School education in the catch-up of developing economies with advanced economies: A perspective from East Asia[1]

Yujiro Hayami
Foundation of Advanced Studies in International Development, Tokyo, Japan

Summary.— This paper aims to identify the role of school education as a critically important institution for backward economies to catch up with the advanced economies by creating the social capability of borrowing advanced technologies. This process is examined though the comparisons between educational catching up of Japan and Korea with the United States in terms of average number of years of schooling and economic catching up in terms of real GDP capita. The results show that a long time lag is likely to be involved before investments school education culminate in sufficient social capability for developing economies to achieve catching up with the developed economies, suggesting the need for careful investment planning so as to be consistent with the institutional and technological environments of the economies..

Key words – East Asia, Japan, Korea, school education, social capability, technology borrowing, catch-up growth

[1] This paper draws on Hayami and Godo (2005, pp.176-81) and Godo and Hayami(2003).

1. Introduction

The accumulation of empirical studies on modern economic growth in the histories of advanced countries by Edward Denison among others has shown that investment in human capital toward upgrading of skill and knowledge embodied in humans represented a much more dominant factor in accounting for growth in national product than investment in physical capital such as machines and factories (Denison, 1962; 1967) The critically important institution for the accumulation of intangible capital is the formal schooling system. School education contributes to economic growth through increases in the income-earning capability of people. Equally or even more important may be its contribution to 'advances in knowledge. Creation of new knowledge through research and its dissemination through extension and training activities depends critically on both the quantity and the quality of scientists, engineers and technicians who received high-level school education. It should not be an unreasonable inference from Denison's results that one third to two thirds of national income growth in advanced economies was ultimately accounted for by the growth of school education (Hayami and Godo 2005, pp.173-6).

At the same time, there are many micro studies to show the high rates of return to school education (Psacharopoulos, 1994). Typically, in these studies only private returns to schooling in the form of income-earning capacity of those who attended schools are counted as the benefit of education. However, much of 'knowledge' advanced by human capital accumulated through school education should be externalized because of the public-good attribute of knowledge and information. If such external benefits could be added to private benefits, the rate of return to education would likely turn out to be extremely large, as argued strongly by Paul Romer(1986)'.

In terms of both the large magnitude of formal education's contribution to economic growth and the high rate of return to society, concentration of public resources to strengthening of school education systems appears to be the most effective way for developing economies to catch up with developed economies. The problem, however, is the time lag between investment in formal education and realization of its outcomes. It usually takes a long time before knowledge learned at schools is translated into useful skill in production and management. Even a longer time would likely be required before a student studying at an advanced educational institution begins to produce useful knowledge and, also, before his invention or scientific discovery is disseminated for wide application to actual production process.

If returns to investment in education are low in the short run, it may not be appropriate to allocate a large share of affordable investment to education, especially to advanced education, even if the rate of return to education is very high in the long run. Thus, the effectiveness of education as a means to promote economic development depends, to a large extent, on the structure of time lag in growth between education and economy.

This paper aims to identify this structure in terms of the economic growth experiences of Japan and Korea for the sake of identifying the problems associated with using investment in school education as a major means for backward economies to acquire the capability of catching up with advanced economies. .

2. The Role of School Education in Technology Borrowing

First, we attempt to identify the vital role of formal school education in increasing the capability of developing countries to borrow advanced technology from developed countries.

Since Alexander Gerchenkron advanced his thesis on the advantage of backward economies (followers) in achieving rapid productivity growth by means of borrowing technologies from advanced economies (leaders), economic historians have long emphasized that for this advantage to be realized, the followers must be equipped with the capability of absorbing the foreign advanced technologies (Ohkawa and Rosovsky 1973; Easterlin 1981; Abramovitz 1986).

