2013

Demographic Changes and Economic Growth: Empirical Evidence from Asia

Sijia Song
Illinois Wesleyan University, ssong@iwu.edu

Demographic Changes and Economic Growth:

Empirical Evidence from Asia

Sijia Song

Advisor: Dr. Amit Ghosh

Illinois Wesleyan University

April 2013

Abstract

Asia has witnessed robust economic growth since the 1960s and the so-called "East Asian economic miracle". Even till today when the world's largest economies are suffering from debt and banking crises, emerging markets in Asia have managed to maintain rapid growth. In the meantime, significant demographic changes are taking place in Asian countries. Using an economic growth model, this article further examines the effects of demographic changes on economic growth in thirteen Asian countries during the period from 1965 to 2009. The results indicate negative effects of growth in the total population and the young population on economic growth while showing positive effects of growth in the working-age population and the working-age population ratio. These findings confirm that rapid economic growth in Asia can be attributed to the favorable demographic changes that took place there.

Keywords: *Asia*, *economic growth*, *demographic changes*, *population, pooled regressions*

1. Introduction

East Asia went through an economic “miracle” between the 1960s and the1990s, with income per capita nearly tripling. The four Asian Tigers, including Hong Kong, Singapore, Taiwan and South Korea, achieved impressive growth rates of more than 7% for more than three decades. While this prolonged period of economic growth is often attributed to export-oriented policies, investment in health and education, high savings rate and capital accumulation, many studies have examined the influence of demographic transition on economic growth in the region. This is an important issue as the timing of demographic transition in Asia largely coincided with the economic miracle (Bloom and Williamson, 1998).

The demographic transition is a process when a country transitions from high fertility and mortality rates to low fertility and mortality rates. Asia has experienced one of the fastest and most dramatic demographic transitions ever (Bloom and Williamson, 1998). Within half a century after the Second World War, Asia undertook rapid demographic changes that took the European countries more than a century to complete. This is because, with large investment in health, Asian countries were able to take advantage of medical technologies and practices that had already been developed. The demographic transition has major effects on the total population growth and age structure of a country. During the phase following the decline in mortality but preceding the decline in fertility, rapid growth of the total population takes place before settling at a stable level. More importantly, the age structure of the country will go through distinct phases of change. When the mortality rate first drops, the decline in infant and child mortality matters the most because the very young are the most vulnerable to diseases, leading to a large proportion of young population relative to the working-age population (Bloom and Williamson, 1998). However, as those children grow up, the society will move towards an age structure where the working-age population dominates, followed by a smaller young population due to decline in fertility. Eventually, the elderly population will become dominant as the society ages and the life expectancy improves.

Many studies on economic growth and demographic changes have found a significant relationship between the two. However, the debate continues until today despite the already vastly rich literature due to the fact that the findings are rather inconclusive and inconsistent depending on data, statistical methods and model specifications. Moreover, most studies on demographic transitions and economic growth in Asia focused only on East Asian countries and on the miracle period between the 1960s and the 1990s. Little research has been done to include the beginning decade of the twenty-first century. Thus, it is important to carry out further studies using the most updated data.

This is exactly the goal of this paper. The present study examines the effects of demographic changes on economic growth in China, Hong Kong, Japan, South Korea, Singapore, Indonesia, Malaysia, the Philippines, Thailand, India, Bangladesh, Pakistan and Sri Lanka, which covers East, Southeast and South Asia. The data span from 1965 to 2009. The longer period of study allows a clearer and more conclusive relationship between demographic changes and economic growth to emerge. It is worth pointing out that demographic changes can be affected in reverse direction by economic growth and some studies have examined this relationship, such as Bloom, Canning and Malaney (2000). However, this paper focuses only on the effects of demographic changes on economic growth.

Currently, as the world's biggest economies are suffering from economic stagnation due to sovereign debt and banking crises and mounting budget deficits, Asia is still experiencing robust growth. Besides the old Asian tigers, major emerging economies such as China, India and Indonesia are amongst the fastest developing economies in the world. On the other hand, most of the countries in this study have some sort of population control or family planning policies in place. Thus, further examining the relationship between demographic changes and economic growth in the region will have profound implications on the effectiveness of their population policies.

The rest of the paper proceeds as follows. In Section 2, I present some review of existing literature on demographic changes and economic growth, with particular reference to Asia. In Section 3, I analyze the general demographic trends of the countries covered in this study. Section 4 contains the theoretical framework and derivation of the estimation equations, followed by descriptive data and econometric results in Section 5.

The last section presents the conclusions.

2. Literature Review

Early studies focused solely on the relationship between economic growth and total population growth. However, a definitive relationship cannot be stated due to inconsistent findings amongst studies. As Kelley and Schmidt (1995: 543) put it,

> "Possibly the most influential statistical finding that has shaped the 'population debates' in recent decades is the failure, in more than a dozen studies using cross-country data, to unearth a statistically significant association between the growth rates of population and of per capita output."

Specifically, studies using cross-country data found the impact of population growth on per capita output growth insignificant in the 1960s and 1970s and negative in the 1980s (Kelley and Schmidt, 1994). As a result, there has been a divide regarding a definitive relationship between total population growth and economic growth.

