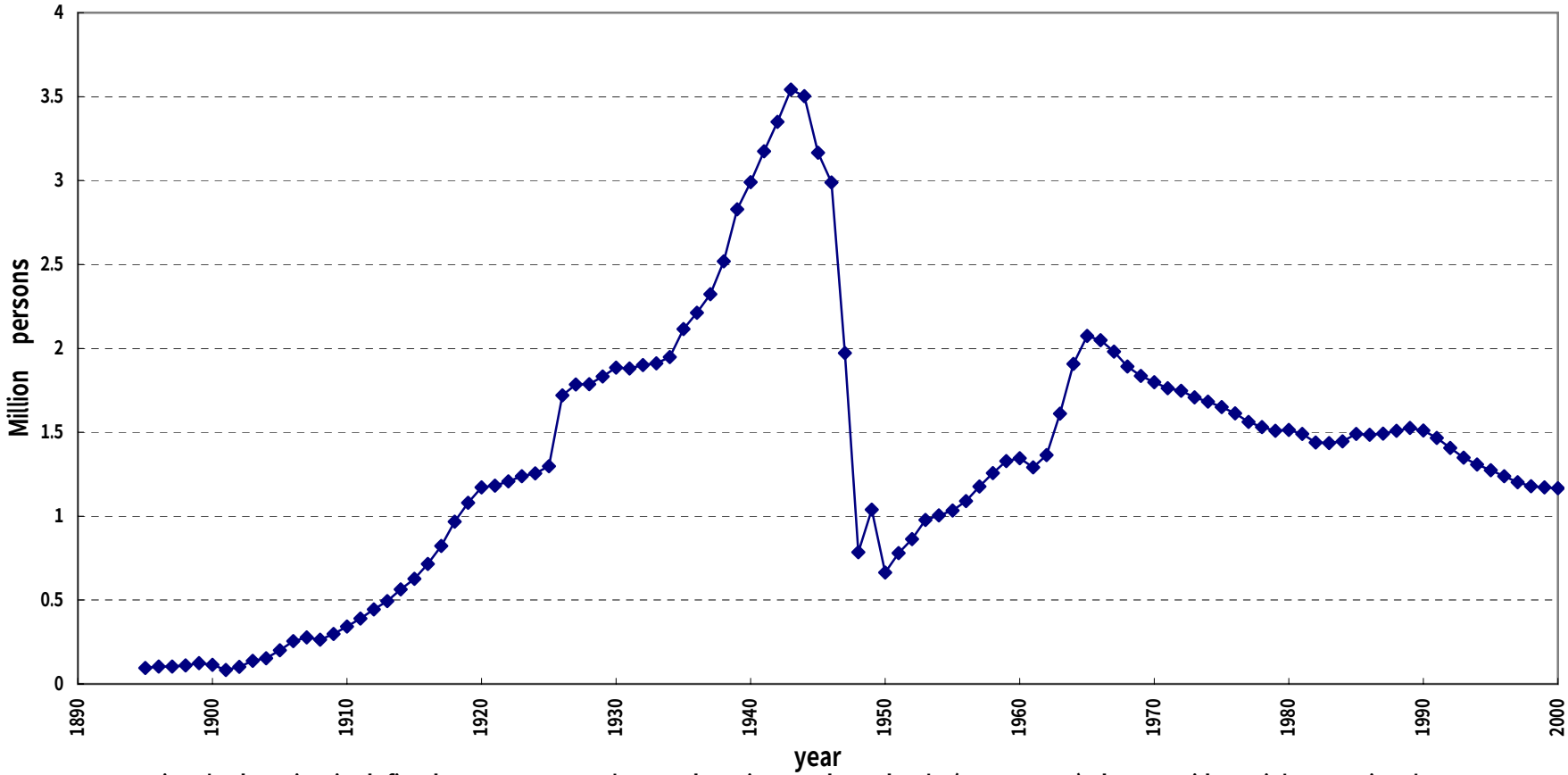
Figure 6 The Japan/USA ratios in *average schooling*[a] by levels of education



a. Average number of years of schooling per person in the working-age population.
b. Schooling of 1st to 8th grades.
c. Schooling of 9th to 12th grades.
d. Schooling of beyond 12th grade.