Then, how would school education contribute to the creation of an economy's capability to absorb foreign technologies? It is conventional among economists to consider this capability consisting of "the skills of domestic workers and managers to implement technologies invented abroad" (Keller 1996, p.200). In contrast, economic historians tend to define it in a broader social context. Kazushi Ohkawa who was the first to emphasize the importance of the absorptive capacity with reference to Japan's industrialization, proposed the term "social capability" including not only the technical competence of workers but also commercial, industrial and financial institutions, such as long –term employment contracts in large-scale firms for the sake of increasing incentives for workers to acquire firm specific skills and subcontracting systems for large-scale principal firms to enable saving of scarce capital (Ohkawa and Rosovsky 1973; Ohkawa and Kohama1989). Of course, the development of financial intermediaries such as banks and stock markets for financing large-scale plants embodying technologies advanced by the leaders is an important component of adoptive capacity for the followers as already pointed out Gerschenkron in his classic treatise, is included in the list. Further, Abramovitz (1986) extended the concept of social capability to include the political structure that prevents vested interests from blocking innovations.

As such, social capability is multifaceted encompassing nearly all aspects of a social system. Yet, in all the aspects, school education plays a dominant role. It should be reasonable to assume that the technical competence of workers to produce goods and services as well as managers' competence to organize labor and capital for production "is roughly proportional to years of school education, at least among modern societies" (Abramovitz 1986, p. 388). Their competence can also be increased by non-school trainings, such as on-the-job-training (OJT), but the effectiveness of OJT as well as other training programs with practical orientation is critically dependent on the level of formal education among the trainees. How efficiently collective actions can be organized for the supply of appropriate institutions and policies depends on the level of intelligence among citizens and the associated advancement of mass media. which should ultimately be dependent on the level of education. Thus, it should be safe to assume that human capital formed from school education is the major determinant of the social capability for followers to borrow advanced technologies from leaders who had achieved the leader status through "modern economic growth" a la Simon Kuznets (1966).

According to Kuznets, the modern economic growth through which today's developed economies rose to the high-income stage, was supported by the 'epochal innovation' in the form of the institutionalization of scientific education and research that made technological progress much faster and steadier than in pre-modern epochs. For a developing economy to introduce science-based technology in the modern economic growth regime, it is indispensable for the country to be equipped with a high caliber of scientists and engineers who can handle new machines and equipment with a good grasp of the underlying scientific principles. Corresponding to this need, countries like Germany and the United States that aimed to catch up with the United Kingdom in industrial strength in the late nineteen century invested heavily in the schools of high-level scientific education, establishing both premier research-oriented universities and those of more practical orientation such as *Technische Hochschulen* (Technical High Schools) in Germany and land-grant colleges in the United States since around the 1870s.

Such experience in catching-up countries contrasted with the delay in the United Kingdom in institutionalizing scientific education. It was in 1883 that the Finsburg Technical College opened as the first advanced engineering school with the support of the City of London (which was incorporated in the University of London as late as 1908). Establishment of new universities such as Birmingham, Liverpool and Manchester with orientation toward applied science and technology was also after 1900. Such a lag in public investment in science and engineering education seems to reflect the fact that the United Kingdom was able to be a front runner of the Industrial Revolution and to maintain the status as the workshop of the world before the late nineteenth century, based on the skill and innovation capability among operators and workers accumulated through on-the-job training over the long period of self-generating industrial development process with no significant competitor in the world market of manufactures. As such, for British entrepreneurs the need of university-trained scientists and engineers would have been smaller than that of German and American entrepreneurs who were geared to catch up with the British through the borrowing of the advanced technology developed in the United Kingdom (Hayami and Godo 2005, ch.6).

Then, it was only natural that Japan followed the German/American model of scientific education system when it began to catch up with the industrial power of Western nations with the so-called "Meiji Restoration" of 1868 that resulted in a shift from the feudal system under the hegemony of the Tokugawa Shogunate to the centralized nation state under the rule of the emperor. As this reform was induced by the threat of colonization by Western powers backed by their supremacy of industrial strength, Meiji leaders considered it a top national priority to promote industrialization. For this end, an engineering college was established in 1886 within the newly-founded Tokyo Imperial University and a network of technical high schools in subsequent decades along the German model. The US land-grant college model was also introduced for the development of Hokkaido which was the last frontier left to Japan.

