Older? Richer? A Study of the Relationship between Population Aging and Economic Growth in Asia

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Abstract

This paper investigated the relationship between population aging and economic growth based on the panel data for 16 Asian countries over the period 1960 to 2014. According to the research of Bloom and Canning (2004)[5] I derived the model for old-age share and economic growth with other factors. Those factors, which may affect economic growth, are capital stock, human capital, population growth, life expectancy, fertility rate. Four regional dummy variables are also added in this paper. Those four regions are West Asia, East Asia, South Asia, and South East Asia. For the panel data regression, pooled OLS model is used for five different specifications, namely basic specification, population growth specification, demographic specification, geographic specification, and all-variable specification. The results of those different specifications show that population aging has negative effects on economic growth. All econometric calculations are operated via R , and based on the study of Yves and Millo (2008)[13], we downloaded the package $'plm'$ to regress the panel data.

Keywords: Aging population, Economic growth, Population growth, Fertility rate, Life expectancy

1. Introduction

Asia, with the world's largest population estimated at 4.436 billion population in 2015, has been exceedingly strong on its economic performance since 1960s. Along with rapid economic growth, population aging has become a common feature in Asian countries. To be more specific, Korea is facing a serious population aging. The study of Choi and Shin (2015)[12] forecasted that the old- age share will be greater that 14% in 2017 and will be approximately 20% in 2060, and the results of their study shows that population aging reduces not only the growth rate of GDP per capita, but also negatively affects human capital in Korea. In 1979, the Chinese government put forward one-child policy, which reduces the fertility rate and leads to an increasing proportion of elderly people. Hesketh, Lu and Xing (2005)[21] presented that with the increasing China's life expectancy the ratio of the old-age population (ages 65 or older) to total population was 5% in 1982 and will rise to more than 15% by 2050 in China. Lutz, Wolfgang and Sanderson (2008)[26] presented that aging population has increased in past decades and in may have increase trend in coming decades. Based on those previous studies above, we examined the effects of population aging on economic growth and how the demographic changes create benifits or drawbacks to Asian economy. First of all, we analyzed the trends of indicators as shown in the Section 3. The model from Bloom,David, Canning, and Finlay (2010)[7] will be enhanced and refine in this paper, and every step and details of the model presents in Section 4. Basically , the model is based on the Cobb-Douglas Production Function. I derived the model in this paper with the relationship between youth-, old-, and working-age population, and mathematical approximation algorithms. I collected data of 15 Asian countries and one special administrative region of China − Hong Kong. After collecting data, I took every 5-year average for initial data and used R to rearrange our data as a panel data. As table 1 shows that I separated Asian countries as four parts − East Asia, West Asia, South Asia, South East Asia. For those 4 regions I added regional dummy variables, in order to test the effects of different regions on dependent variable. Then I examined variables by five different specification via OLS. The results of all specifications show that old-age share has a significant and negative effect on economic growth from 1960 to 2014, and other demographic indicators performed diversely in different specifications. The main motivation for testing the relationship between aging population and economic growth is that it may give policy makers or relevant departments of government to judge the response of the aging population to economic growth.

Table 1: Asian Country dummy list

South Asia	Shout East Asia	East Asia	West Asia
Bangladesh	Indonesia	China	Isreal
India	Malaysia	China, Hong Kong	Jordan
Nepal	Philippines	Japan	
Pakistan	Thailand	Korea Rep.	
Sri Lanka		Singapore	