Source: Godo(2005).

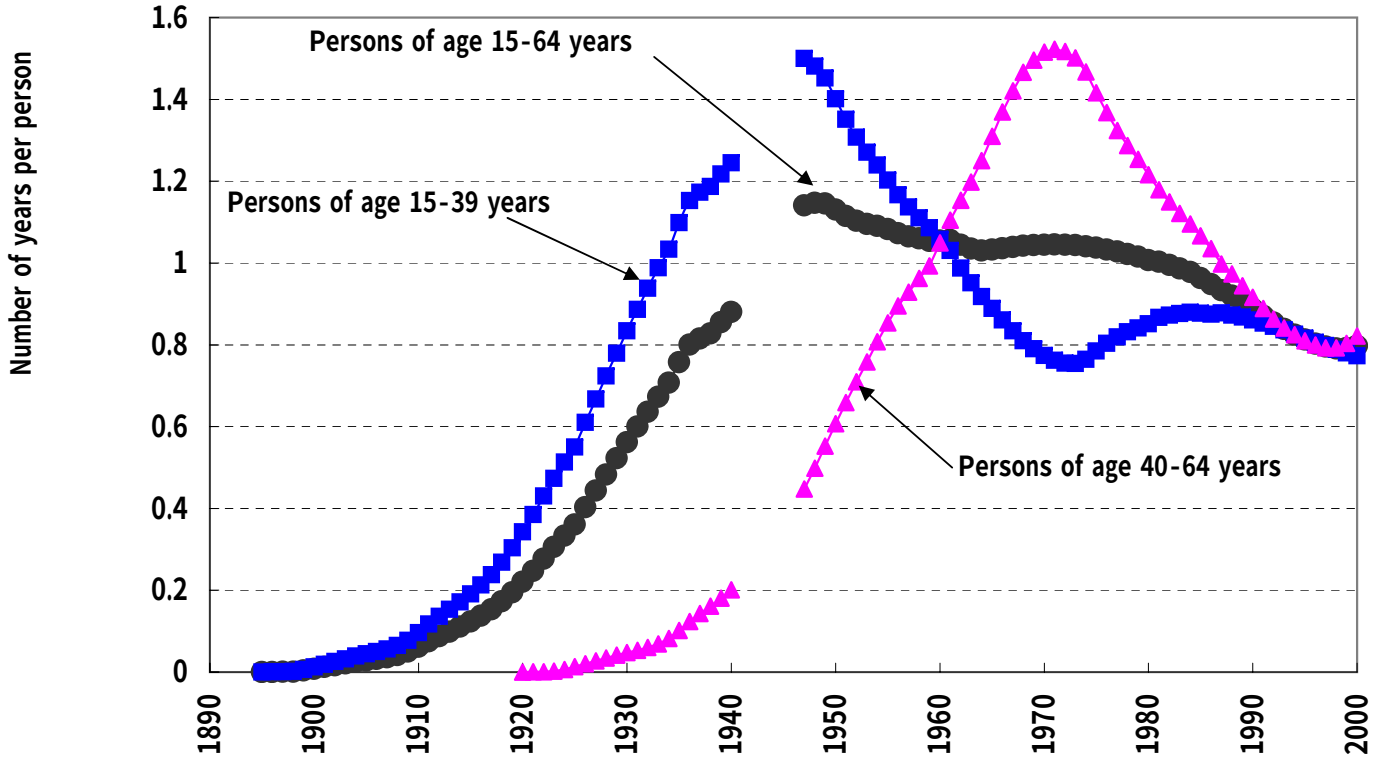
Figure 7 Enrollment of vocational education[a] in Japan



a. Vocational education is defined as post-compulsory education at the schools (or courses) that provide mainly vocational training. Higher education is not included. The concrete list of vocational schools (or courses) is given in Godo and Hayami (1999)

Source: Godo(2005).

