

Does Population Aging Slow Down Per Capita Income Growth?

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Abstract

This study examined the issue of whether per capita income growth rate will decline as a result of population aging, utilizing cross-country data. First, this paper shows that the most distinguishing demographic characteristics of the “growth miracle” country of Korea during the period from 1961 to 1990 lies in the miraculous *speed of changes* in various demographic indicators—such as working-age population ratio, fertility rate, and population growth rate—not in the level of such indicators. Second, based on simple correlation analysis, it was found that there exist significant correlations between measures of *speed of demographic transition* and per capita income growth rate. That is, countries which experienced more rapid increase in their working-age population ratio, faster decline in fertility rate, or faster decline in population growth rate, tend to exhibit higher per capita income growth rate. Meanwhile, although the *level* of working-age population ratio is strongly and positively related to per capita income growth rate of countries, the correlation between the change in (i.e., differenced) working-age population ratio and the change in per capita income growth rate is very low. This suggests that the positive cross-country correlation between per capita income growth rate and the age structure of population, which seems to underlie the argument that population aging will slow down per capita income growth, reflects country-specific fixed effects. Finally, although both the level and the speed of change in working-age population ratio, for example, were estimated to be positive in cross-country regressions, the coefficient on the former was not robust to the inclusion of control variables. Overall, the empirical evidence provided in this paper suggest that population aging by itself is not likely to be a serious threat to per capita income growth in the future.

I. Introduction and Background

One of the salient features of the Korean economy which experienced fast economic growth in the past is that its demographic transition also proceeded at fast speed by any international standard. As well known, the death rate and the fertility rate have steadily declined in Korea since the 1960s. Accompanied with these changes is the increase in the number of working-age population per dependent population (working-age population ratio henceforth) during the latter half of the twentieth century; it rose from 1.5 person in 1965 to 2.5 person in 1999. In short, the fast demographic transition in Korea since the 1960s has been in the direction of increasing the working-age population ratio.

However, the demographic transition in Korea is entering a new phase and, in the foreseeable future, population aging is expected to proceed at much the same phenomenal rate as the past increase in the working-age population ratio. In 2000, Korea has already become an “aging society” with 7.2 percent of the population aged 65 years or more. It is believed that Korea will become an “aged society” by 2019 with the above ratio 14 percent or higher, and that by 2026, it will become a “super-aged society” with the same ratio 20 percent or higher. Under these circumstances, there seems to be a wide-spread belief that although the demographic transition in the past has worked favorably to economic growth of Korea, it will threaten economic growth in the future. Will population aging slow down economic growth in Korea, as measured by per capita income growth?

This study aims to assess empirically whether per capita income growth rate will decline as a result of population aging utilizing cross-country data since 1960s.

Specifically, this study examines how a country's per capita income growth rate is related to various indicators on demographic structure as well as (the speed of) demographic transition, using cross-country regression framework. It is true that how and how much population aging will affect a country's economic growth are likely to be influenced by country-specific factors, such as pension system, welfare system, and labor and financial market institutions. So, the effect of population aging on economic growth might well vary across countries depending on the details of the relevant institutions as well as on the nature of institutional reforms. Nevertheless, we believe that examining cross-country relationship between economic growth and various demographic indicators provides a starting point for understanding the effect of population aging on economic growth.

The empirical analysis in this study is based on two contrasting, but not necessarily mutually exclusive, theoretical frameworks on the relationship between demography and per capita income growth. One theoretical framework relevant for this issue is the neoclassical overlapping generations models, such as Mills (1999) and Auerbach and Kotlikoff (1987), which takes not only technical progress but also demographic structure of an economy as exogenously determined. These theories suggest that population aging, which involves the increase in dependency ratio, decreases the rate of per capita income growth mainly by lowering aggregate saving rate. In these types of models, an individual's decision on saving is based on life-cycle motive. So, the higher the fraction of youth and elderly population an economy has, who has relative high consumption propensity, the lower the aggregate saving rate and, hence, the per capita income growth rate. Thus, one hypothesis that can be drawn out is as follows.

Hypothesis 1: A country with lower working-age population ratio

experiences lower rate of per capita income growth, other things being equal.

An alternative theoretical framework on the relationship between economic growth and demography is indirectly provided by several recent theoretical models, such as Becker, Murphy, and Tamura (1991) and Lucas (2002), both of which view the *fertility rate* as well as the growth rate of an economy as being *endogenously* determined. Becker, Murphy, and Tamura (1991) show that under the trade-off between the number and the quality of children, changes in economic environment which raise the rate of return to investment in the quality of children, such as increases in initial human capital stock, decreases fertility rate but promotes human capital accumulation and per capita income growth. Lucas (2002) views sustained economic growth of countries since the late 19th century—i.e., industrialization—as a process of diffusion of the Western industrial revolution to other regions of the world. He further suggests that countries with open trading regime and private property right protection went through changes in household's decision in the direction of favoring quality, rather than quantity of children and experienced *both demographic transition and sustained increase in per capita income*. Under these perspectives, both demographic transition and sustained per capita income growth could be understood as two different manifestations of one phenomenon, in as much as demographic transition is primarily driven by fertility decisions of households. Then it could be conjectured that the faster the speed of demographic transition of a country, the faster the rate of per capita income growth. Thus, an alternative hypothesis on the relationship between demography and per capita income growth might be as follows.

Hypothesis 2: *A country with faster speed of demographic transition experiences higher rate of per capita income growth, other things being equal.*

The empirical analysis in this study is mainly based on the fact that the above two hypotheses suggest somewhat contrasting relationships between per capita income growth and demographic structure, such as working-age population ratio. Hypothesis 1 implies that the *level* of per capita income growth rate is systematically related to the *level* of working-age population ratio. Thus, demographic transition, which involves changes in the working-age population ratio, will be accompanied by changes in per capita income growth rate. This seems to be the key presumption underlying the argument that population aging will slow down per capita income growth.

By contrast, hypothesis 2 implies that the *speed of changes* in working-age population ratio is systematically related to the *level* of per capita income growth rate. One thing to note here is that the speed of changes, not the direction of changes in demographic structure matters for growth. It is well known that the time profile of a country's working-age population ratio exhibits a non-linear pattern—roughly inverted-U shape—in one cycle of demographic transition; it mildly declines for a short time and then continues to increase with the decline in fertility rate during the early stage of a demographic transition and, in later stage, it declines until it levels off with less people entering working-age population and more people remaining as the elderly (Figure 1). Here, the decline in working-age population ratio or population aging is just a part of one cycle of demographic transition. Then, the hypothesis 2 could be interpreted as implying that a country with faster progress of population aging is likely to experience faster per capita income growth. In other words, in so far as those factors which triggered past demographic transition and economic growth remain unchanged, population aging by itself is not likely to reduce per capita income growth rate.

// Insert Figure 1 here//

With these theoretical frameworks as background, this study examines whether per capita income growth is related to the level of demographic structure or the speed of its changes or both. While we primarily focus on the working-age population ratio as a measure of demographic structure, we also consider fertility rate and population growth rate in the analysis. A systematic relationship between per capita income growth and the level of these demographic indicators could be interpreted as supporting the framework of neoclassical overlapping generations models. If per capita income growth is systematically related to the speed of changes in demographic structure and not to its level, then it could be interpreted as supporting theories of endogenous demography and growth.

Despite popular concerns on the effect of population aging on the growth of living standard, there seems to be little cross-country studies that examine relationship between per capita income growth and level or changes in demographic structure. One exception is Bloom and Williamson (1998) that examines the relationship between per capita income growth and changes in demographic structure, taking a modified Solow growth model as their empirical framework. They argued that since past miraculous growth performance of East Asian countries was heavily indebted to rapid rise in working-age population ratio, these countries' per capita income growth in the future will significantly slow down with expected decline in the working-age population ratio. Although there are some methodological similarities, this study differs from Bloom and Williamson (1998) in terms of theoretical background and, hence, interpretation of empirical results. This study evaluates two contrasting theoretical frameworks on the relationship between population aging and economic growth, taking into account not only working-age population ratio but also other demographic indicators such as

fertility rate and population growth rate.