'Population pessimists' believe population is detrimental to economic development, as it tends to hike up demographic overhead while overwhelming capital accumulation and technological progress (Coale and Hoover 1958). On the other hand, 'population optimists' or 'boomsters' stress the importance of population growth in advancing productivity, promoting technological innovation and capturing economies of scale (Boserup, 1981, Hirschman 1958, Kuznets 1967 and Simon 1981). Still, some studies found no significant effects of population growth on economic growth, giving rise to 'population neutralism'. As a reconciliation of the three positions, some state that the different perspectives of the relationship between population growth and economic growth really just reflect different phases a country goes through (Kelley and Schmidt 1994, Weeks 1996). A reversed U-shaped curve best explains this position that population growth tends to increase with economic growth at early stages of development while flattening out and eventually decreasing at higher levels of economic development.

Theoretically, the Solow-Swan growth model establishes the linkage between population growth and economic growth (Barro and Sala-i-Martin, 2004). This is also the model that many previous studies on the subject matter adopted. In this neoclassical model, which assumes constant returns to scale and diminishing marginal returns to factors of production, the output per worker is a function of capital per worker, which is determined by savings per worker, population growth and capital depreciation rates. While at the steady-state output per worker is constant and the total output grows at the rate of population growth, the population growth rate is critical in determining the steady state in the first place. If the population growth rate decreases, the steady-state level of output per worker increases. Thus, the Solow-Swan model theoretically predicts a negative impact of population growth on economic growth at steady state.

Empirically, to break the impasse in the population debate, researchers have shifted their attention to the changes in demographic components that underlie the overall population growth. One of the most important studies is on India by Coale and Hoover (1958) using data analysis and projections. By looking at population size, age distribution and corresponding growth rate, they point out that a larger population may lead to falling per capita income because of diminishing returns to scale although optimal population size yielding maximum per capita output can shift with the passage of time. Furthermore, a higher rate of population growth implies a higher level of investment needed to achieve a given per capita output or, in other words, a decrease in the capital available for each worker if the supply of capital is inelastic. This prevents an increase in the average productivity of the work force and, hence, the average per capita income. While the distribution of population by age is mainly influenced by fertility, with the same resources and capital available, a lower birth-rate population should have higher per capita output due to a smaller fraction of dependent children (Coale and Hoover, 1958).

Using cross-country analysis and employing a growth regression for a panel of 78 countries, Bloom and Williamson (1998) examine the effects of demographic transitions on economic growth, with a particular focus on East Asia's economic miracle during the period from 1965 to 1990. They initially find mixed relationships between population growth and growth of GDP per capita depending on the model specification. However, when the growth rate of the economically active population is added into the regression, the study confirms a negative impact of the total population growth and a positive impact of working-age population growth on economic growth. While the two growth factors affect economic growth in opposite directions, higher growth rates of GDP per capita appear when the growth rate of the economically active population exceeds that of the overall population. The study indicates that as much as one-third of the East Asian economic miracle can be explained by the region's demographic transitions in that period.

In a later study using data of 70 countries covering the same period from 1965 to 1990, Bloom, Canning and Malaney (2000) further establish a two-way causality between demographic changes and economic growth. Using OLS regressions, they confirm the negative effect of growth in total population and positive effect of growth in working-age population on economic growth. In reverse, they further find a negative impact of higher income on fertility rates. For East Asia, they reason that the region's success was due to favorable demographic and economic characteristics that mutually reinforced each other and promoted a virtuous cycle of cumulative causation.

In general, existing literature has confirmed the importance of demographic changes in stimulating a country's economic growth and stated at least theoretically a negative relationship between the total population growth and economic growth, despite mixed empirical results. Changes in age structure mainly influenced by reduced fertility also play a significant role in economic growth when a decrease in the young dependent population growth leads to a higher fraction of working-age population.

3. Demographic Trends in Asia

This study looks at data of thirteen countries from East, Southeast and South Asia, which cover the period from 1965 to 2009. Following previous studies, the present analysis will decompose the overall population growth into individual components to examine their effects on economic growth. Thus, it is important to first analyze the changes in various components that constitute the demographic transition. For all the countries in this study, the population growth rates dropped significantly between 1965 and 1999 except for Singapore. The population growth rates for East Asian countries were well below 1 percent by 2009. Especially noticeable is Japan with a negative growth rate of -0.11 percent, meaning that the total population was dwindling. This is mainly due to the fact that the Japanese population was fast ageing while the fertility rate was well below replacement level. As mentioned before, almost all the countries in this study have government sponsored family planning programs in place, despite differences in intensity. Among the programs, the most renowned are those of China and India. Fertility rates in these two countries more than halved since the adoption of family planning policies. Thus, the family planning policies certainly played their role in reducing population growth by bringing down fertility rates.