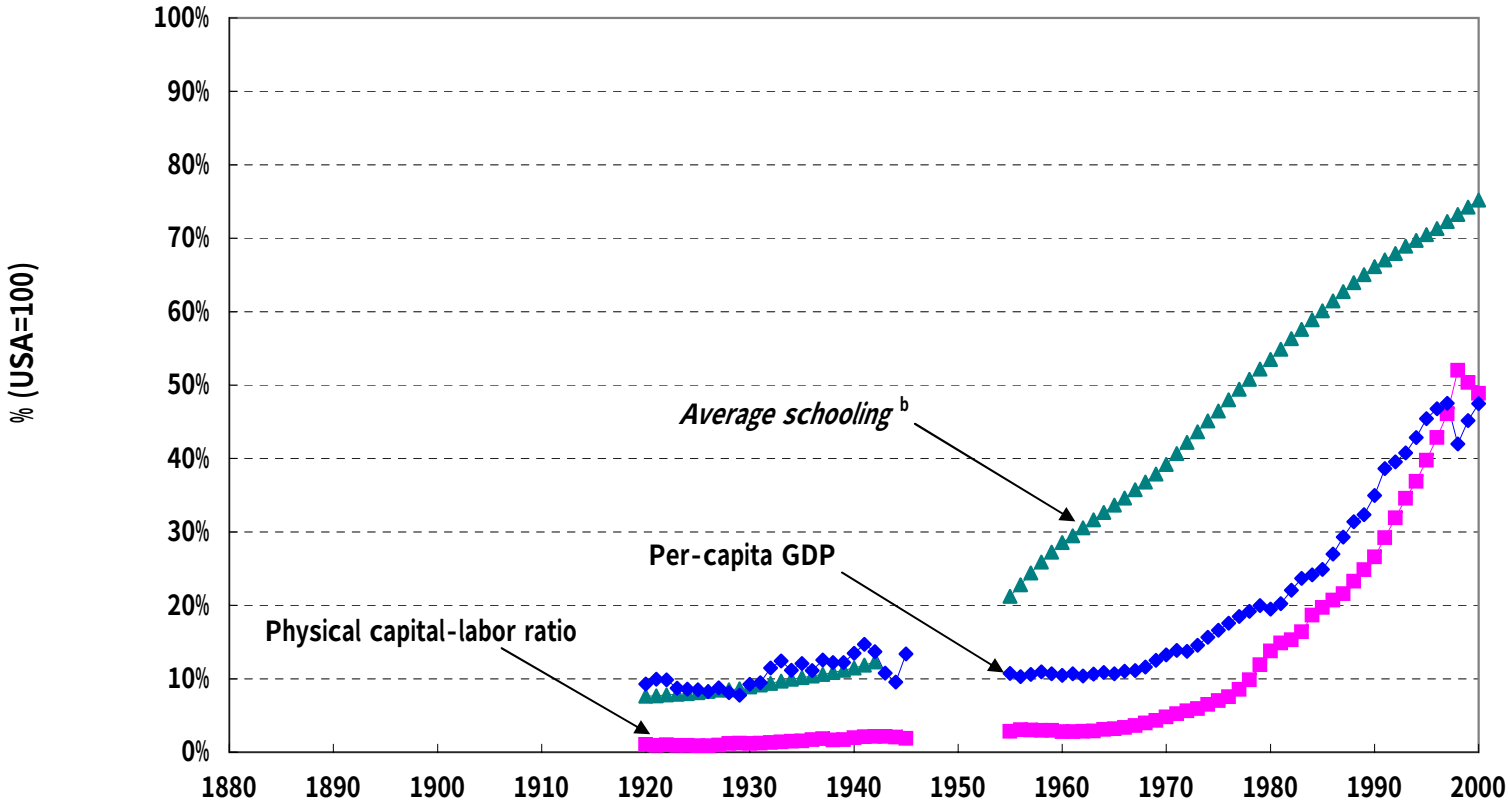
Figure 8 *Average schooling*[a] of vocational education[b] in Japan



a. Average number of years of schooling per person in the working-age population
b.. Vocational education is defined as post-compulsory education at the schools (or courses) that provide mainly vocational training. Higher education is not included. The concrete list of vocational schools (or courses) is given in Godo and Hayami (1999)

Source: Godo(2005)