This study is organized as follows. In the next section, a brief overview of demographic transition in Korea will be provided in a broad international perspective. In section 3, the empirical results from simple correlations and cross-country regressions will be provided. The final section summarizes main findings and concludes.

II. Key Features in Demographic Transition of Korea

In terms of per capita income growth, Korea has been one of the miracle countries in East Asia. Also miraculous but often neglected is the fact that the demographic transition in Korea also proceeded very rapidly by any international standard (Table 1). The fertility rate, which was 5.7 in 1960, has declined continuously since then to record 1.4 in 2000 and 1.3 in 2001. Death rate per 1,000 population was 13.5 in 1960 but declined rapidly since then to record 6.4 in 1980. Since 1980 the death rate has declined moderately but continuously to register 5.8 in 1999. Life expectancy at birth in 1960 was 54.2 years, rising continuously to reach 73.2 in 2000. With rapid decline in fertility rate and death rate and increase in life expectancy, population growth rate and demographic structure went through rapid change as well. Population growth rate registered 3.1% in 1960 but has declined since then to record 0.9% in 2000. The number of working-age population per dependent population (working-age population ratio) was as low as 1.21 in 1960 and it further declined to 1.15 in 1965. Since 1965, it rose continuously to reach 2.5 in 1999.

// Insert Table 1 here//

Then what are the key features of demographic transition in Korea for the period of 1960 to 2000, compared with experiences of other countries? Was Korea's demographic

transition outstanding at all in terms of level of demographic indicators, or in terms of the speed of changes of those indicators? To answer these questions, we compare various demographic indicators of Korea for the period of 1960 to 2000 with those of three regions: developed countries, sub-Saharan African countries, and East Asian countries excluding Korea.

To begin with, population growth rate of Korea has declined very rapidly, compared not only with developed countries and sub-Saharan African countries but also with other East Asian countries (Figure 2). Until late 1960s, population growth rates of Korea and other East Asian countries were higher than sub-Saharan African countries. However, it has declined rapidly to become comparable to those of developed countries after mid-1980s. Although average population growth rate of East Asian countries excluding Korea also decreased more rapidly than both developed and sub-Saharan African countries, its pace is less pronounced than Korea. Developed countries on average also experienced decline in population growth rate for the same period. However, the average population growth rate of sub-Saharan African countries, which lagged the most in terms of economic growth since the Second World War, *increased* somewhat for the same period. Meanwhile, in terms of the level of population growth rate as average of this period, Korea stands between developed and sub-Saharan African countries.

// Insert Figure 2 here//

As in population growth rate, Korea was one of the countries with the most rapid pace of decrease in fertility rate (Figure 3). Again, other East Asian countries also experienced rapid decline in fertility relative to the rest of the world. Fertility rates of both developed countries and sub-Saharan African countries also declined for the period,

although the pace of decline is only modest. However, the patterns differ somewhat between the two regions. The average fertility rate of developed countries has declined to below 2.0 until early 1980s and stabilized since then. By contrast, the average fertility rate of sub-Saharan African countries remained stable at 6.5 until early 1980s but has declined since then. As in the case of the level of population growth rate, Korea does not stand out in terms of the level of period-average fertility rate.

// Insert Figure 3 here//

In terms of the pace of decline in death rate, Korea and other East Asian countries do not distinguish themselves from other developing countries (Figure 4). It is true that the decline in death rate of Korea outpaces developed countries and that the level of death rate of Korea is even lower than the average of developed countries. However, sub-Saharan African countries exhibit the pace of decline in fertility comparable to Korea. Why Korea is not distinguished from sub-Saharan countries in terms of the pace of decline in death rate seems to be a question to be examined more thoroughly. Nevertheless, compared with fertility rate, the death rate is likely to be influenced more by changes in supply side factors, such as the diffusion of medical technology and improved sanitary conditions.

// Insert Figure 4 here//

Finally, the working-age population ratio in Korea has risen very rapidly for the period of 1960 to 2000, with the fast decline in fertility rate as well as the gradual inflow of baby-boom generations into working-age population. The working-age population ratio of other East Asian countries also rose very rapidly, compared with other regions of the world (Figure 5). The working-age population ratio in developed

countries mildly increased for the period as a whole. However, since 1990s it remained stable at around 2. In sub-Saharan African countries, the working-age population ratio has been stagnant through out the period at a lowest level by international standard. It is interesting to note that sub-Sahara is the most under-developed region of the world, where “industrialization” has yet to start for most countries. Again, in terms of the level of period-average working-age population ratio, Korea does not stand out from other countries.

// Insert Figure 5 here//

The above overview of Korean demographic transition in comparison with other regions of the world clearly shows that, in terms of demography, what distinguishes Korea most from other regions is not the level, but the speed of changes of various demographic indicators. In terms of period-average levels of various demographic indicators, Korea stands only in between developed and sub-Saharan African countries.

III. Empirical Analysis: Demographic Structure, Demographic Change, and Per Capita Income Growth

In this section, we analyze cross-country relationship between per capita GDP growth rate and demographic indicators for the period from 1960 to 1990, relying on simple correlations as well as regressions. As mentioned earlier, the primary interest of this study lies in examining whether per capita income growth is systematically related to the level of working-age population ratio, or to the speed of its changes or to both. Nevertheless, this study also takes into account population growth rate and fertility rate as well for the following reasons. Above all, neoclassical overlapping generations models focus on demographic structure, such as working-age population ratio, in

analyzing the effect of population aging on per capita income growth. These models, however, do not tell us directly how fertility rate and population growth rate are systematically related to per capita income growth rate. By contrast, theories of demography and growth such as Becker, Murphy, and Tamura (1990) and Lucas (2002) has implications on the relationship between per capita income growth and fertility rate and population growth rate.¹ A significant relationship between changes in fertility and population growth rates and the level of per capita income growth rate might be interpreted as a favorable piece of evidence to theories of demography and growth. Conversely, no significant relationship between changes in fertility and population growth rates and per capita income growth rate would weaken empirical validity of those theories, even if a significant relationship is found between changes in working-age population ratio and per capita income growth. Another reason for considering population growth and fertility rate as demographic indicators is that the discussions on the effects of aging on economic growth are not confined to the channel of age structure of population. For example, Cutler, Poterba, Sheiner, Summers (1990) examine the effect of population growth rate on productivity growth and report that lower population growth rate is conducive to labor productivity growth. Also, Romer (1990), arguing that labor-scarce countries are in a better position to improve productivity, tries to explain exceptional productivity performance of the U.S. in the era of low labor force growth.

III.1. Simple Correlations

a) Correlations Between Demographic Indicators

¹ As noted earlier, these theories are set up and analyzed only in highly abstract form, and have only indirect implications on the relationship between age structure of population and per capita income growth rate.

As a preliminary analysis we examine correlations between *levels* of population growth rate, fertility rate, and working-age population ratio. If there exist significant correlations between these variables, it might suggest that the phenomenon of population aging should not be understood simply as a decline in working-age population ratio. <Table 2> shows that there do exist strong correlations between levels of the three demographic variables. Here, each variable is measured as an average over the period from 1961 to 1990 for each country. The correlations between fertility rate and population growth rate and between fertility rate and working-age population ratio are high and significant at 0.88 and -0.92, respectively. Also, there is a strong negative correlation (-0.84) between population growth rate and working-age population ratio. In short, there was a tendency for a country with lower fertility rate to have lower population growth rate and higher working-age population ratio.

// Insert Table 2 here//

Next, are there any significant relationships at all between *changes* in population growth rate, fertility rate, and working-age population ratio? For example, do countries which experienced rapid rise in working-age population ratio also exhibit rapid decline in fertility and population growth rate? If the answer turns out to be “yes”, then it would imply that it might be misleading to try to predict the consequences of population aging focusing exclusively on the behavior of working-age population ratio. To examine this issue, we generated differenced variables for each original level variable. The differenced variables were calculated by first dividing the sample period into two sub-periods, and then by taking differences between average values for the two sub-periods. <Table 3> shows that there are fairly strong correlations between the differenced variables. Specifically, countries with rapid rise in working-age population ratio tend to

be countries with rapid decline in fertility and population growth rate. This finding suggests that it is necessary to discuss the effect of aging on per capita income growth taking into account together the behaviors of fertility rate, population growth rate, and working-age population ratio.