Besides changes in total population, significant changes also took place in the different components of the population, namely the young population ages below 15, the working-age population ages 15-64 and the elderly population ages 65 and above. In the past four and a half decades, the working-age population of most Asian countries has been continually growing, achieving an average of 2.3 percent in annual growth rate for the countries in this study. However, the young population has been growing at much slower rates than the working-age population in Asia. Moreover, East Asian and some Southeast Asian countries have witnessed negative rates of young population growth for the most part since 1965. A low growth rate of the young population is associated with reduction in fertility. All of the countries in this study, except for Japan and Pakistan, saw their fertility rates drop more than half from 1965 to 2009, while six countries had a fertility rate below the replacement level by 2009. This could be attributed to the family planning programs in Asian countries as well as increasing education and employment opportunities for women. On the other end of the age spectrum is the elderly population. The cohort of elderly population has had a high growth rate in Asia with an average of 3.5 per cent for all countries in this study from 1965 to 2009. Indeed, population aging is one of the major concerns for countries going through demographic transitions. Once the large portion of working-age population retires, followed by a smaller population to replace them due to low fertility, the percentage of the elderly population in a country will increase rapidly and significantly. This is what Japan is currently experiencing. While its working-age population has been growing at a negative rate ever since 1996, the share of the elderly population has nearly quadrupled from 6.3 per cent in 1965 to 23.4 percent in 2009. Nevertheless, despite fast growth, the elderly population was not a dominant demographic force in most Asian Countries. In the period of 1965-2009, the elderly population was below 10 percent of total population for all countries in this study, except for Japan, Hong Kong and South Korea.

As a result of the trends in different age groups, the proportion of working-age population in most of the Asian countries has grown over 1965-2009 with the exception of Japan. That means, the size of working-age population not only grew in absolute terms, but also in relative terms. The percentage of the young population, on the other hand, has been dwindling. The age dependency ratio, calculated as the young and the elderly population divided by the working-age population, reflects how many people each working-age person has to support. Increasing working-age population, slowly growing or decreasing young population and small proportion of the elderly population have led to decreases in the age dependency ratios in Asian countries, except, again, in Japan where the elderly population is a dominant force. Tables 1-3 below, categorized by region, contain the demographic variables of each country that potentially affect economic growth. Values of 1965 and 2009 are shown for comparison.

Table 1. Demographic variables affecting economic growth: East Asia, 1965 and 2009

Indicator Name	China	China	Hong Kong	Hong Kong	Japan	Japan	South Korea	South Korea
Year	1965	2009	1965	2009	1965	2009	1965	2009
GDP Per Capita (current US$)	100.14	2208.40	5488.83	34216.93	11376.56	38242.02	1351.03	15325.94
Population growth (annual %)	2.38	0.51	2.63	0.37	1.07	-0.11	2.46	0.47
Population ages 0-14 (% of total)	40.26	19.85	39.63	11.92	25.77	13.44	43.00	16.95
Population ages 0-14 Growth (Annual %)	2.42	-1.57	1.61	-3.67	-1.69	-0.71	3.14	-2.70
Population ages 15-64 (% of total)	56.04	72.11	57.22	75.53	67.96	64.52	53.62	72.28
Population ages 15-64 growth (Annual %)	2.44	0.91	3.25	0.90	1.98	-0.89	2.10	0.74
Population ages 65 and above (% of total)	3.70	8.03	3.15	12.55	6.27	22.05	3.38	10.77
Population ages 65 and above Growth (Annual %)	1.81	2.18	5.52	1.23	3.17	2.62	0.50	4.02
Age dependency ratio (% of working-age population)	78.44	38.67	74.76	32.40	47.15	55.00	86.51	38.36
Fertility rate (Birth per woman)	5.87	1.61	4.55	1.06	2.14	1.37	5.16	1.15

Source: World Bank. Annual growth rates of the three age groups are author’s calculations.

Table 2. Demographic variables affecting economic growth: Southeast Asia, 1965 and 2009

Indicator Name	Singapore	Singapore	Indonesia	Indonesia	Malaysia	Malaysia	Philippines	Philippines	Thailand	Thailand
Year	1965	2009	1965	2009	1965	2009	1965	2009	1965	2009
GDP Per Capita (current US$)	2782.51	28949.86	195.53	1089.72	966.29	4901.55	758.33	1307.14	389.94	2531.23
Population growth (annual %)	2.41	3.02	2.54	1.04	3.00	1.61	3.13	1.68	3.04	0.64
Population ages 0-14 (% of total)	43.68	17.89	42.20	27.36	46.43	30.75	47.45	35.81	43.63	20.90
Population ages 0-14 Growth (Annual %)	1.69	0.60	3.54	-0.18	2.95	0.29	3.03	0.69	3.51	-1.16
Population ages 15-64 (% of total)	53.68	73.34	54.47	67.17	50.38	64.61	49.54	60.62	53.01	70.39
Population ages 15-64 growth (Annual %)	2.80	3.51	1.89	1.44	3.15	2.11	3.35	2.20	2.71	0.95
Population ages 65 and above (% of total)	2.65	8.77	3.33	5.47	3.19	4.64	3.01	3.57	3.36	8.70
Population ages 65 and above Growth (Annual %)	8.14	4.50	1.51	2.56	2.66	3.85	2.69	3.39	3.67	2.59
Age dependency ratio (% of working-age population)	86.30	36.35	83.59	48.89	98.47	54.79	101.85	64.97	88.66	42.06
Fertility rate (Birth per woman)	4.70	1.22	5.61	2.15	5.77	2.67	6.78	3.19	6.13	1.60

Source: World Bank. Annual growth rates of the three age groups are author’s calculations.