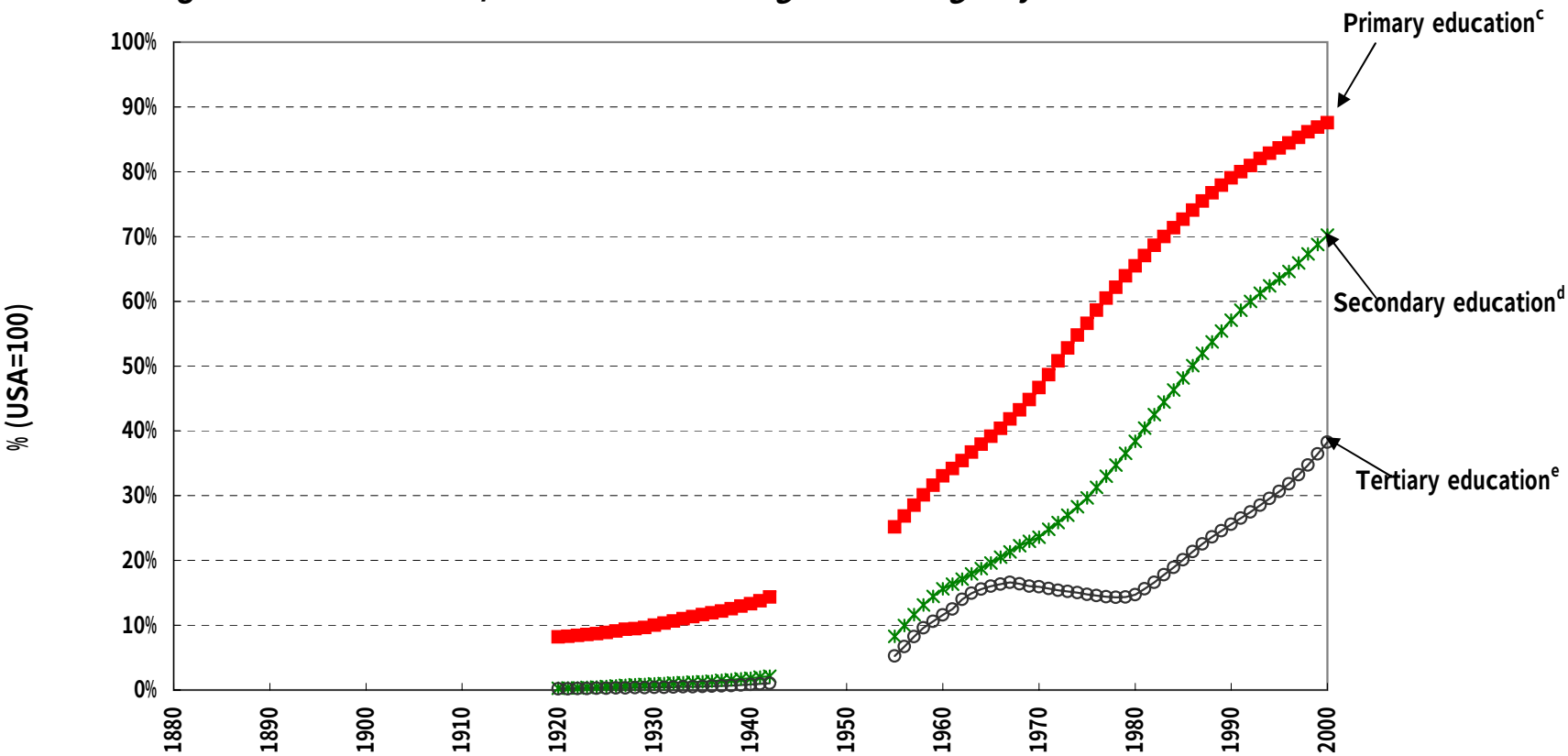
Figure 9 The Kore[a]/USA ratios in *average schooling*[b], per-capita GDP and physical capital-labor ratio



a..Korea in the pre- and post-war periods refers to all the Korean Peninsula and the Republic of Korea respectively.
b. Average number of years of schooling per person in the total working-age population..
c. Labor is measured by total employment. Capital is measured by gross nonresidential non-military physical capital stock at the beginning of year. GDP is measured in PPP 1990 USA dollars.