// Insert Table 3 here //

b) Levels of Demographic Indicators and Per Capita Income Growth

As discussed earlier, neoclassical overlapping generations models with life-cycle savings predict a systematic relationship between the level of working-age population ratio and per capita income growth. We examine simple correlations between per capita income growth rate and levels of three demographic indicators: working-age population ratio, fertility rate, and population growth rate. Again, each variable is measured as an average over the period from 1961 to 1990 for each country. <Table 4> and <Figure 6> shows that there is a positive and significant correlation between working-age population ratio and per capita income growth rate. This evidence seems apparently supportive of hypothesis one. That is, countries with higher share of population at working age tend to exhibit faster improvement of standard of living.

// Insert Table 4 here//

// Insert Figure 6 here//

One interesting point to note here is that not only working-age population ratio but also fertility rate and population growth rate are systematically correlated with per capita GDP growth rate. Specifically, countries with lower fertility rate and population growth rate tend to improve per capita income faster. This evidence seems to be at odds with the argument that the decline in fertility rate will slow down, probably with some

time lag, per capita income growth rate, which seems to be a prevailing idea these days in the Korean society. What the data shows is that countries with lower fertility rate and population growth rate have grown faster, not slower, in per capita terms. Another point to mention is that neoclassical overlapping generations models with life-cycle savings do not have a clear implication on how fertility rate should be related to per capita income growth rate. In these models, fertility rate is only indirectly related to per capita income growth rate through its effect on age structure of population. The existence of clear negative correlations between per capita income growth rate and fertility and population growth rate needs some explanation from these models, if these models are to be considered as a useful theoretical framework on aging and growth.

Before discussing the correlation between per capita income growth and changes in demographic indicators considered in this study, we perform one supplementary exercise to look more closely into the significant cross-country correlations between per capita income growth rate and levels of three demographic indicators which are reported in Table 4. If the *level* of working-age population ratio, for example, is correlated with the *level* of per capita income growth rate, then it is expected that the *change* in working-age population ratio is also correlated with the *change* in per capita income growth rate. That is, if g and D are correlated, Δg and ΔD is likely to be also correlated, where g is per capita income growth rate and D is a demographic indicator. In fact, the popular belief that population aging slows down per capita income growth rate seems be based on the presumption that Δg and ΔD is correlated. Thus, if no significant correlation is found between Δg and ΔD , then the cross-country correlation between g and D , shown in Table 4, is likely to reflect country-specific fixed effects.

<Table 5> shows correlations between Δg and ΔD . As before, the changes in variables were calculated by first equally dividing the sample period into two sub-periods, and then by taking differences between average values for the two sub-periods. The results show no significant correlations in any of the pairs. In particular, even the correlation between changes in working-age population ratio and changes in per capita income growth rate is very low (Figure 7). We prefer to interpret this result as suggesting that the positive cross-country correlation between per capita income growth rate and the age structure of population is likely to reflect at least some country-specific factors which are largely fixed during the period analyzed here.

// Insert Table 5 here//

// Insert Figure 7 here//

The argument that population aging will slow down per capita income growth frequently relies on the presumption that the decline in working-age population ratio, often preceded by the decline in fertility rate, will be empirically associated with the decline in the rate of per capita income growth. Apparently, this presumption seems justified by the significant and positive correlation found between the level of working-age population ratio and the level of per capita GDP growth rate. However, we could not find any significant correlations between changes in per capita income growth rate and changes in working-age population ratio, fertility rate, or population growth rate. This suggests that the positive correlation between the level of working-age population ratio, for example, and per capita GDP growth rate might reflect country fixed effects. To the extent that this is true, the argument that population aging will slow down per capita income growth seems to be weakened.

c) Changes in Demographic Indicators and Per Capita Income Growth

Now we turn to the relationship between changes in demographic indicators and per capita income growth. We discussed earlier that a country with faster speed of demographic transition experiences higher rate of per capita income growth (Hypothesis 2). That is, hypothesis 2 implies that g and ΔD is systematically correlated. Table 6 shows correlations between per capita GDP growth rate and changes in demographic indicators (See also Figure 8). Here, per capita GDP growth rate for each country is the average for the period from 1961 to 1990, while the changes in demographic indicators are measured as before. Above all, the correlation coefficient between changes in working-age population ratio and per capita income growth is positive and significant at 0.56. In other words, countries which experienced a larger increase in their working-age population ratio over the two sub-periods tend to exhibit higher per capita income growth rate during the period from 1961 to 1990. In addition, there are also negative and significant correlations between changes in fertility rate and per capita income growth rate, and between changes in population growth rate and per capita income growth rate—countries with faster decline in fertility rate or in population growth rate experienced faster per capita income growth.

// Insert Table 6 here//

// Insert Figure 8 here//

Systematic correlations between demographic transition, measured by changes in demographic indicators, and per capita income growth are supportive of hypothesis 2. They are also consistent with theories of demography and growth, such as Becker, Murphy, and Tamura (1990) and Lucas (2002), where countries going through changes

in the choice between quality and quantity of children experiences both demographic transition and sustained increase in per capita income. Together with the absence of any systematic correlations between changes in demographic indicators and changes in per capita income growth rate, these empirical findings lend more support to hypothesis 2 over hypothesis 1.

Here, a question might be raised as to whether the “magnitude of increase,” rather than the “speed of change” in working-age population ratio matters for per capita income growth. It is true, as indicated in Figure 5, that for the last fifty years countries that experienced fast demographic transition experienced the increase in working-age population ratio. This phenomenon is the main background behind Bloom and Williamson’s argument that East Asian countries’ per capita income growth in the future will significantly slow down with expected decline in the working-age population ratio.

Then, will East Asian countries’ per capita income growth rates “significantly” slow down with “significant” amount of decline in working-age population ratio? Let us think about this question by asking another hypothetical question “What would happen to the relative rankings of regions in terms of per capita income growth rate, if the answer to the above question is yes?”. To conjecture answers to the latter question, it would be natural to assume that the positive simple correlation between the level of working-age population ratio and per capita income growth rate will still hold in the future, in so far as the miraculous growth East Asian countries are mainly attributed to the “miraculous” rise in working-age population ratio. To simplify matters, let us suppose that, for developed countries as well as sub-Saharan African countries, the working-age population ratio in the future remains the same as shown in Figure 5. Now, if we draw a similar figure as in Figure 4 for the next 50 years or so, the time profile of

working-age population ratio for East Asian countries, including Korea, will slope most steeply downward with unprecedented speed of population aging expected in these countries. Then, if the above positive simple correlation is to hold, the per capita income growth rates of East Asian countries should become, at least in statistical sense, even lower than those of sub-Saharan African countries. This doesn't seem to be a very plausible scenario. Thus, the positive correlation between changes in working-age population ratio and per capita income growth rate seems to suggest that the speed of changes, rather than the direction of changes, in working-age population ratio is important in understanding per capita income growth rate.

Before turning to regression analysis, in order to examine further the significant cross-country correlations between changes in demographic indicators and per capita income growth, as shown in Table 6, we try to do a supplementary exercise as before. That is, we ask whether the correlation holds in differenced form. Due to the limited time span of available data relative to the time it takes for one cycle of demographic transition to be completed, it is not easy to examine this issue in a rigorous way. Nevertheless, the figures provided by Lucas (2002) suggest the possibility that the correlation holds in differenced form as well (Figure 9 and 10). As discussed by Lucas (2002), countries which led the industrial revolution or which later joined the industrialization process commonly experienced demographic transition, characterized by initial rise and subsequent decline in population growth rate. Although cross-country data on demographic patterns before industrial revolution is not provided by Lucas (2002), it might well be conjectured that the speed of demographic transition before industrial revolution had been relatively slow, as discussed by Lucas. Comparison of Figure 9 with Figure 10 reveals a tendency, if not a very clear one, that regions that

joined the industrialization process later experience both relatively faster demographic transition and relatively faster improvement of standard of living.