2. Literature Review

The existing literature on modeling aging population focus on the different channels and yield different results . Prskawerz (2010)[20] researched a long−term effects of population aging on economic growth with generalizations economic growth models and age-specific heterogeneity. Loumrhari (2014)[25] testified an overlapping generations model (OLG) with annual data from 1980 -2010 of Morocco, presenting that aging population negatively affects on the growth rate of savings. Theoretically, based on the theory of life cycle, aging population has negative influence on national saving and thus on economic growth. Auerbach and Kotlikoff (1987)[2], Auerbach et al. (1989)[3], Miles (1999)[27] and Hviding and Merette (1998)[23] utilized general equilibrium models with OLG to test the relationship between national saving rates. Fougere and Merette(1999)[16] also utilized OLG models to test the effects of population aging on economic growth. Li and Zhang (2015)[24] proposed Solow Model with panel data of China, and studies the short-term consequences of population aging on economic development. Faruqee and Muhleisen (2002)[15] used a life−cycle approach with empirical age-earnings profiles in Japan. Cervellati and Sunde(2011)[11] studied the effect of life expectancy on economic growth and presented that increases in life expectancy significantly and positively influence on income per capita. In contrast to the opinions above,Gomez and Hernandez de Cos (2008) [19] argued that population aging actually can improve economic performance but dampen it. This is in line with Aisa and Pueyo(2013)[1], who claimed that population aging probably fosters economic development. Futagami and Nakajima (2002)[17] used a general equilibrium model of life cycle to investigate how population aging affects economic growth, and the results show that population aging is not necessarily a negative factor for economic growth.

From the literature review above, I fount that the results are different country by country or region by region, and all previous researches were based on time series or panel data. Following Bloom, Canning and Fink (2010)[6], this paper constructs a panel data for 16 Asian countries (includes China-Hong Kong). This panel dataset not only considers that the population aging affects economic growth, but also includes the data of capital stock, human capital, fertility rate, population growth, and life expectancy.

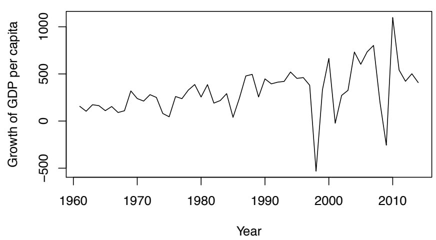
3. An overview of indicator tendency

3.1. Indicator trend at Asia level

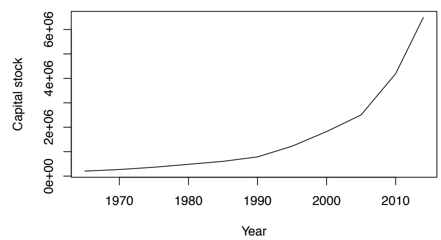
As Figure 1 (a) shows that growth of gross domestic product (GGDP) per capita has been rockier since 1960. From 1960 to 1996 we observe that GGDP per capita steadily increased by about 86% with some small fluctuations. Obviously, there is a huge decline from 1997 to 1998 which was the hardest time for Asia due to financial crisis. Since June 1997 the turmoil has struck Asian foreign-exchange and equity markets which is called the third major currency crisis of the 1990s[18]. Same scenario happened in Asia again in 2008. The Global Financial Crisis, triggered by the housing bubble in the United States, caused a significant decline in the GDP of the majority of the European economies. In contrast, most Asian economies experienced a temporary slowdown in their rates of economic growth, particularly Japan, South Korea, and China, resuming their normal growth soon after[22]. Generally, GDDP of Asia has been experienced various changes and grows slowly.

Regardless of the financial crisis, Bloom and Williamson (1998)[10] demonstrated that changes of age structure have had a dramatic influence on economic growth. Declining fertility rate in this period has decreased the youth-age share and increased the old-age share. (Figure 1 (e) ,(g), (h))The Asian fertility rate fell from about 5.7 children per women in 1965 to over 2.4 in 2014, and it also leads to the decrease on from 41.23% to 26.46%. From Figure (g) we are able to observe that the old-age share has a significant upward tendency, being 3.7% in 1965 to 8.03% in 2014. The next key factor is life expectancy (Figure 1 (f)), which has been risen from 56.77 in 1965 to 75 in 2014. Then trend of population growth has a downward tendency with two fluctuations.