Source: Godo(2005)

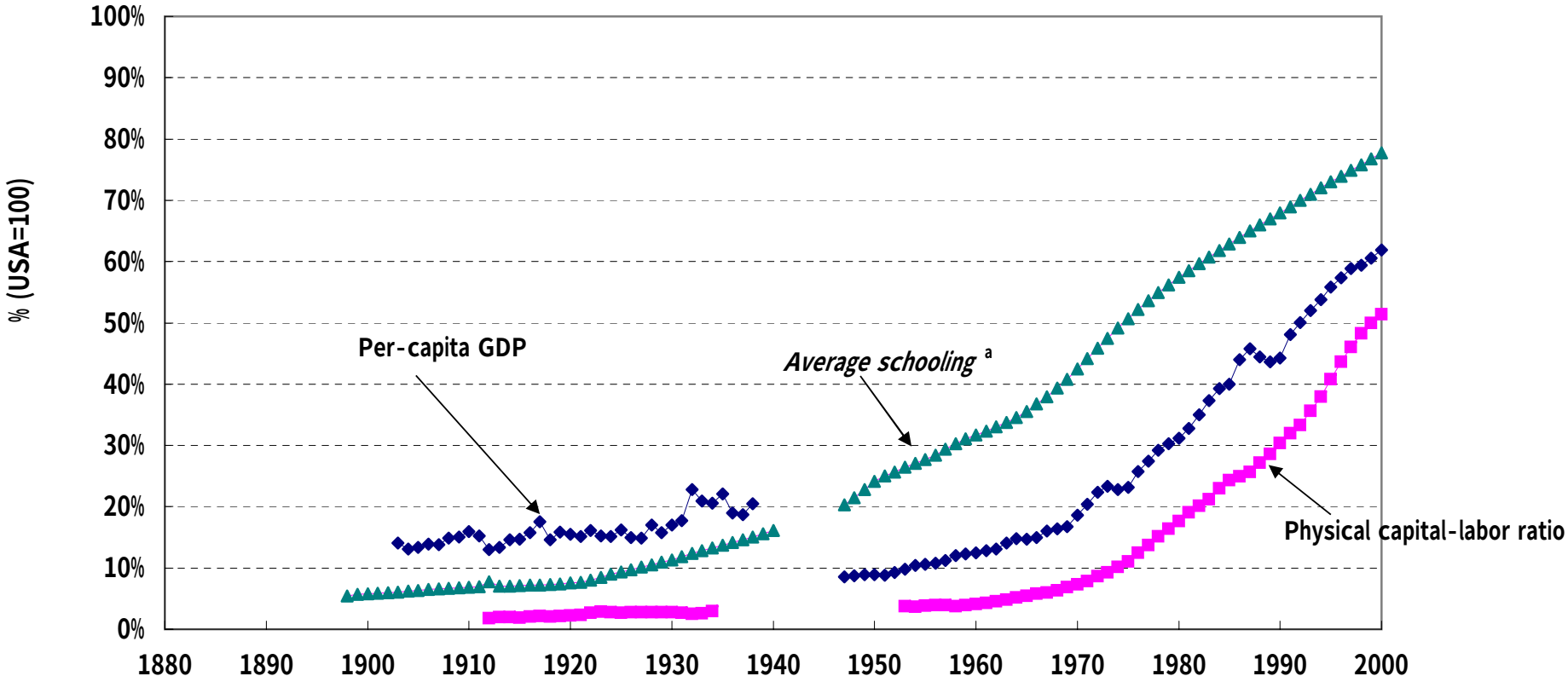
Figure 10 The Korea[a]/US ratios in *average schooling*[b] by levels of education



a. Korea in the pre- and post-war periods refers to all the Korean Peninsula and the Republic of Korea respectively.
b. Average number of years of schooling per person in the working-age population.
c. Schooling of 1st to 8th grades.
d. Schooling of 9th to 12th grades.
e. Schooling of beyond 12th grade.