Table 3. Demographic variables affecting economic growth: South Asia, 1965 and 2009

Indicator Name	India	India	Bangladesh	Bangladesh	Pakistan	Pakistan	Sri Lanka	Sri Lanka
Year	1965	2009	1965	2009	1965	2009	1965	2009
GDP Per Capita (current US$)	193.29	735.63	277.27	532.08	236.70	653.61	286.74	1223.69
Population growth (annual %)	2.11	1.41	3.02	1.06	2.56	1.81	2.37	1.15
Population ages 0-14 (% of total)	41.73	30.97	44.66	31.92	41.58	35.89	40.83	24.87
Population ages 0-14 Growth (Annual %)	2.30	0.16	3.34	-0.79	3.21	0.39	1.92	1.13
Population ages 15-64 (% of total)	55.09	64.18	52.01	63.55	54.52	59.84	55.28	67.19
Population ages 15-64 growth (Annual %)	1.95	1.93	2.81	1.94	2.24	2.64	2.95	0.87
Population ages 65 and above (% of total)	3.18	4.85	3.34	4.54	3.91	4.27	3.89	7.95
Population ages 65 and above Growth (Annual %)	3.12	2.86	3.42	2.35	1.11	2.76	-0.33	3.67
Age dependency ratio (% of working-age population)	81.51	55.82	92.29	57.37	83.42	67.11	80.88	48.84
Fertility rate (Birth per woman)	5.78	2.66	6.87	2.30	6.60	3.50	4.96	2.33

Source: World Bank. Annual growth rates of the three age groups are author’s calculations.

4. The Theoretical Framework

This study uses growth regression equations derived from the Solow-Swan model. I follow Bloom and Williamson (1998), and Bloom, Canning and Malaney (1999, 2000) in deriving the estimation equations because their study on demographic transitions and economic growth in Asia is largely applicable here. The Solow-Swan model predicts conditional convergence where each country's income per capita continually approaches its steady state (Barro and Sala-i-Martin, 2004). A larger difference between a country's steady-state and current levels of output per worker indicates a faster growth rate of that country. Therefore, if we assume an exponentially growing production per worker function, $y = Ak^{\alpha}$, where A represents the total factor productivity, α the output elasticity of capital, and k the capital stock per worker, the average growth rate of output per worker is proportional to the difference between the output per worker at the steady state and that of the initial period. That is,

$$g_y = \lambda(y^* - y) \qquad (1)$$

where g_y is the growth rate of output per worker, y^* the natural logarithm of the steady-state output per worker, y the natural logarithm of the initial output per worker, and λ the rate of convergence. The steady state is determined by a set of factors, X, that influence total factor productivity and capital accumulation, which can be represented as:

$$y^* = X\beta \qquad (2)$$

where β is a vector of parameters. The typical variables included in the vector X are life expectancy in the initial period, gross capital formation in the initial period, average years of secondary schooling in the initial period, a measure of trade openness, a measure of institutional quality, and geographic variables indicating a country's proximity to the ocean coastline and the proportion of land area within the geographic tropics. Substituting equation (2) into (1) yields:

$$g_y = \lambda\beta X - \lambda y \quad (3)$$

The model can be transformed from output per worker (y) to output per capita (ŷ) which is a better indicator of the overall welfare for a country, used in most empirical researches. Since

$$\frac{Y}{P} = \frac{Y}{L}\frac{L}{P} \quad (4)$$

where Y is the total output, P the total population, and L the number of workers, if we take natural logarithm of both sides of the equation, the expression can be converted to

$$\hat{y} = y + Ln(\frac{L}{P}) \quad (5)$$

where ŷ is the natural logarithm of the initial output *per capita*, y, again, the natural logarithm of the initial output *per worker*, and (L/P) workers per capita in the initial period. Following Bloom and Williamson (1998) and Yu (2011), this can be expressed in growth rate terms as

$$g_{\hat{y}} = g_y + g_{workers} - g_{population} \quad (6)$$

By substituting g_y and y in equation (3) with identities (5) and (6) and adding an error term, the estimation equation for the growth rate of income per capita is

$$g_{\hat{y}} = \delta_0 + \delta_1 X + \delta_2 \hat{y} + \delta_3 g_{workers} + \delta_4 g_{population} + \delta_5 Ln(\frac{L}{P}) + \varepsilon \qquad (7)$$

Where $g_{workers}$ and $g_{population}$ are the growth rates of the work force and the total population respectively. This equation serves the purpose of my research question as it captures the effects of work force growth and total population growth.