// Insert Figure 9 and Figure 10 here//

III.2. Regressions

So far, we examined whether the speed of changes in demographic indicators or their levels matter for per capita income growth of countries. In this subsection, we examine the relationship between per capita income growth rate and levels and changes in demographic indicators relying on cross-country regressions. The dependent variable in the following regressions is average per capita GDP growth rate between 1961 and 1990. The control variables included are per worker GDP in 1960 (initial per capital GDP), average years of secondary schooling of population aged 25 years or older from Barro and Lee (1994), average share of government consumption in GDP for the period from 1960 to 1989, average years open between 1950 to 1990 from Sachs and Warner (1995), institutional quality from Knack and Keefer (1995), the share of primary product exports in GDP in 1970 from Sachs and Warner (1995), average terms of trade growth rate between 1960 and 1989, and region dummy variables for Latin America and sub-Saharan Africa. The independent variables are the level and change in demographic indicators—working-age population ratio, fertility rate, and population growth rate.

<Table 7> shows regressions for the levels and changes of working-age population ratio. Overall, not only the level but also the change of working-age population ratio turned out to be significant with expected signs. In particular, the coefficient on the change in working-age population ratio remained highly significant regardless to the inclusion of various control variables. The level of working-age population ratio,

however, lost significance when regional dummy variables were included. Thus, the regressions suggest that countries with rapid change in working-age population ratio grew faster. The argument that countries with high working-age population ratio grow faster is only mildly supported at best.

// Insert Table 7 here//

Next, we consider regressions for the level and change in fertility rate. As shown in <Table 8>, the coefficients on both level and change in fertility rate are negative and significant, suggesting that countries with low or rapidly declining fertility rate experienced higher growth rate of per capita income. They are also fairly robust to the inclusion of additional controls. In particular, the negative and significant coefficient on changes in fertility rate is consistent with hypothesis 2. Finally, neither the level nor change in population growth was significant enough in most regressions (Table 9). Nevertheless, the negative coefficient on the change in population growth rate seem to be supportive of the theoretical framework provided by Becker, Murphy, and Tamura (1990) and Lucas (2002).

// Insert Table 8 here//

// Insert Table 9 here//

IV. Summary and Concluding Remarks

This study examined the issue of whether per capita income growth rate will decline as a result of population aging, utilizing cross-country data. Main results of this paper are as follows. First, this paper shows that the most distinguishing demographic characteristics of the “growth miracle” country of Korea during the period from 1961 to 1990 lies in the miraculous *speed of changes* in various demographic indicators—such

as working-age population ratio, fertility rate, and population growth rate—not in the level of such indicators.

Second, based on simple correlation analysis, it was found that there exist significant correlations between measures of *speed of demographic transition* and per capita income growth rate. That is, countries which experienced more rapid increase in their working-age population ratio, faster decline in fertility rate, or faster decline in population growth rate, tend to exhibit higher per capita income growth rate during the period from 1961 to 1990.

Meanwhile, although the *level* of working-age population ratio, for example, is strongly and positively related to per capita income growth rate of countries, the correlation between the change in (i.e., differenced) working-age population ratio and the change in per capita income growth rate became very low. This suggests that the positive cross-country correlation between per capita income growth rate and the age structure of population, which seems to underlie the argument that population aging will slow down per capita income growth, reflects country-specific fixed effects.

Finally, although both the level and the speed of change in working-age population ratio, for example, were estimated to be positive in cross-country regressions, the coefficient on the former was not robust to the inclusion of standard determinants of growth as controlling variables.

Overall, the empirical evidence provided in this paper suggests that population aging by itself is not likely to be a serious threat to per capita income growth in the future. This will be particularly true if demographic transition reflects the tendency to prefer quality to quantity of children which arose with the process of industrialization, and if

population aging is just another name of such demographic transition. If we step back to admit that population aging has an effect of slowing down per capita income growth through channels postulated by neoclassical overlapping generations models, the evidence from this study suggests that there exist mechanisms which work to offset this effect, at least partially.

Recently, it seems to be widely believed that Korea's per capita income growth will slow down, aggravating fiscal burden, as a result of population aging. Based on this recognition, various policy proposals have been suggested. These include not only reforms in pension system and labor market institutions but also subsidization of child births and expansion of inflow of foreign unskilled workers. One indirect implication of this study is that the latter policies need to be carefully reviewed to the extent that they are aimed at slowing down the aging process itself.

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Table 1. The Demographic Change in Korea

Year	Fertility rate	Death rate	Life expectancy (Age)	Population growth rate (%)	Working age population ratio
1960	5.67	13.46	54.15	3.09	1.21
1965	4.87	11.24	56.68	2.46	1.15
1970	4.27	9.44	59.93	2.13	1.20
1975	3.32	7.42	63.89	1.93	1.42
1980	2.56	6.38	66.84	1.56	1.64
1985	2.04	6.24	68.65	0.99	1.92
1990	1.77	6.26	70.28	1.15	2.24
1995	1.75	5.30	71.77	1.21	2.46
2000	1.43	5.73	73.15	0.89	2.54
2001	1.30
2002	1.17

Note: a. The fertility rate is the number of babies that one woman gives birth to throughout her life.
b. The death rate is the number of the deceased per 1,000 people.
c. The working age population ratio is the reciprocal of dependency ratio, which is the number of working age people aged 15-64 per one dependent person aged under 15 or over 65.

Sources: a. World Bank, World Development Indicator, various issues

b. Korea National Statistical Office, Annual Report on the Vital Statistics, 2001, 2002

Table 2. Correlations between Levels of Demographic Indicators

	Population growth rate	Fertility rate	Working age population ratio
Population growth rate	1.00 (0.0000)	0.88 (0.0001)	-0.84 (0.0001)
Fertility rate	0.88 (0.0001)	1.00 (0.0000)	-0.92 (0.0001)
Working age population Ratio	-0.84 (0.0001)	-0.92 (0.0001)	1.00 (0.0000)

Note: a. Numbers in parentheses are P-values.

b. All variables used for correlation analysis are average values between 1961 and 1990.

Table 3. Correlations between Changes in Demographic Indicators

	Δ (Population growth rate)	Δ (Fertility rate)	Δ (Working age population ratio)
Δ (Population growth rate)	1.00 (0.0000)	0.67 (0.0001)	-0.55 (0.0001)
Δ (Fertility rate)	0.67 (0.0001)	1.00 (0.0000)	-0.71 (0.0001)
Δ (Working age population ratio)	-0.55 (0.0001)	-0.71 (0.0001)	1.00 (0.0000)

Note: a. Numbers in parentheses are P-values.

b. All variables used for correlation analysis are average values for 1976-1990 minus average values for 1961-1975.

Table 4. Correlations Between Levels of Demographic Indicators and per capita Income Growth Rate

	Population growth rate	Fertility rate	Working age population ratio
Per capita GDP growth rate	-0.36 (0.0003)	-0.57 (0.0001)	0.54 (0.0001)

Note: Numbers in parentheses are P-values.

Table 5. Correlations between Changes in Demographic Indicators and Change in Per Capita Income Growth Rate

	Δ (Population growth rate)	Δ (Fertility rate)	Δ (Working age population ratio)
Δ (Per capita GDP growth rate)	-0.10 (0.3347)	-0.06 (0.5642)	0.17 (0.0918)

Note: Numbers in parentheses are P-values.

Table 6. Correlations Between Changes in Demographic Indicators and Per Capita Income Growth Rate

	Δ (Population growth rate)	Δ (Fertility rate)	Δ (Working age population ratio)
Per capita GDP growth rate	-0.21 (0.0378)	-0.38 (0.0001)	0.56 (0.0001)

Note: Numbers in parentheses are P-values.