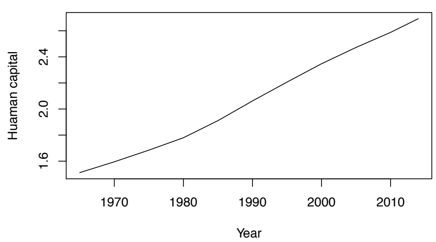
Figure 1: All indicators' tendency from 1960 to 2014 at Asian level



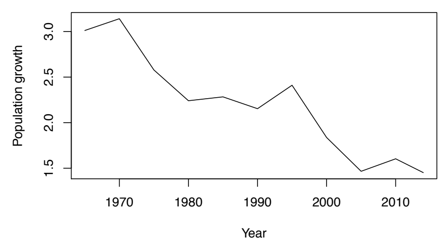
(a) Growth of GDP per capita



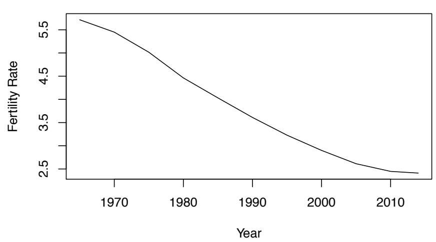
(b) Capital stock



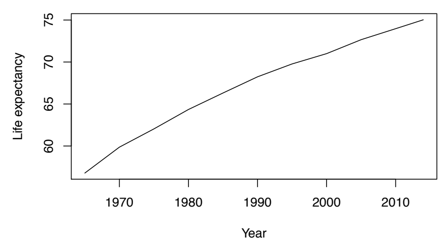
(c) Human capital



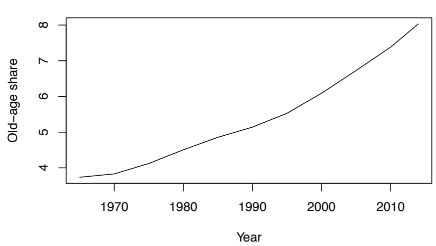
(d) Population growth



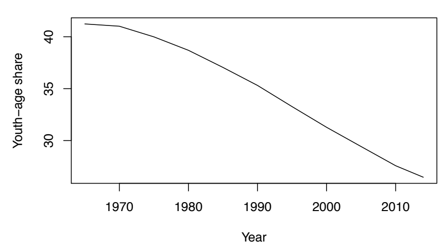
(e) Fertility rate



(f) Life expectancy



(g) Old-age share



(h) Youth-age share

3.2. Indicator tendency at region level

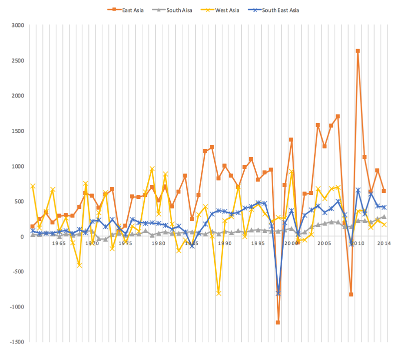
As I analyzed in *section*3.1, the financial crisis greatly impacted the GGDP per capita of Asia; however, generally the GGDP has not increased dramatically (In Figure 2 (a)). Trends in population growth vary by region. Population growth in those regions have been steadily decreased over the given years. (Figure 2 (d)) From1965 the West Asian (average for every 5-year data) population growth at 4.28 (in millions), and it decreased by 2.61 (in millions) in 2014. The population growth in South Asia and South East Asia have been falling slowly, and the changes are 1.829 (in millions) and 1.989 (in millions) respectively over 1960 to 2014. In East Asian the population growth has been decline continuously, and reached the bottom in 2005.

The fertility rates in all regions have downward tendencies. Obviously, the fertility rate of East Asia is in the lowest position (Figure 2 (e)), being 4.715% in 1960 to 1.511% in 2014. The fertility rate of South East Asia is just above that of East Asia, while in South and West Asia have similar tendencies and levels. Although South and West Asia have the highest fertility rate, those regions include many countries which have experienced large declines in fertility rate, such as Bangladesh.

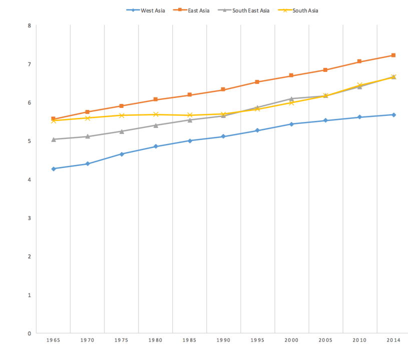
Currently, life expectancy in those four regions have steadily increased . life expectancy in East Asia has been changed significantly and stands above that in other three regions in Figure 2 (f), and it has been increased from 61 in 1965 to 79 in 2014 (combined both genders). West and South East have high life expectancies (77 and 71 respectively for both men and women). The trend of life expectancy in South Asia is similar, yet its life expectancy is stands a lower position in Figure 2 (f).