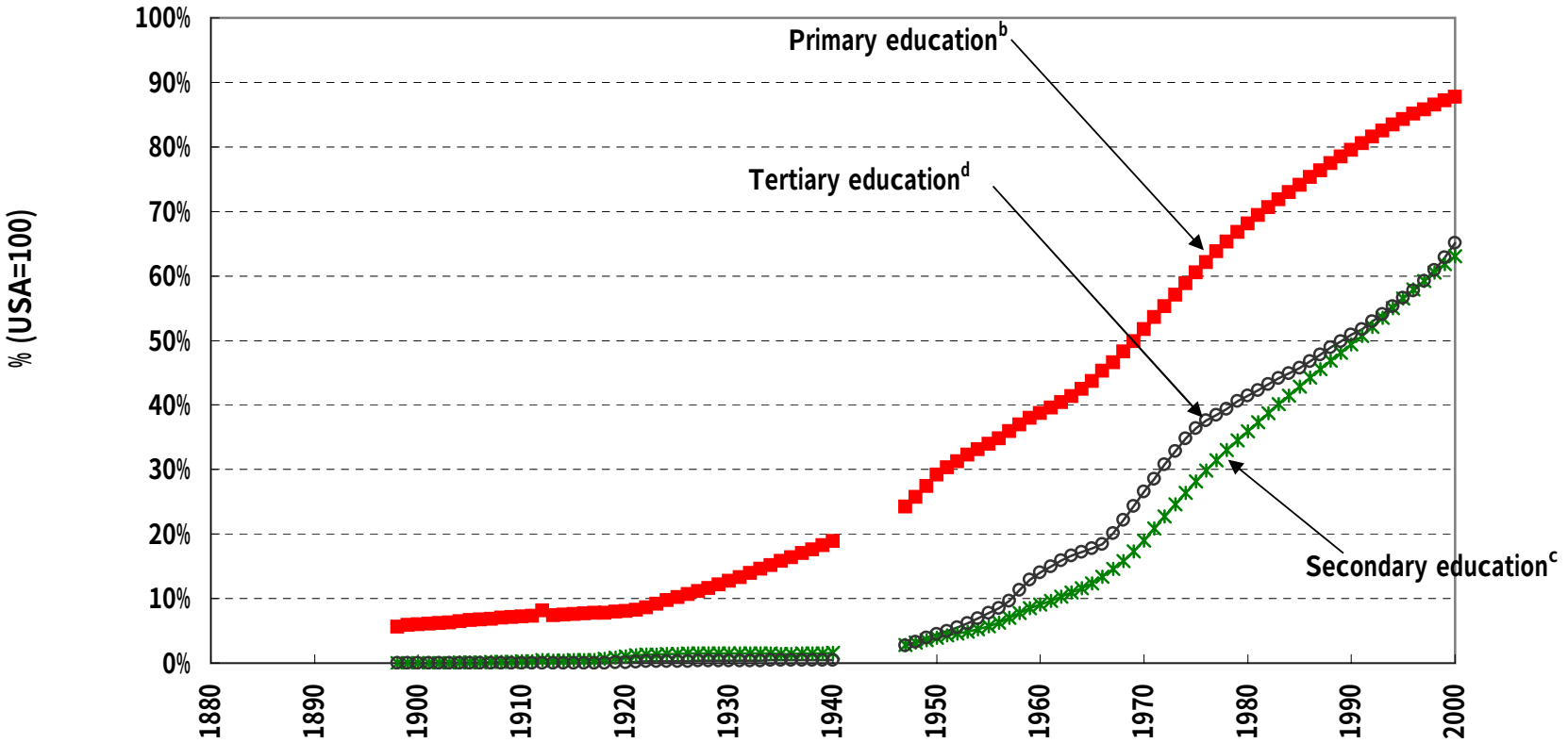
Source: Godo(2005)

Figure 11 The Taiwan/USA ratios in *average schooling* [a], per-capita GDP and physical capital-labor ratio



a. Average number of years of schooling per person in the total working-age population..
b. Labor is measured by total employment. Pysical capital is measured by gross nonresidential non-military physical capital stock at the beginning of year. GDP is measured in PPP 1990 USA dollars.
Source: Godo and Fukami (2005)..

Figure 12 The Taiwan/USA ratios in *average schooling*[a] by levels of education



a. Average number of years of schooling per person in the working-age population.
b. Schooling of 1st to 8th grades.
c. Schooling of 9th to 12th grades.
d. Schooling of beyond 12th grade.

Source: Godo and Fukami (2005).