Table 7. The Regressions of Level and Change in Working-age Population Ratio

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP per capita (Logged)	-1.892 (-8.217)	-2.022 (-7.983)	-1.921 (-8.262)	-2.050 (-9.046)	-1.913 (-8.893)	-1.988 (-8.988)	-2.214 (-8.920)
Log years of secondary schooling	0.686 (5.064)	0.661 (4.735)	0.521 (3.932)	0.504 (3.953)	0.469 (3.937)	0.506 (4.198)	0.437 (3.777)
Openness	1.969 (3.893)	1.667 (3.251)	1.226 (2.544)	1.008 (2.210)	1.207 (2.813)	1.026 (2.307)	0.499 (1.112)
Quality of institutions	0.492 (6.096)	0.403 (4.507)	0.359 (4.364)	0.366 (4.747)	0.347 (4.813)	0.329 (4.516)	0.437 (5.203)
Working age population ratio		1.397 (2.012)	1.671 (2.623)	1.525 (2.544)	1.060 (1.840)	1.274 (2.176)	0.972 (1.602)
Change in the working age population ratio			2.379 (3.771)	1.915 (3.126)	2.080 (3.633)	2.016 (3.542)	1.421 (2.489)
Government consumption ratio				-7.203 (-2.825)	-4.739 (-1.901)	-4.917 (-1.982)	-4.893 (-2.096)
Natural resource abundance					-3.374 (-3.248)	-3.336 (-3.201)	-2.210 (-2.124)
Terms of trade						0.081 (1.297)	0.085 (1.452)
Latin America dummy							-0.322 (-1.087)
Africa dummy							-1.278 (-3.189)
Sample size	72	70	70	69	69	68	68
Adj. R-square	0.70	0.70	0.75	0.77	0.80	0.80	0.83

Note: a. Dependent variable is average growth rate of real GDP per capita from 1961 to 1990.

b. Numbers in parentheses are t-statistics.

Table 8. The Regressions of Level and Change in Fertility Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP per capita (Logged)	-1.892 (-8.217)	-2.458 (-10.063)	-2.420 (-10.844)	-2.514 (-11.913)	-2.388 (-11.567)	-2.551 (-12.216)	-2.488 (-10.725)
Log years of secondary schooling	0.686 (5.064)	0.526 (4.149)	0.393 (3.252)	0.392 (3.452)	0.380 (3.506)	0.427 (4.047)	0.415 (3.932)
Openness	1.969 (3.893)	1.170 (2.525)	0.897 (2.089)	0.689 (1.721)	0.867 (2.240)	0.549 (1.400)	0.368 (0.906)
Quality of institutions	0.492 (6.096)	0.370 (4.974)	0.430 (6.170)	0.421 (6.505)	0.403 (6.513)	0.388 (6.382)	0.398 (5.214)
Fertility rate		-0.677 (-4.916)	-0.673 (-5.356)	-0.623 (-5.335)	-0.544 (-4.724)	-0.623 (-5.438)	-0.525 (-4.054)
Change in the Fertility rate			-0.504 (-3.744)	-0.426 (-3.385)	-0.441 (-3.674)	-0.410 (-3.514)	-0.387 (-2.763)
Government consumption ratio				-7.300 (-3.363)	-5.634 (-2.611)	-5.947 (-2.864)	-5.987 (-2.892)
Natural resource abundance					-2.480 (-2.700)	-2.289 (-2.558)	-1.947 (-2.104)
Terms of trade						0.137 (2.499)	0.131 (2.398)
Latin America dummy							-0.361 (-1.365)
Africa dummy							-0.569 (-1.359)
Sample size	72	70	70	69	69	68	68
Adj. R-square	0.70	0.77	0.81	0.83	0.84	0.85	0.86

Note: a. Dependent variable is the average growth rate of real GDP per capita from 1961 to 1990.

b. Numbers in parentheses are t-statistics.

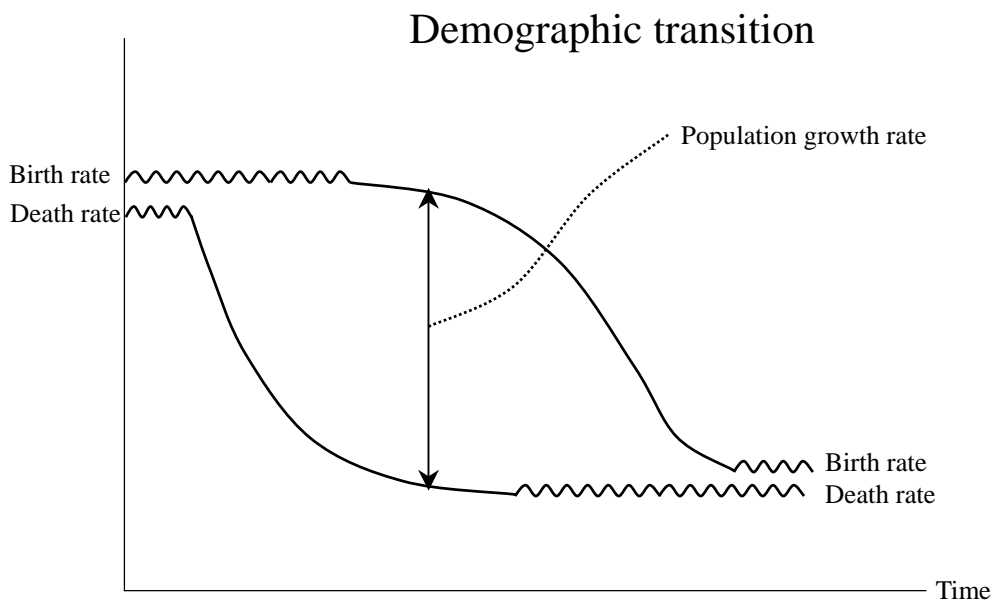
Table 9. The Regressions of Level and Change in Population Growth Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP per capita (Logged)	-1.892 (-8.217)	-2.021 (-7.335)	-2.145 (-7.324)	-2.448 (-9.061)	-2.311 (-8.910)	-2.469 (-9.164)	-2.480 (-9.042)
Log years of secondary schooling	0.686 (5.064)	0.707 (4.986)	0.700 (4.950)	0.648 (5.063)	0.607 (4.988)	0.666 (5.421)	0.537 (4.402)
Openness	1.969 (3.893)	1.810 (3.511)	1.675 (3.187)	1.114 (2.321)	1.296 (2.834)	1.007 (2.117)	0.533 (1.137)
Quality of institutions	0.492 (6.096)	0.466 (5.614)	0.499 (5.736)	0.494 (6.416)	0.463 (6.291)	0.451 (6.088)	0.525 (6.256)
Population growth rate		-0.224 (-1.163)	-0.252 (-1.305)	-0.364 (-2.110)	-0.258 (-1.548)	-0.376 (-2.173)	-0.207 (-1.180)
Change in the Population growth rate			-0.363 (-1.216)	-0.522 (-1.963)	-0.546 (-2.174)	-0.564 (-2.262)	-0.263 (-1.046)
Government consumption ratio				-10.718 (-4.102)	-8.268 (-3.175)	-8.772 (-3.408)	-7.250 (-2.944)
Natural resource abundance					-3.198 (-2.930)	-3.089 (-2.856)	-2.012 (-1.887)
Terms of trade						0.118 (1.743)	0.101 (1.600)
Latin America dummy							-0.355 (-1.186)
Africa dummy							-1.410 (-3.209)
Sample size	72	70	70	69	69	68	68
Adj. R-square	0.70	0.69	0.69	0.75	0.78	0.78	0.81

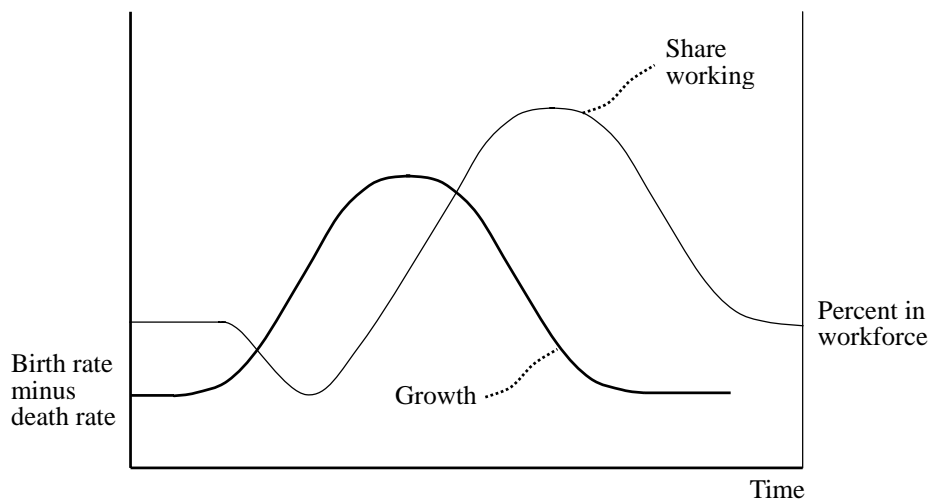
Note: a. Dependent variable is the average growth rate of real GDP per capita from 1961 to 1990.

b. Numbers in parentheses are t-statistics.