The demographic changes analysis previously shape population structures. The proportion of children (aged 0-14) in the total population in the those regions have fallen steadily from 1960 to 2014, while the proportion of elderly (aged 65 and above)in those four regions have been steadily increasing. The changes of the proportion of children in West, East, South East and South are approximately 8, 23,16,10 respectively over the given period, and the proportion of elderly increased accordingly in the same period.

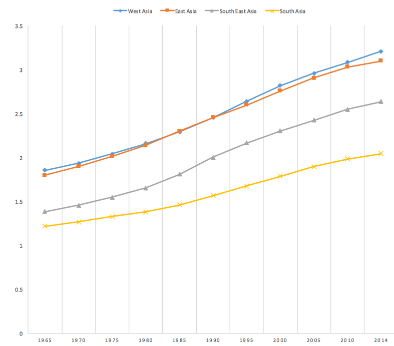
Figure 2: All indicators' tendency from 1960 to 2014 at region level



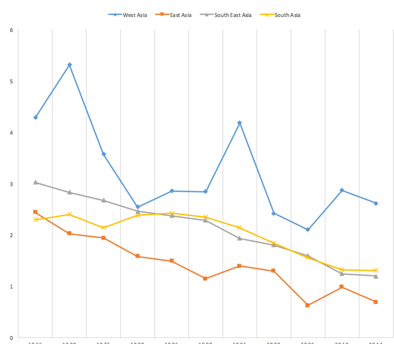
(a) Growth of GDP per capita



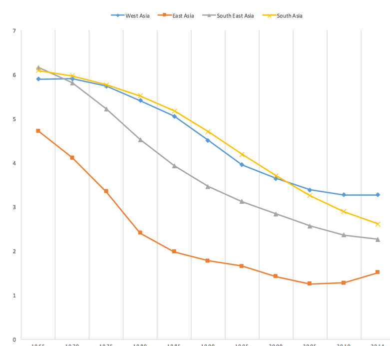
(b) Capital stock (converted to logrithm)



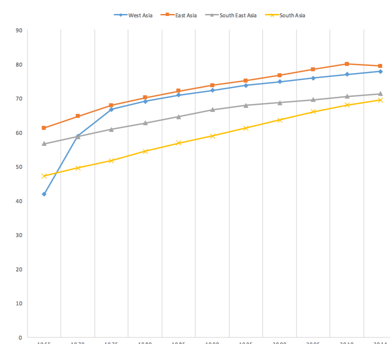
(c) Human capital



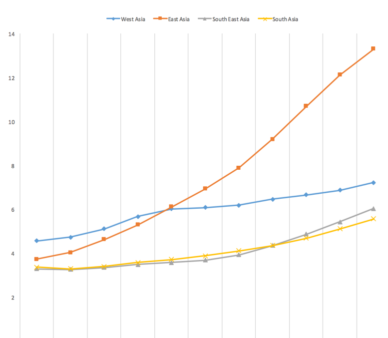
(d) Population growth



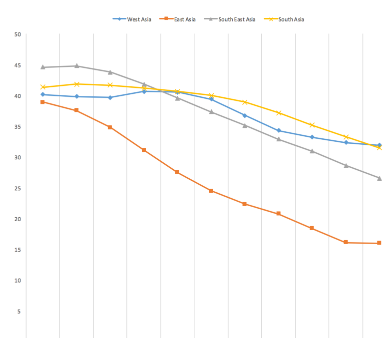
(e) Fertility rate



(f) Life expectancy



(g) Old-age share



(h) Youth-age share

4. Model

The relationship between old age share (ratio of population ages 65+ to total population) and economic growth was derived from Bloom and Williamson(1998). With convergence model outlined by Barro and Sala-i-Martin(2004)[4], Bloom and Finlay(2009)[9], we consider the Cobb-Douglas Production Function