Those tertiary-level schools were critically important for technology borrowing as they produce the high caliber scientists and engineers who can understand the scientific principles underlying the mechanism of foreign technology and thereby capable to design appropriate production layouts for using the technology in a way consistent with the local conditions of borrowing countries as well as to prepare production manuals for workers on the operation of new production systems. However, such high-level human resources are not sufficient for backward agrarian economies to establish modern industrial systems. For a developing economy traditionally dependent on agriculture and small-scale cottage industries, the borrowing of modern industrial technologies usually involves the importation of the factory system that had already been established in the western world since the time of the Industrial Revolution. The factory system can be characterized by a system of division of labor, whereby a large number of workers are assembled in one workshop to work in cooperation, while each worker takes responsibility to perform one of tasks along a production line usually designed for the effective operation of a large machinery according to a predetermined work schedule under the command of a centralized management hierarchy. The high efficiency of this system for the mass production of standardized industrial commodities has been well-known since the famous example of a pin factory illustrated by Adam Smith (1776).

For the effective operation of the factory system, the supply of high caliber scientists and engineers is not sufficient. In addition, a large number of laborers who have aptitude to collaborative work according to a set schedule while faithfully following the instructions of foremen and supervisors who convey instructions from the top management to floor workers in the workshop. Such a discipline as to work in close coordination with many fellow workers in a way consistent with the rhythm of machine operation dictated by the inorganic time of clock under the command of supervisors is not easy to acquire for a worker who is used to farming on his own land, according to the rhythm of the nature with implicit agreements on collaboration with his family members and close neighbors (Thompson 1967). For the laborers who used to work according to “peasant time” (Thomas Smith 1988), the development of their aptitude to work in the factory system involves a change in the value system or a change in culture broadly defined. If workers who cannot change their culture in this regard, namely who continued to stick to the peasant time are employed in a factory, their frequent absenteeism would damage the working of the factory system with the result of serious loss in production efficiency.

School education at the primary and secondary levels represents a highly effective apparatus for embedding such an aptitude for the factory system among the youth in traditional agrarian societies. Being forced to come to school at a prescribed time and study for the duration of class hours together with classmates under the instruction of teachers, children are regimented to follow the disciplines of collective actions. Such school-wide activities as morning assemblies, entrance and graduation ceremonies, and sports days, provide opportunities for them to get accustomed to larger collective actions under hierarchical commands. Needless to say, basic literacy and arithmetic as well as the elementary knowledge of sciences acquired by students at primary and secondary level schools add much to the efficiency of their labor through the better understanding of production manuals and instructions given to them when they are employed to work at factories.

The demand for schools that can mass-produce such laborers having the aptitude for the factory system should have been especially large in the economies that have newly introduced the factory system as an inseparable process of technology borrowing, as evident from the faster and more complete diffusion of elementary education systems in late industrializing countries such as Germany and the United States than in the United Kingdom. Likewise, the government of Meiji Japan launched an ambitious project of propagating the compulsory elementary education system over the entire nation by the School System Rule (*Gakusei*) of 1872, only 4 years after the Meiji Restoration, with its famous preface announcing its goal as “there shall not be a single household in any village, which does not let children study in school”. This target was virtually achieved in the following four decades with the school enrollment ratios of children at elementary school ages rising from 28 percent in 1873 to 81 percent in 1900 and further up to 98 percent in 1910 (Japan Ministry of Education, p.132).

Thus, it is important to recognize that the school education system represents a critically important institution for backward economies to catch up with the advanced through the supply of the two kinds of human capital needed to achieve effective borrowing of advanced industrial technologies: (1) the capability of high-level scientists and engineers who can decode the scientific principles underlying the machines and equipments embodying advanced technology, so that they can design appropriate layouts and manuals for the use of foreign technologies in local conditions – this is the kind of human capital that the tertiary-level school education is mainly expected to produce, and (2) the aptitude of laborers to work under the factory system, with respect to their conformity with the disciplines of collective work in the factory as well as their compliance with the instructions from employers conveyed through a hierarchy of management – this is the kind of human capital that the schools at the primary and secondary levels are mainly expected to produce.