Figure 1. Patterns of Demographic Indicators in A Demographic Transition



Population growth and the age structure



Source: Bloom and Williamson (1998)

Figure 2. Trends of Population Growth Rate in Major Regions

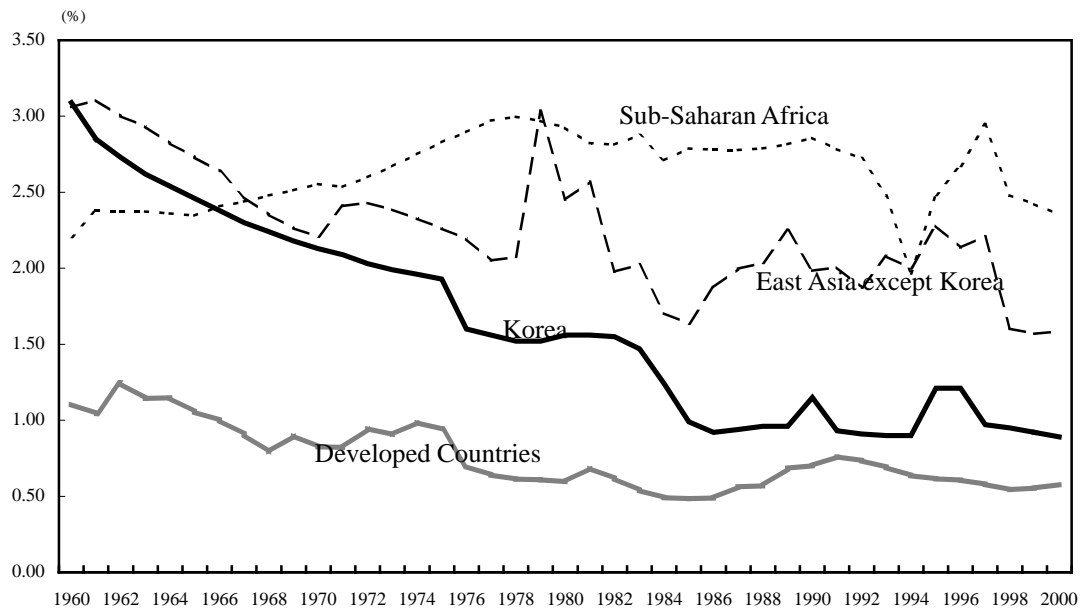


Figure 3. Trends of the Fertility Rate in Major Regions

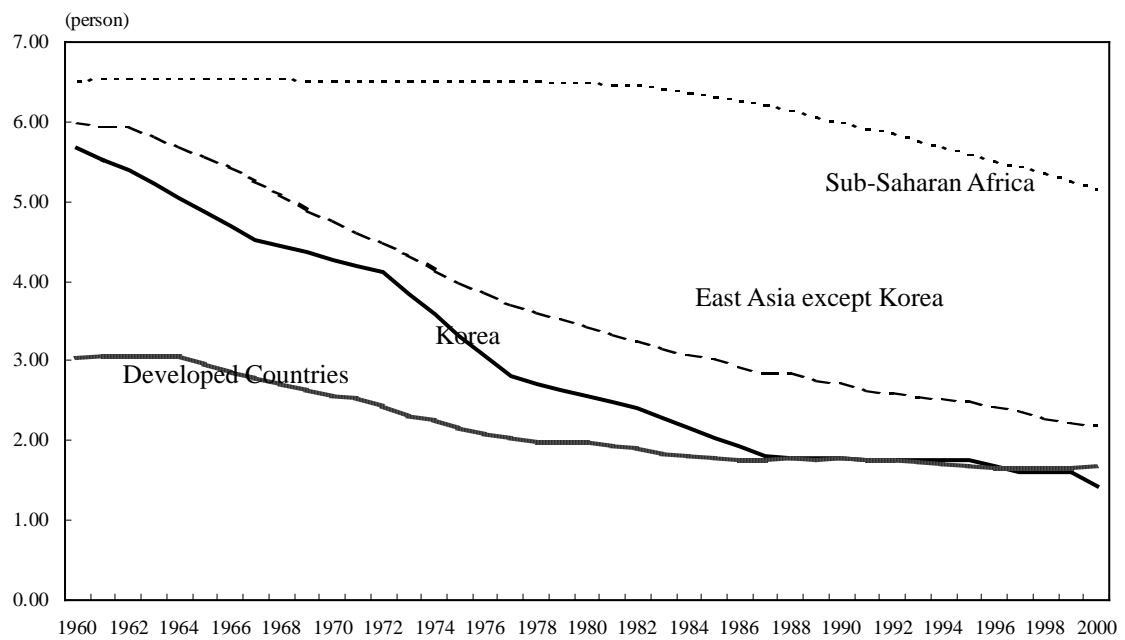


Figure 4. Trend of the Death Rate in Major Regions

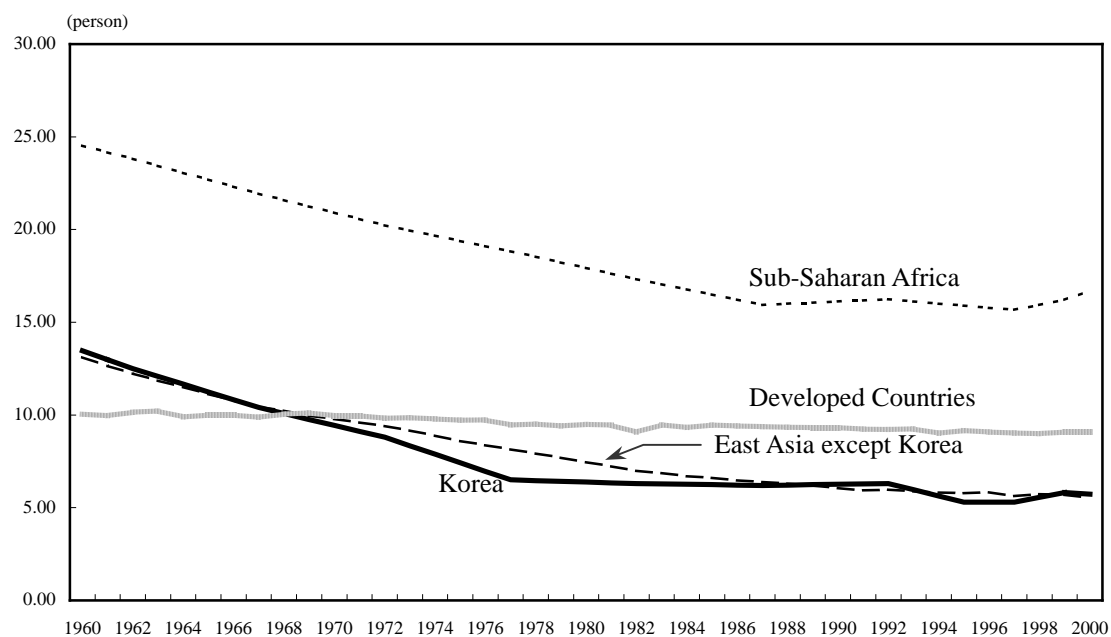