In order to understand specifically how the changes in dependent population affect economic growth in Asia, I further modify the estimation equation, following Bloom and Williamson (1998), by inserting the growth rates of the young population and the elderly population to replace the growth rate of the total population. Then the estimation equation becomes

$$g_{\hat{y}} = \sigma_0 + \sigma_1 X + \sigma_2 \hat{y} + \sigma_3 g_{workers} + \sigma_4 g_{youth} + \sigma_5 g_{elderly} + \sigma_6 Ln(\frac{L}{P}) + \varepsilon \qquad (8)$$

where g_{youth} and $g_{elderly}$are growth rates of the young population and the elderly population respectively. In this way, the equation captures the effects of growth rates of all age groups on economic growth.

To further explore the effects of changes in age structure on economic growth, I follow Yu (2011) and Mody and Aiyar (2011) to combine the growth rates of the total population and the working-age population in equation (7) into the growth rate of the ratio of the working-age population to the total population, $g_{W/P}$. The equation then becomes

$$g_{\hat{y}} = \gamma_0 + \gamma_1 X + \gamma_2 \hat{y} + \gamma_3 g_{W/P} + \gamma_4 Ln(\frac{L}{P}) + \varepsilon \qquad (9)$$

5. Empirical Models and Results

Multiple regressions were run based on different model specifications. The first model uses equation (7) as follows,

$$g_{\hat{y}} = \delta_0 + \delta_1 X + \delta_2 \hat{y} + \delta_3 g_{workers} + \delta_4 g_{population} + \delta_5 Ln(\frac{L}{P}) + \varepsilon \qquad (7)$$

The expected sign for the growth rate of the total population is negative following the Solow-Swan model and several theories put forth in the literature review section. The expected sign for the growth rate of the working-age population is positive, as people in that group are more economically active in the sense that they work and save more than they consume (Higgins and Williamson 1997, Bloom and Williamson 1998). The second model looks at the effects of individual age groups on economic growth and uses equation (8),

$$g_{\hat{y}} = \sigma_0 + \sigma_1 X + \sigma_2 \hat{y} + \sigma_3 g_{workers} + \sigma_4 g_{youth} + \sigma_5 g_{elderly} + \sigma_6 Ln(\frac{L}{P}) + \varepsilon \qquad (8)$$

In this case, the growth rates of both young population and elderly populations are expected to have negative signs as these two age groups are considered dependent population that consumes more than they produce and depends on the output and savings generated by the working-age population (Higgins and Williamson 1997, Bloom and Williamson 1998). In the third model, how age structure affects economic growth gets examined, using equation (9),

$$g_{\hat{y}} = \gamma_0 + \gamma_1 X + \gamma_2 \hat{y} + \gamma_3 g_{W/P} + \gamma_4 Ln(\frac{L}{P}) + \varepsilon \tag{9}$$

The working-age population ratio indicates the proportion of the working-age population in the total population. This is equivalent to the dependency ratio in a country because the larger the dependent population, the smaller the working-age population ratio. Mathematically, the working-age population ratio is the reciprocal of one plus the dependency ratio. The expected sign for the growth rate of the working-age population ratio is positive as a relative larger and faster growing working-age population tends to promote economic growth.

The expected signs for the control variables, included in X in the equations, shall follow the traditional growth literature, where the coefficients of life expectancy, gross capital formation, trade openness, average schooling, proximity to coastline and quality of institution all have positive signs whereas the coefficient of land area within tropics takes on a negative sign. The coefficient of initial GDP per capita relative to that of the U.S. is expected to have a negative sign due to conditional convergence predicted by the Solow-Swan model.

5.1 Data

All the data in this study are sourced from or created with the World Development Indicators except for average years of secondary schooling from Barro and Lee (forthcoming), the two geographic variables and the index of public institution from

Gallup, Sachs and Mellinger (1999). The index of public institution is based on an index created by Knack and Keefer (1995), which reflects efficiency of the government bureaucracy, the extent of corruption, efficacy of the rule of law, presence of expropriation and risk of repudiation of contracts by the government (Gallup, Sachs and Mellinger, 1999). The index here is scaled 0-10. Higher values of the index indicate better quality of public institution. Furthermore, the data for the two geographic variables and quality of public institution do not vary over time.

The data cover the period from 1965 to 2009 for each of the thirteen countries. Following convention, they are further divided into nine five-year periods. The average growth rates of GDP per capita, total population, young population, working-age population, elderly population and working-age population ratio are used in the regressions. The rest of the variables take the values for the beginning year of each period. For instance, for the 1965-1969 period, all the growth rates are five-year averages while the other variables use data of 1965.

Table 4 provides a complete description of the data with sources. It is noteworthy that the Asian countries in this study achieved an average of 3.83 per cent in GDP per capita growth. While the total population grew at an average of 1.840 per cent, the working-age population grew at a faster rate of 2.330 percent and the young population only at 0.567 per cent. Working-age population ratio on average grew by 0.46 percent.