Which type of human capital is more instumental to foreign technology borrowing depends on what kinds of technologies to be imported. Here, it is important to recognize that technology borrowing by followers needs not to begin with the importation of frontier technologies being used by leaders. In fact, it is common for any advanced economy to be using the technologies with different degrees of sophistication using the capital goods of different vintages. For backward economies often find it advantageous to borrow the technologies of older vintages because of greater congruence with their economic environments. A typical example is Meiji Japan's importation of the narrow-gauged railway system through the purchase of second-hand equipment from British colonies. The importation of second-hand machineries together with the efforts to further modify them towards a more capital-saving direction characterized the development of light industries in Japan in the 19th to the early 20th century, such as the replacement of iron frame by wooden frame in imported looms and the change of steam-powered silk reelers to foot-pedaled ones (Minami 1984; Makino 1996). To the extent that the technologies of older vintages are less sophisticated, their translation for domestic use by followers would not have entailed so much of high-level human capital created from advanced school education, while workers trained in elementary and secondary schools could easily acquire skills to implement them through OJT. Therefore, where the technological gap between leaders and followers are so wide that old-vintage technologies are better options than frontier technologies for the followers to borrow, elementary and secondary education could be more instrumental to the catch-up growth of the followers than tertiary education. However, as they finish borrowing old-vintage technologies, they have to move to the borrowing of newer more sophisticated technologies for sustaining their catch-up growth... Correspondingly, the relative importance of high-level human capital created from tertiary education will rise.

3. The Experiences of Japan and Korea

In this section we attempt to provide a quantitative overview on the process of economic catching-up by Japan and Korea with the United States in terms of real GDP per capita over one hundred years since the late 19th century in comparison with its educational catching-up in terms of average schooling. Here it is assumed that the United States represents the frontier of the word economy with which Japan and Korea aimed to catch up during the period of analysis.

In Figure 1, the growth of school education is measured by increases in the average number of years of schooling per person in working-age population (abbreviated as 'average schooling'). Average schooling represents the stock of human capital accumulated from investments in school education in the past. This figure compares changes in this measure with those of real GDP per capita and capital-labor ratio.

As shown in the upper section of this figure, Japan began rapid catching up in school education with the USA soon after the Meiji Restoration in 1868. Average schooling in Japan rose from 1.3 years in 1890, which was only 20 percent of that in the USA, to 5.6 years or 62 percent of the US level in 1930. Such achievements were based on the Meiji government's determination to shoulder the extraordinarily heavy cost of education under the strong belief that catching-up in education was the efficient means to catch up with Western economic and military power.

A conspicuous aspect is that this rapid catching up in education of Japan with the USA before the Second World War was not associated with catching up in the income level. Indeed, GDP per capita in Japan remained to be at about 20 percent of that in the USA throughout 1890-1930. Meanwhile, physical capital stock in Japan increased significantly faster than in the USA, but Japan's capital-labor ratio remained very low, only 13 percent of the US level even in 1930.

However, the pattern of Japan's economic catch-up changed sharply after the Second World War. Japan's capital-labour ratio relative to the US ratio rose very fast from 17 percent to nearly 90 percent in 2000. This was paralleled with an relative increase in per-capita GDP in Japan from 21 percent to about 80 percent. During the postwar period, the level of education in Japan continued to approach the US level but its speed was rather slow with the Japan-USA gap in education closed by only about ten percentage points.

Then, why was the gap between Japan and USA in per capita GDP not reduced significantly before the War, especially before 1930, despite the very rapid closing of the educational gap? And Why did the income gap begin to close rapidly in the postwar period with the major investment spurt of the high-growth era despite relatively slow growth in average schooling? One hypothesis to answer this question is to assume complementarity between physical and human capital, which is a major building block of the endogenous growth model especially emphasized by Robert Lucas (1988). While the accumulation of physical capital is bound to face sharp decreasing returns unless supported by parallel increases in human capital as argued by Lucas, improved skills and knowledge created from education will not contribute much to productivity growth, unless appropriately combined with physical capital. For example, education would not raise productivity in simple manual work, such as digging a ditch with a shovel, but it would significantly increase efficiency in the operation of modern sophisticated earth-moving machinery. It might be that the speed of educational growth in Japan before World War II was too fast to maintain the appropriate combination between physical and human capital. Another hypothesis postulates that the level of education, instead of its growth rate, is the major determinant of a country's capability for borrowing external technology and, hence, its economic growth rate, as attested by Robert J. Barro (1991) and Gregory Mankiw et al.(1992) in their cross-country regression analyses.