Figure 5. Trend of Working-age Population Ratio in Major Regions

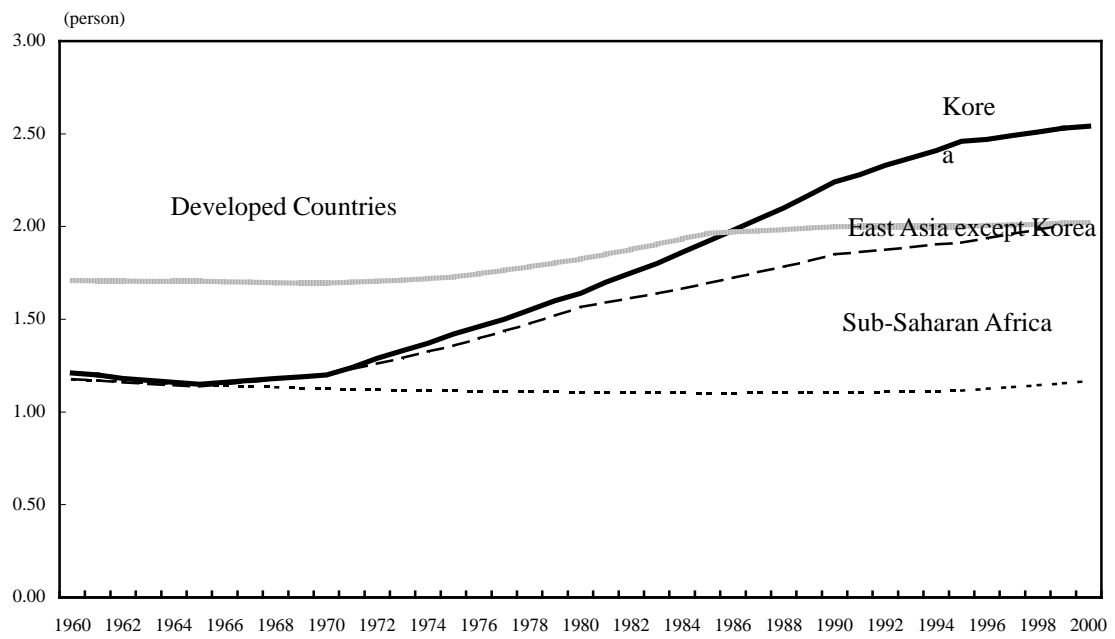


Figure 6. Correlation between Working-age Population Ratio and Per Capita Income Growth Rate

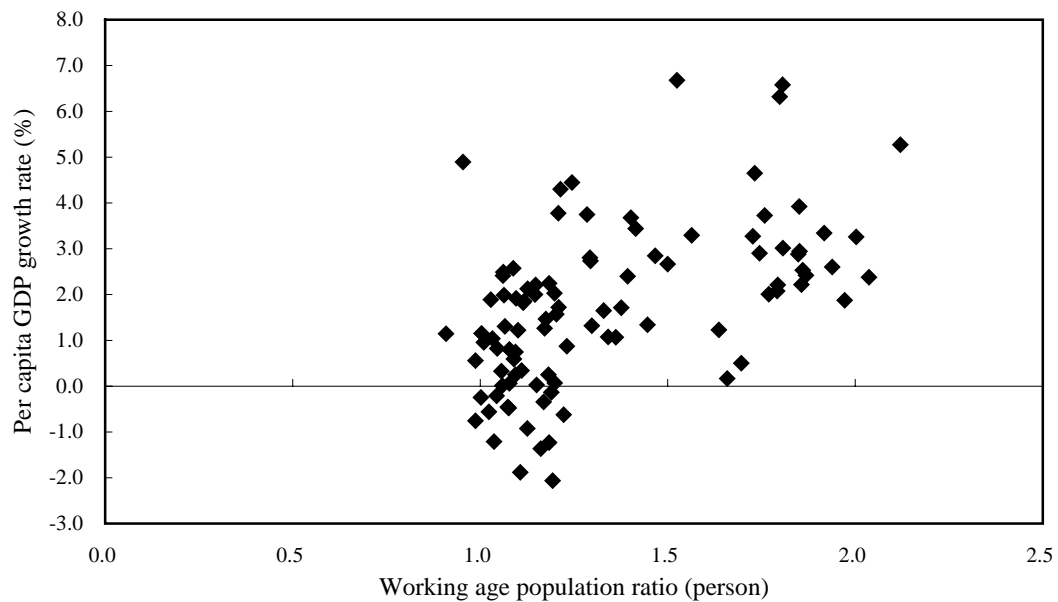


Figure 7. Correlation between Change in Working-age Population Ratio and Change in Per Capita Income Growth Rate

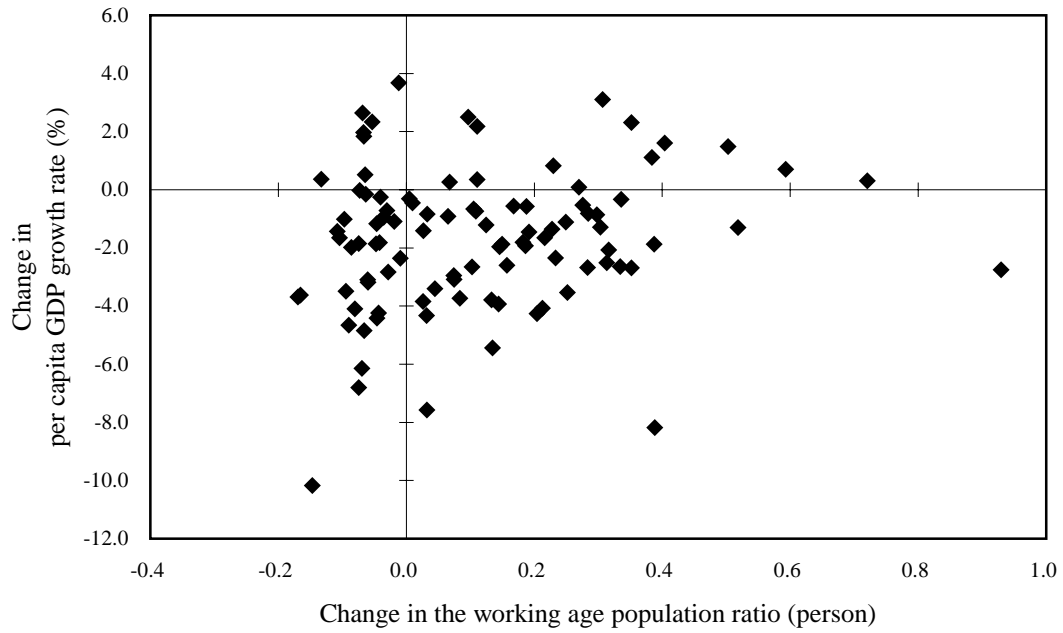


Figure 8. Correlation Between Changes in Demographic Indicators and Per Capita Income Growth Rate