Table 4. Variable Definitions and Selected Descriptive Statistics

Variable	Source	Minimum	Maximum	Mean	Std. Deviation
GDP per capita growth in five-year period (%)	World Bank	-1.434	10.803	3.831	2.566
Log initial GDP per capita as a ratio of US GDP per capita	World Bank	-5.091	.190	-2.867	1.576
Log initial ratio of working-age to total population	World Bank	3.903	4.298	4.099	.109
Total population growth (%)	World Bank	-.032	3.597	1.840	.812
Working-age population growth (%)	World Bank	-.708	4.470	2.330	.961
Young population growth (%)	World Bank	-3.700	3.498	.567	1.645
Elderly population growth (%)	World Bank	.972	8.622	3.504	1.183
Working-age population ratio growth (%)	World Bank	-.677	1.805	.460	.484
Life expectancy (years)	World Bank	41.886	81.925	65.959	8.637
Log gross capital formation (log domestic investment as % GDP)	World Bank	1.816	3.806	3.199	.349
Openness (log imports and exports as a percentage of GDP)	World Bank	1.670	6.064	3.999	.980
Average years of secondary schooling (years)	Barro and Lee (forthcoming)	1.250	11.467	5.948	2.712
Proportion of land area within 100km of the ocean coastline (%)	Gallup, Sachs and Mellinger (1999)	5.171	100.000	64.157	37.060
Proportion of land area within the geographic tropics (%)	Gallup, Sachs and Mellinger (1999)	.000	100.000	61.128	44.638
Quality of institution index (0-10)	Gallup, Sachs and Mellinger (1999)	2.740	9.367	5.748	2.046

5.2 Econometric Results

The econometric results from the OLS regressions using various model specifications are reported in Table 5 below. Again, the analyses are based on the data for 13 countries in East, Southeast and South Asia, which cover nine five-year periods from 1965 to 2009.

Table 5. Regression results explaining the economic growth in Asia: 1965-2009

Variable	Model 1	Model 2	Model 3
Constant	-27.246*	-20.954	-36.408***
	(15.864)	(16.264)	(13.546)
Log initial GDP per capita as a ratio of US GDP per capita	-1.935***	-2.191***	-1.929***
	(.444)	(.437)	(.438)
Log initial ratio of working-age to total population	2.640	.524	4.851
	(4.144)	(4.173)	(3.592)
Growth rate of total population	-1.707***		
	(.491)		
Growth rate of working-age population	1.264***	.226	
	(.456)	(.347)	
Growth rate of young population		-.527***	
		(.150)	
Growth rate of elderly population		.217	
		(.172)	
Growth rate of working-age population ratio			1.457***
			(.404)
Life expectancy	-.015	-.033	-.019
	(.069)	(.067)	(.067)
Log gross capital formation	1.768**	1.994**	1.722**
	(.796)	(.777)	(.810)
Openness	1.345***	1.406***	1.174***
	(.413)	(.408)	(.365)
Average years of schooling	-.218	-.169	-.158
	(.214)	(.203)	(.200)
Land area within 100km of coastline	.031**	.034**	.031**
	(.016)	(.016)	(.015)
Land area within tropics	-.027***	-.029***	-.027***
	(.009)	(.009)	(.009)
Quality of institution	1.016***	1.052***	1.010***
	(.228)	(.225)	(.231)
Adjusted R^2	.460	.460	.459
F-statistic	9.738***	9.007***	10.594***
Durbin-Watson Statistic	1.753	1.775	1.758

Note: Based on 114 observations from five-year panel of 13 countries over the period 1965-2009. The dependent variable is the five-year average growth rate of GDP per capita. Estimates are from ordinary least squares. Heteroskedasticity-consistent standard errors are reported in parentheses.

*Significant at the 10 percent level

**Significant at the 5 percent level

***Significant at the 1 percent level

Based on the estimation equation derived from the Solow-Swan model, Model 1 in Table 5 shows the effects of the total population growth as well as the working-age population growth on economic growth in Asia. Although there have been inconsistent results in previous studies regarding the effect of total population growth on economic growth, I find a significant and negative coefficient of -1.707. This implies a one-percentage point increase in total population growth lowers economic growth by 1.707 percentage points. A higher fraction of working-age population at the beginning of the period does not seem to have a significant impact on the economic growth rate of that period. However, the growth rate of the working-age population during that period does have a strong, positive effect. The coefficient shows that one percentage point increase in the working-age population growth rate brings a 1.264 percentage point increase in the GDP per capita growth. While total population growth and working-age population growth affect economic growth in two opposite directions, Asian countries enjoyed rapid economic growth as their working-age population generally grew at faster rates than the total population, making the positive effect of growing working-age population overshadow the negative effect of the overall population growth.

Model 2 in Table 5 contains the growth rates of the dependent groups in place of the growth rate of the overall population. The expectation of signs is partially met in that the coefficient of the young population growth rate is significant and negative. The result predicts a 0.527 percentage point decrease in the growth rate of GDP per capita with one percentage point increase in the young population growth rate. As mentioned in Section 3, the 13 countries in this study had decreasing or negative growth rates of the young population for the most part between 1965 and 2009, which favorably contributed to the rapid economic growth in Asia. The strong effect of reduction in young population growth stems most directly from sharp drop in fertility rate in Asian countries, shown in Tables 1-3, due to both the natural process of demographic transitions and the government facilitated programs. The coefficient of the natural logarithm of workers per capita at the beginning of each five-year period is again insignificant in relation to the GDP per capita growth in that period. However, while the coefficient of the working-age population growth rate appears significant in Model 1, it becomes insignificant in Model 2. Also insignificant is the coefficient of the elderly population growth rate. This could indicate the predominance of the young population in Asia as a demographic force in affecting economic growth. Since the proportion of the elderly population has been low with less than 10% in most Asian countries, the unfavorable effect of growing elderly population should be relatively minor compared to the effect of the young population. Therefore, the overall dependent population yielded a favorable effect on the economic growth in Asia mainly stemming from low, even negative, growth rates of the young population.