These two hypotheses are not mutually exclusive but complementary. In our perspective, human capital created from school education in Japan had not yet reached the threshold at which frontier technology practiced in the USA could be effectively borrowed before the War, despite the rapid accumulation of investments in education. As a result, the immediate economic return to education was not very high in the prewar period. It appears that the accumulation of educational investments in the first half-century of modern economic growth brought Japan to such a threshold, but the opportunity of importing foreign technology was stopped by the War. However, the opportunity to profitably employ premier frontier technology with sufficiently elevated human capital was open for exploitation in the postwar period. It appears that this profit opportunity for physical capital investment based on previously accumulated human capital brought about the major investment spurt, resulting in rapid economic catch-up of Japan with the USA during the first three decades after the War.

Such lead-lag relationships among average schooling, per-capita GDP and capital-labor ratio are also observable for the Republic of Korea in the lower section of Figure 6.4. Only a year after Korea was annexed to Japan in 1910, the colonial government transplanted the primary education system of the Japanese type in this new territory. However, Japan was not eager to provide higher-level education for Koreans. As the result, average schooling in Korea barely reached only about 10 percent of the US level by the end of the colonial period. Correspondingly, both GDP per capita and capital- labour ratio remained to be very low and largely stagnant before World War II.

After achieving independence in 1948, the new Republic undertook major efforts for the development of education systems. Immediately, average schooling began rapid catching up in closing the gap with the US A. Nevertheless, catching up in the levels of GDP per capita and capital-labor ratio was slow during the first two decades of independence. During the 1970s, however, a sharp reversal occurred in the relative speed of educational catch-up versus economic catch-up; while the growth of average schooling began to decelerate, both per-capita GDP and capital-labor ratio began to grow in acceleration. Factors underlying this pattern change in Korea appear to be the same as for the change in Japan from the prewar to the postwar period, though such geopolitical and political factors as perpetual confrontation with North Korea following the Korean War (1650-53) and the developmental dictatorship of Pak Chong-hui (1961-79) should have had significant influences specific to South Korea.

4. Implications

The historical relationship between the educational and the economic catching up of Japan and Korea with the USA, as observed in Figure 1, confirms the dependency of social capability to borrow frontier technologies on a certain threshold of human capital accumulated through education. It appears that cumulative investments in school education in the first half-century of modern economic growth brought Japan to such a threshold of human capital accumulation. Based on this accumulation of past educational investments, Japan was able to profit from the importation of world frontier technologies. Likewise, the miraculous economic growth of Korea from the 1970s should have been strongly supported by the accumulation of past educational investments including those during the colonial period.

Such a perspective based on the experience of Japan and Korea is consistent with the consensus view that investment in education is the key for developing economies to catch up with the advanced. However, it also implies that developing economies cannot expect quick harvesting of fruits from school education. They must be prepared to endure the heavy burden of investment in schooling relative to their income level for many years before the stock of human capital together with physical capital reaches a sufficiently high level for rapid economic catch-up. It is still likely that education may prove to be the investment outlet of the highest economic return in the long run. Yet, the return might not be quite so attractive in the short run for political leaders in developing economies, relative to their high discount rates. What forms of education (such as primary versus higher-level education and general versus vocational education) should be given priority considering their different investment gestation periods? What would be an optimum investment mix between human and physical capital? These are among the hard choices that policy makers have to make, while the right answers are different across economies with different resource endowments under different development stages.