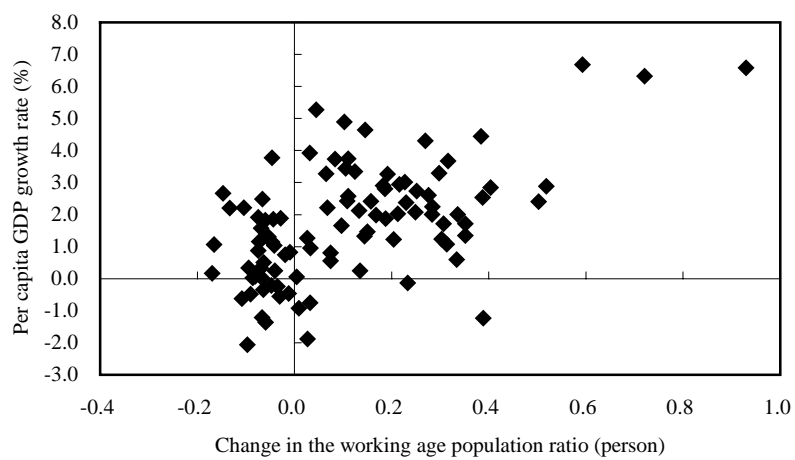
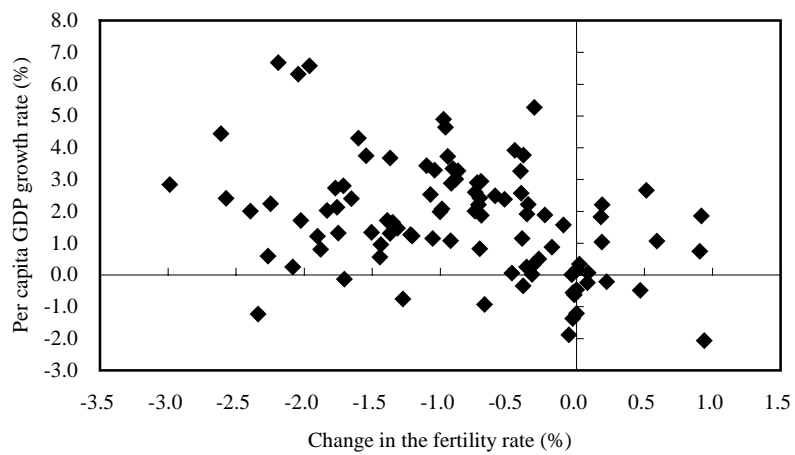
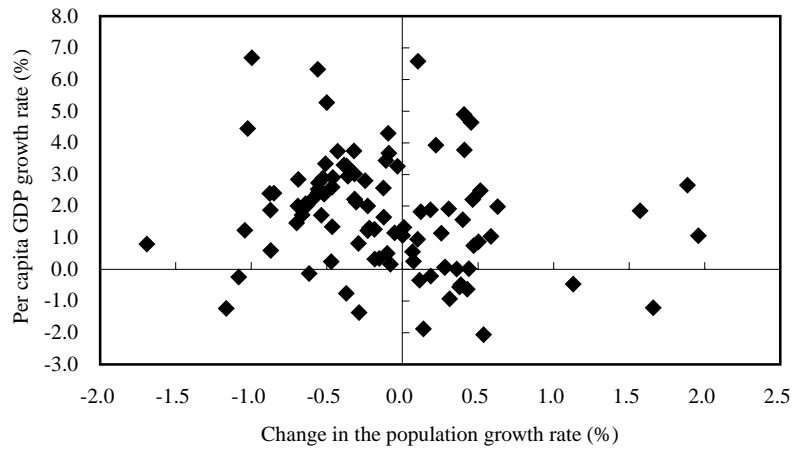
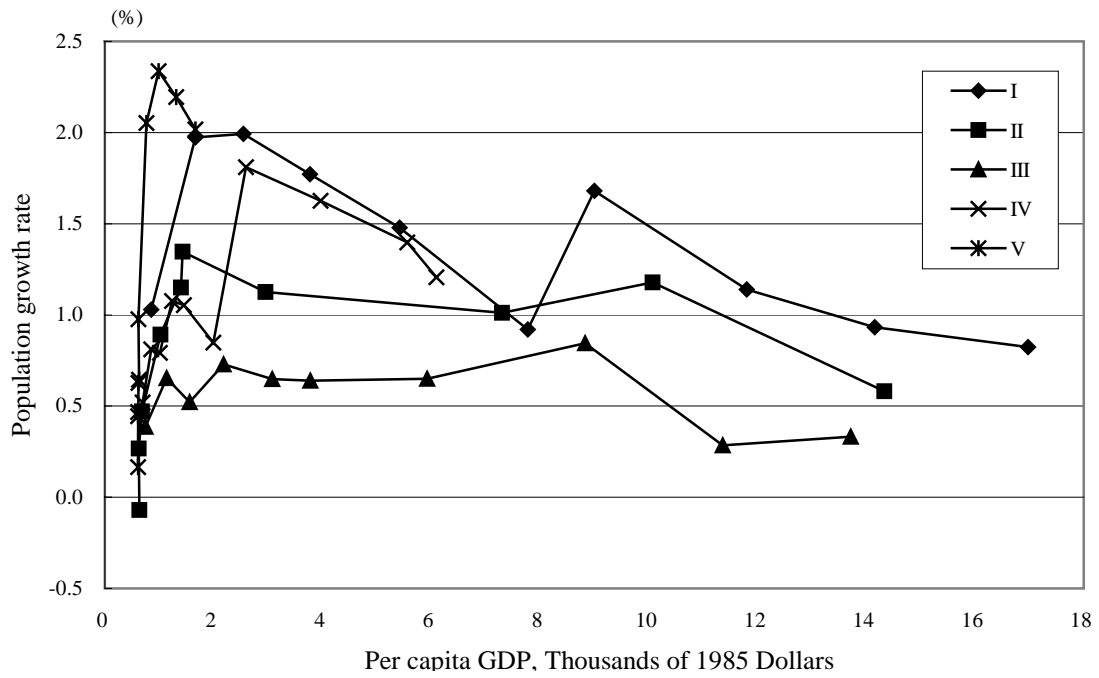


Figure 9. Demographic Transitions by Region, 1750-1990



UK, USA, Canada, Australia, New Zealand

Japan

France, Germany, Netherlands, Scandinavia

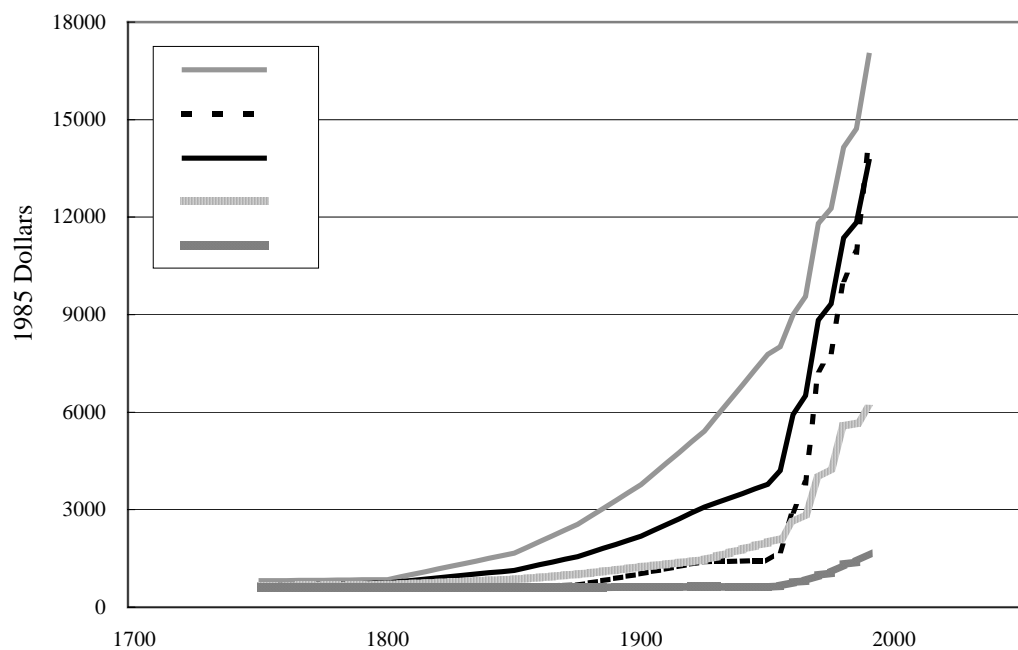
Rest of Western Europe, Latin America, Eastern Europe, Soviet Union

Asia (except Japan), Africa

Note: Each curve connects 10 points, indicating the average population growth rate of the country groups over the years 1800, 1850, 1875, 1900, 1925, 1950, 1960, 1970, 1980, and 1990.

Source: Lucas (2002)

Figure 10. Trends of GDP Per Capita by Region, 1750-1990



	1990 Population in millions
UK, USA, Canada, Australia, New Zealand	354
Japan	124
France, Germany, Netherlands, Scandinavia	184
Rest of Western Europe, Latin America, Eastern Europe, Soviet Union	986
Asia (except Japan), Africa	3590

Source : Lucas (2002)