Model 3 examines the effect of age structure on economic growth. The coefficient of the growth rate of the working-age population ratio is significant and positive, confirming the importance of a relatively large working-age population, as opposed to the young and elderly population, in promoting economic growth. As shown in Section 3, all the countries except for Japan witnessed growth in the relative size of the working-age population from 1965 to 2009, which had favorable impact on economic growth. The regression results indicate that one percentage point increase in the growth rate of the working-age population ratio raises GDP per capita growth by 1.457 percentage points.

It is noteworthy that the results for the control variables are largely consistent with the economic growth literature. The coefficient of natural logarithm of initial GDP per capita relative to that of the U.S. at the beginning of each five-year period is significantly negative in all three models. That is, a lower level of GDP per capita at the beginning of a period is associated with a higher economic growth rate during that period. This confirms the conditional convergence predicted by the Solow-Swan growth model that the further away a country is from its steady-state level of income, the faster it grows to approach the steady state. Also significant and positive in all three models are the coefficients of gross capital formation, which capture the effect of factor accumulation. This is consistent with the assumption of the Solow-Swan model in that higher capital formation promotes economic growth. The results show that one percent increase in gross capital formation increases GDP per capita growth by 1.7-2 percentage points. The coefficients of the openness index, which is calculated as the natural logarithm of a country's exports and imports as a percentage of its GDP, are strong and positive in all three models, confirming the importance of trade in a country's economic growth. One point increase in the openness index promotes economic growth by 1.2-1.4 percentage points. Indeed, trade openness is often cited as one of the most important reasons for rapid economic growth in Asia. Besides the more advanced economies such as Japan, South Korea and Hong Kong that depend heavily on trade, the emerging markets such as China and India are playing an increasingly important role in international trade.

The geographic variables prove to have significant effects on economic growth in Asia as well. Proximity to ocean coastline proves beneficial to economic growth for one percentage point increase in the proportion of land area within 100km of ocean coastline promotes economic growth rate by .031-.034 percentage points. This is because closeness to ocean coastline usually means more engagement in trade, higher degree of industry specialization and more convenient means of transportation. On the other hand, being within tropics has a negative impact for one percentage point increase in the proportion of land area within geographic tropics decreases economic growth by .027-.029 percentage points. Indeed, tropic areas are more often associated with harsh weather conditions and epidemics of diseases. This could potentially explain, in part, the relatively slower economic growth of South Asia compared to East and Southeast Asia. The positive sign for the coefficient of institutional quality shows that the higher the quality of a country's public institution, the more rapidly its economy will grow. Rather surprisingly, the coefficients of life expectancy and average secondary schooling are insignificant in all three models.

As an alternative econometric specification, OLS regressions were run using pooled data that span from 1965 to 2011 for these thirteen countries. The variables in the three models are the same as those used for 5-year average regressions. The results remain largely unchanged and are shown in Appendix Table 1.

6. Conclusion

This study shows that over the last four and a half decades, economic growth in Asia was significantly affected by demographic changes, besides the factors often cited in traditional literature on economic growth. Total population growth showed a negative relationship with GDP per capita growth whereas the working-age population growth had a positive impact. These relationships proved beneficial for Asian countries as most of them enjoyed decreases in total population growth and robust growth in the working-age population. Even more favorable for most of these Asian countries in the sample is the fact that they have had faster growing working-age population compared to the total population. This means the positive impact of the former on economic growth outweighed the negative impact of the latter. When looking at the changes in different age groups, the young population had a significant and negative relationship with economic growth. This again benefits Asian countries as they have seen decreasing or even negative growth in the young population over 1965 and 2009. The effect of the elderly population growth is insignificant mainly because the elderly population was not yet a dominant demographic force in most Asian countries, except for Japan.

The results also confirm the effectiveness of population control policies and family planning programs in promoting economic growth during the period of 1965-2009. Most Asian countries have some family planning policies in place, which played an important role in slowing down the total population growth and the young population growth while sustaining a robust growth in the working-age population, in both absolute and relative terms. This forms a contrast to earlier belief that population growth would promote economic growth by improving productivity, which gave rise to policies that favored high fertility rate. However, this does not seem to be the case anymore, partly because with fast development of technology, the benefit of added productivity from a fast growing population is outweighed by a lower labor-to-capital ratio, which depresses economic growth.

Nevertheless, it is worth pointing out that such policies may work against economic growth in the future. This is because, as the population ages and the elderly population becomes the dominant demographic force, continued low fertility will eventually lead to smaller working-age population compared to the elderly population and higher dependency ratio.