In the end we would like to emphasize the role of education not to be limited in its direct contribution to economic growth through the creation of better skill and technology (schematized as the economic subsystem in Figure 1.1). A more basic role of education may be to transform culture or people's value system by improving their knowledge of their own position in wider national and international perspectives. Particularly important for many developing countries today, which are torn apart by ethnic and local rivalries, should be education's power to develop people's identity with the newly created nation state. School education, especially at the elementary level, with a uniform curriculum using a common language over a nation should indeed be the most effective means to foster a national identity and to develop a consensus among different groups of people on what are their common national interests, as elucidated by a classic treatise on the emergence of nationalism by Benedict Anderson (1983). Indeed, a disproportionately heavy investment in education by the Meiji government in Japan in terms of conventional economic criteria cannot be explained without considering its leaders' burning desire for transforming the feudal regime to the modern nation state. Without such transformation, the political will for institutional and organizational reforms needed for modern economic development are unlikely to be mobilized.

References

Abramovitz, M. (1986) “Catching UP, Forging Ahead, and Falling Behind,” *Journal of Economic History* 46: 385-406.

Andesrson, B. 1983. *Imagined Communities: Reflections on the Origin and Spread of Nationalism* (London: Verso).

Barro, R. J. 1991. “Economic Growth in a Cross-Section of Countries,” *Quarterly Journal of Economics* 106 (May): 407-43.

Denison, E. F. 1962. *The Sources of Economic Growth in tha United States and the Alternatives before US* (New york: Committee for Economic Development)。

Denison, E. F. 1967. *Why Growth Rates Differ: Post-war Experience in Nine Western Countrie*s (Washington D.C.: Brookings Institution).

Easterlin, R. A., 1981, “Why Isn’t the Whole World Developed?” *Journal of Economic History 41*: 1-17.

Gerschenkron, A., 1962, *Economic Backwardness in Historical Perceptive*, Cambridge, Mass.: Harvard University Press.

Godo, Y. 2004. *Revised Estimates of Education in modern Economic Growth* (Tokyo: Foundation of Advanced Studies in International Development Studies), mimeo.

Godo, Y. and Hayami, Y. 2003. “ Catching UP in education in the Economic Catch –up of Japan with the Uited States, 1980-1990,” *Economic Development and Cultural Change 50* （January):961-78.

Hayami, Y. and Godo, Y. 2005. *Development Economics: From the Poverty to the Wealth of Nations* (Oxford, Oxford University Press).

Japan Ministry of Education, 1967, *Wagakuni Kyoiku no Ayumi* (History of Japanese Educational Development), Tokyo: Meiji Tosho Shuppan.

Keller, W. (1996). “ Absorptive Capacity : On the Creation and Acquisition of Technology in Development”, *Journalof Development Economics 49*: 199-227.

Makino, F. 1996, *Manekareta Prometheus: Kindai Nihon no Gijutsu Shimpo (Invited Prometheus: Technological Progress in Modern Japan)*. Tokyo: Fukosha.

Mankiw, N. G., Romer, D., and Weil, D. N., 1992. “A Conribution to the Empirics of Economic Growth,” *Quarterly Journal of Economics 107*(May):407-37

Minami, R,. 1984、"Industrialization and Technological Progress In Japan", *Asian Development Review* 2 : 69-79.

Ohkawa, K., and H. Kohama (1989), *Lectures on Developing Economies: Japan’s experience and Its relevance* (Tokyo: University of Tokyo Press).

Ohkawa, K., and H. Rosovsky,(1973) *Japanese Economic growth: Trend Acceleration in the Twenty*

Century.(Stanford: Stanford University Press).

Psacharopoulos,G. 1994. Returns to Education Investment in Education: A Global Update," *World Development 22* (May):1325-43.

Romer, P. M, "Increasing Returns and Long-Run Growth," *Journal of Political Economy 94* (October):1002-37.

Smith, A., 1937 (originally publication 1776), *An Inquiry into the Nature and Causes of the Wealth of Nations,* ed. E. Cannnan, 6th ed.., New York: Modern Library.

Smith, T. C., 1988, *Native Sources of Japanese Industrialization, 1750-1920,* Berkeley and Los Angeles, CA: University of California Press.