$$Y = AK^{\alpha}L^{1-\alpha} \tag{1}$$

Where Y is Real Gross Domestic Product (real GDP); A is productivity; L is the labor force; K is the capital stock. Then real GDP per worker is

$$\frac{Y}{L} = A(\frac{K}{L})^{\alpha} \tag{2}$$

If both sides are taken log, then GDP per worker is

$$g_{\frac{Y}{L}} = \lambda(z^{*} - z_{0}) \tag{3}$$

Where z=ln($\frac{Y}{L}$), and z^{*} is steady-state(SS) level of log GDP per worker. z_0 is the initial value of log GDP per worker. λ is the speed of convergence. A vector X denotes the variables which can influence the SS level of GDP per worker.(Thus $z^{*} = x\beta$). Then $g_{\frac{Y}{L}}$ can be characterized as :

$$g_{\frac{Y}{L}} = \lambda(x\beta - z_{0}) + \epsilon \tag{4}$$

where ϵ is a random error to the $g_{\frac{Y}{L}}$. Based on Bloom et. al (1999)[8], we can express the relationship between GDP per worker, labor force participation rate (LFPR), the ratio of working-age population to total population, and GDP per capita.

$$\frac{Y}{P} = \frac{Y}{L}\frac{L}{W}\frac{W}{P} \tag{5}$$

Where Y is GDP; P is population; L is labor force; W is working-age population.Taking the logs for both sides of (5) , we obtain that

$$ln(\frac{Y}{P}) = ln(\frac{Y}{L}) + ln(\frac{L}{W}) + ln(\frac{W}{P}) \tag{6}$$

Recall z=ln($\frac{Y}{L}$), and we denote y=ln($\frac{Y}{P}$). If working-age share represents the age structure, and the LFPR ($\frac{L}{W}$) is constant. Since the term of ln($\frac{L}{W}$) can be ignored, we rearrange (6)

$$z = y + ln(\frac{W}{P}) \tag{7}$$

and substitute (7) into (4) ,

$$g_{\frac{Y}{L}} = \lambda(X\beta - y_0 - ln(\frac{W}{P})_0) + \epsilon \tag{8}$$

From (6) We also are able to obtain (ln($\frac{L}{W}$) is constant)

$$g_{\frac{Y}{P}} = g_{\frac{Y}{L}} + g_{\frac{W}{P}} \tag{9}$$

where

$$g_{\frac{Y}{P}} = ln(\frac{(\frac{Y}{P})_t}{(\frac{Y}{P})_{t-1}}) = ln(\frac{Y}{P})_t - ln(\frac{Y}{P})_{t-1} \tag{10}$$

$$g_{\frac{Y}{L}} = ln(\frac{(\frac{Y}{L})_t}{(\frac{Y}{L})_{t-1}}) = ln(\frac{Y}{L})_t - ln(\frac{Y}{L})_{t-1} \tag{11}$$

$$g_{\frac{W}{P}} = ln(\frac{(\frac{W}{P})_t}{(\frac{W}{P})_{t-1}}) = ln(\frac{W}{P})_t - ln(\frac{W}{P})_{t-1} \tag{12}$$

Based on the definition of working age population, working-age population equals to total population less the youth-age population (ages 0-14) and old-age population (ages 65+) which can be expressed W=P-O-C , and from (8) ,(9) and (12) new expression of $g_{\frac{Y}{P}}$ is

$$g_{\frac{Y}{P}} = \lambda(X\beta - y_0 - ln(\frac{W}{P})_0) + g_{\frac{W}{P}} + \epsilon \tag{13}$$

$$g_{\frac{Y}{P}} = \lambda(X\beta - y_0 - ln(\frac{W}{P})_0) + ln(\frac{W}{P})_t - ln(\frac{W}{P})_{t-1} + \epsilon \tag{14}$$

$$g_{\frac{Y}{P}} = \lambda(X\beta - y_0 - ln(\frac{P-O-C}{P})_0) + ln(\frac{P-O-C}{P})_t - ln(\frac{P-O-C}{P})_{t-1} + \epsilon \tag{15}$$