Further research should expand the sample size and countries observed to find a more general relationship between demographic changes and economic growth. It should also further examine the reverse effect of economic growth on demographic changes to establish more comprehensive causality between them while taking into account the potential problem of endogeneity associated with running regressions using a similar growth model.

Appendix Table 1. Pooled OLS results explaining the economic growth in Asia: 1965-2011

Variable	Model 1	Model 2	Model 3
Constant	-20.248	-15.880	-35.647**
	(15.441)	(15.755)	(14.431)
Log initial GDP per capita as a ratio of US GDP per capita	-1.103***	-1.189***	-1.193***
	(.305)	(.302)	(.298)
Log initial ratio of working-age to total population	1.350	.196	4.825
	(3.848)	(3.863)	(3.855)
Growth rate of total population	-1.431***		
	(.406)		
Growth rate of working-age population	0.849**	-.023	
	(.352)	(.262)	
Growth rate of young population		-.430***	
		(.134)	
Growth rate of elderly population		.144	
		(.156)	
Growth rate of working-age population ratio			1.061***
			(.349)
Life expectancy	-.087	-.102	-.090
	(.070)	(.071)	(.070)
Log gross capital formation	4.838***	4.986***	4.696***
	(.693)	(.703)	(.697)
Openness	1.094***	.998***	1.115***
	(.369)	(.363)	(.369)
Average years of schooling	-.249	-.262	-.098
	(.169)	(.168)	(.167)
Land area within 100km of coastline	.023**	.026**	.020*
	(.011)	(.011)	(.011)
Land area within tropics	-.018***	-.018***	-.018***
	(.005)	(.005)	(.005)
Quality of institution	0.496***	.479***	.491***
	(.150)	(.150)	(.152)
Adjusted R^2	.292	.288	.285
F-statistic	20.99***	20.2***	21.9***
Durbin-Watson Statistic	1.542	1.539	1.548

Note: Based on 591 observations from 13 countries over the period 1965-2011. The dependent variable is the growth rate of GDP per capita. Estimates are from ordinary least squares. Heteroskedasticity-consistent standard errors are reported in parentheses.
*Significant at the 10 percent level
**Significant at the 5 percent level
***Significant at the 1 percent level

References

Barro, R. J. & Lee, J.-W.. A New Data Set of Educational Attainment in the World, 1950–2010. *Journal of Development Economics (2012)*, http://dx.doi.org/10.1016/j.jdeveco.2012.10.001

Barro, R. J. & Sala-i-Martin, X. (2004). *Economic Growth.* Cambridge, Mass.: MIT Press.

Bloom, D. E., Canning, D., & Malaney, P. N. (1999). Demographic Change and Economic Growth in Asia. Center for International Development Working Paper No. 15. Harvard University, Cambridge, MA.

Bloom, D. E., Canning, D., & Malaney, P. N. (2000). Population Dynamics and Economic Growth in Asia. *Population and Development Review*, *26*, 257-290.

Bloom, D. E., & Williamson, J. G. (1998). Demographic Transitions and Economic Miracles in Emerging Asia. *The World Bank Economic Review*, 12(3), 419-455.

Boserup, E. (1981). *Population and Technological Change: A Study of Long-Term Trends*. Chicago: University of Chicago Press.

Coale, A. J. & Hoover, E. M. (1958). *Population Growth and Economic Development in Low-Income Countries: A Case Study of India's Prospects*. Princeton: Princeton University Press.

Higgins, M., & Williamson, J. G. (1997). Age Structure Dynamics in Asia and Dependence on Foreign Capital. *Population and Development Review*, *23*(2), 261-293.

Hirschman, A. O. (1958). *The Strategy of Economic Development.* New Haven: Yale University Press.

Gallup, J., Sachs, J. D., & Mellinger, A. D. (1999). Geography and Economic Development. http://hdl.handle.net/1902.1/14428 UNF:5:e8nAF9donDeI49Ec5c4Heg== Murray Research Archive [Distributor] V1 [Version]

Kelley, A. C., & Schmidt, R. M. (1994). *Population and Income Change: Recent Evidence*. Discussion Paper, no. 249.

Kelley, A. C., & Schmidt, R. M. (1995). Aggregate Population and Economic Growth Correlations: The Role of the Components of Demographic Change. *Demography*, 32(4), 543-555.

Knack, S., & Keefer, P. (1995). Institutions and Economic Performance: Cross-Country Tests Using Alternative Institutional Measures. *Economics and Politics*, *7*(3), 207-227.

Kuznets, S. (1967). Population and Economic Growth. *Proceedings of the American Philosophical Society, 111 (June), 170-93*.

Mody, A., & Aiyar, S. (2011). The Demographic Dividend: Evidence from the Indian States. IMF Working Paper, WP/11/38.

Simon, J. (1981). *The Ultimate Resource*. Princeton: Princeton University Press.

Weeks, J. R. (1996) *Population: an Introduction to Concepts and Issues.* Belmont : Wadsworth Pub. Co.

Yu, Z. (2011). Demographic Dynamics and Economic Take-Off: Economic Impact of China's Population-Control Policies. *Chinese Economy*, *44*(1), 72-90.