Thompson, E. P., 1967, 'Time, Work-Discipline, and Industrial Capitalism,' *Past and Present,* 38(December): 56-97.

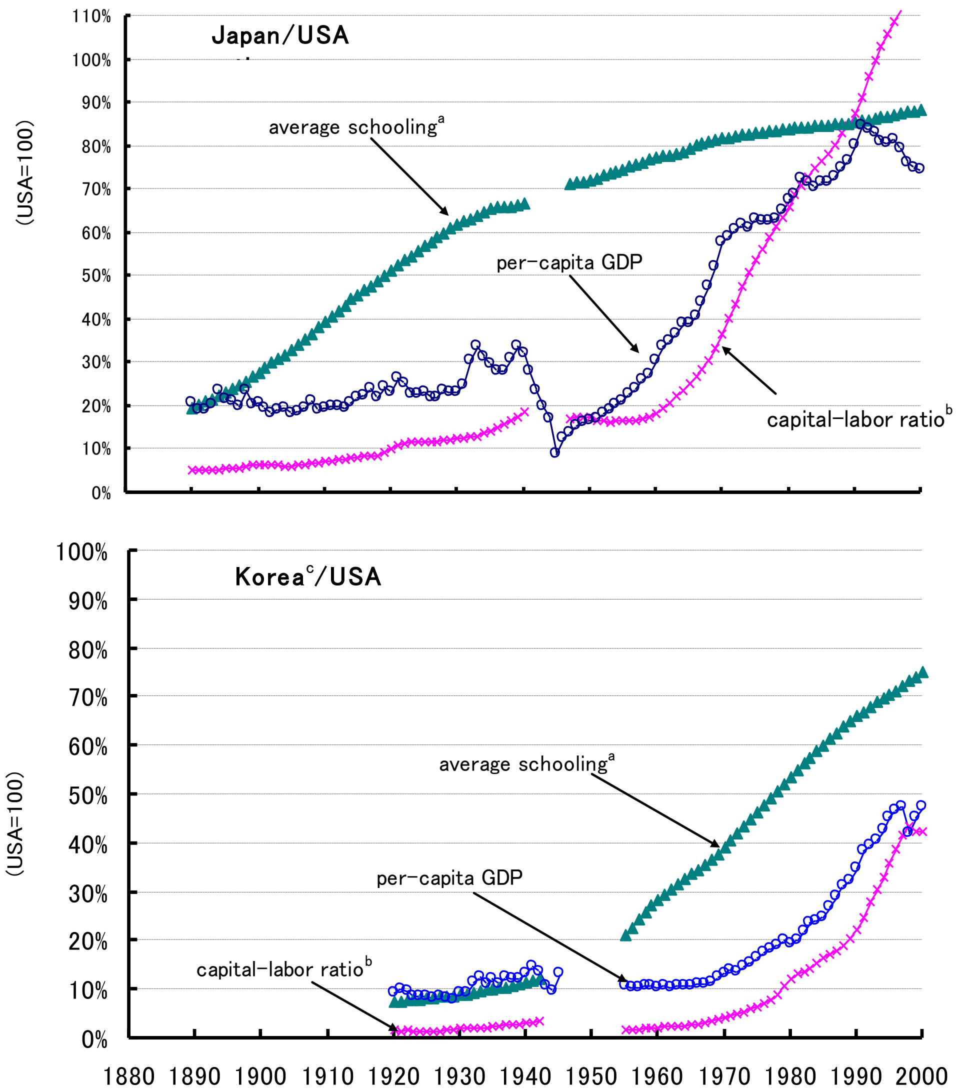

Figure 1. *The Japan/USA and Korea/USA ratios in average schooling, per-capita GDP, and capital-labor ratio*

a. Average number of years of schooling per person in the total working-age (15 to 64 years old) population.

b. Labour is measured by total employment. Capital is measured by gross nonresidential fixed capital capital (excluding that for military use). GDP is measured in PPP 1990 US dollars.

c. Data for Korea in the postwar period are for the Republic of Korea.

Source: Godo (2004).