The Approximation accuracy of $ln(1+x) \approx x$ is increasing in the working-age share,

$$ln(\frac{P-O-C}{P})_t + ln(\frac{P-O-C}{P})_{t-1} \approx -[(\frac{C}{P})_t - (\frac{C}{P})_{t-1} + (\frac{O}{P})_t - (\frac{O}{P})_{t-1}] = -(\Delta\frac{C}{P} + \Delta\frac{O}{P})) \tag{16}$$

$$ln(\frac{P-O-C}{P}) = ln(1 - \frac{O+C}{P}) \approx -\frac{C}{P} - \frac{O}{P} \tag{17}$$

Substitude (10) (16) and (17) into (15) , and X are capital stock, human capita and other variables that may affect g_y, then our model is

$ln(\frac{Y}{P})_t - ln(\frac{Y}{P})_{t-1}= \beta_1 X_{i,t-1} + \beta_2 y_{i,t-1} + \beta_3 \frac{C}{P}_{i,t-1} + \beta_4 \frac{O}{P}_{i,t-1} + \beta\Delta\frac{C}{P}_{i,t} + \beta_1\Delta\frac{O}{P}_{i,t} + \mu_i + \alpha_t + \epsilon_{i,t}$

(18)

where i = 1, 2, ..., N represents each country in Asia in the panel, t = 1, 2,...,T refers to the time period. As Table 2 presents,Y denotes real GDP (constant 2011 national prices (in mil. 2011US$)), P denotes the population (in millions), $\frac{O}{P}$ is represented by OTP which is the ratio of the old-age population to total population, $\frac{C}{P}$ is referred by CTP which is the ratio of youth-age population to the total population , $\Delta\frac{O}{P}$ is represented byΔOTPwhich is the change of the ratio of population ages 65+ to total population, $\Delta\frac{C}{P}$ is represented by ΔCTP which is the change of the ratio of population ages 15-64 to total population .The parameters βs represent the elasticity estimates of all given variables, as well as for country (μ) ,for time (α) and for trend-effects (ϵ). X are capital stock, human capital, fertility rate, population growth

5. Data Description

For this paper, set a 5-year panel dataset from 1960 to 2014 using country-level data. Real GDP (Y), total population (P), human capital (H), and capital stock (K) were collected from Penn World Table Version 9.0. Demographic data in this paper (life expectancy, population growth, ratio of population ages 0-14 to total population, ratio of population ages 65+ to total population) are from World Development Indicators (WDI 2016 Nov.). Fertility rate is from UNdata (Table 1 and Table 2). Based on Sanderson and Scherbov (2010), old- age population is defined as the population ages 65 and older; working-age population is defined as the population ages 15-64. In this paper , the population ages 0-14 denote youth-age population. Table 2 presents that all variables' description and definitions. In model part , g_y denoted $ln(\frac{Y}{P})_t - ln(\frac{Y}{P})_{t-1}$, which implies economic growth; y denoted $ln(\frac{Y}{P})$. After calculating those values, I made Pooled OLS regression for the panel data. In order to test our dependent variable has different performances in difference regions, I added regional dummy variables for given regions as independent variables. Besides, I converted capital stock (K) and life expectancy (LE) in to their natural logarithms. The reason why I take log for those two variables is that statistically, taking the log not only can help this by reducing or eliminating skew but also can enhance our model. In Table 3 I present the variable statistics in the regression of analysis. We see from these statistics that a range of countries are represented in the sample: high to low GGDP per capita, fertility rate, capital stock, human capital, life expectancy and population growth.

Table 2: Data Sources

Variable	Variable description	**Variable definition**	Source
Y	Real GDP	Real GDP at constant 2011 national prices (in mil. 2011US$)	PWT9.0
P	Total population	Population (in millions)	PWT9.0
K	Capital stock	Capital stock at current PPPs (in mil. 2011US$)	PWT9.0
H	Human Capital	Human capital index, based on years of schooling and returns to education	PWT9.0
FR	Fertility rate	Total fertility rate represents the number of children that would be born to a woman	WDI
LE	life expectancy	Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life	UN
PG	Population growth	Annual population growth rate over a 5- year period	WDI
CTP	Population ages 0−14 to total population	Population between the ages 0 −14 as a percentage of the total population.	WDI
OTP	Population ages 65+ to total population	Population ages 65 and above as a percentage of the total population.	WDI
ΔCTP	Youth-age share	Change of the ratio of population ages 0 −14 to total population	WDI
ΔOTP	Old-age share	Change of the ratio of population ages 65+ to total population	WDI

Table 3: Variable statistics

Statistic	N	Mean	St. Dev.	Min	Max
$g_y = ln(\frac{Y}{P})_t - ln(\frac{Y}{P})_{t-1}$	176	0.014	0.011	−0.026	0.042
y $=ln(\frac{Y}{P})$	176	3.739	0.471	2.961	4.795
K	176	2,050,957.000	5,656,448.000	2,490.428	55,311,746.000
log(K)	176	12.795	1.962	7.820	17.828
H	176	2.077	0.679	1.017	3.612
FR	176	3.667	1.791	0.942	8.007
LE	176	66.601	9.566	39.470	83.499
log(LE)	176	4.188	0.154	3.676	4.425
PG	176	2.008	1.016	−0.143	7.570
CTP	176	34.053	9.105	12.494	48.427
OTP	176	5.438	3.282	2.385	24.306
ΔCTP	176	−0.302	0.328	−1.221	0.459
ΔOTP	176	0.098	0.131	−0.174	0.698

6. Estimation

From the results of basic specification in first column, we are able to observe that the coefficients of CTP , OTP and ΔCTP are negative and statistically significant at the 0.01%, which implies that youth-age share, old-age share and change of youth-age share negatively correlated with economic growth. In second column, population growth is accounted, and the results of the second column present that not only youth-age share, old-age share and change of youth-age share negatively affect economic growth, but also there exists the negative association of population growth with economic growth. In third column, demographic change is accounted - life expectancy and fertility rate. The coefficients of the third column indicates that human capital, old-age share, population growth are negative, and old-age share is statistically significant at level 0.01. Nevertheless, the coefficient of $ln(E)$ is 0.029 and significant at level 0.05, which means the positive association of life expectancy with economic growth. In forth column, geographic specification is introduced. In this part, I added four regional dummy variables and made regression, and the results of this specification is similar with those of basic specification. The coefficients of youth-age share, old-age share and change of youth-age share are significant, and they have negative correlation with economic growth. There is no baseline, yet I set the "*constant*" term zero in 'R'. we see that on average East Asian annual average 5-year growth rates are 0.044 percentage points higher that other regions. In the last column, all variables are accounted in the Pooled OLS estimation, and the results show that old-age share, population growth have negative effect on economic growth, while life expectancy positively influence economic growth. Other variables are not statistically significant in this specification. It is interesting to compare the results from forth column and the last column. After including all variables and making regression, I find that the East Asian dummy is not significant at all, yet East Asian dummy is statistically significant in geographic specification. This comparison implies that among the four regions youth-age share, old-age share and change of youth-age share affect East Asia more than other regions.

Table 4: Regression results

	OLS(1) Basic specification	OLS(2) Population growth specification	OLS(3) Demographic specification	OLS(4) Geographic specification	OLS(5) Geographic and demographic specification
y=ln($\frac{Y}{P}$)	0.0003	0.005	0.0004	-0.002	-0.003
	(0.003)	(0.004)	(0.005)	(0.004)	(0.005)
ln(K)	0.0003	0.0002	-0.0001	0.0001	-0.0003
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
H	-0.002	-0.003	-0.005**	0.0004	-0.004
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
CTP	-0.001***	-0.0004*	-0.0004	-0.0005**	-0.0003
	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0004)
OTP	-0.002***	-0.002***	-0.002***	-0.001**	-0.001**
	0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ΔCTP	-0.010***	-0.009***	-0.005	-0.009***	-0.003
	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)
ΔOTP	0.006	0.001	0.002	-0.002	-0.004
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
PG		-0.002*	-0.003*		-0.003*
		(0.001)	(0.001)		(0.002)
ln(LE)			0.029**		0.028**
			(0.014)		(-0.013)
FR			-0.0004		-0.001
			(0.002)		(0.002)
South Asian Dummy				0.037	-0.063
				(0.023)	(0.048)
South East Asian Dummy				0.04	-0.06
				(0.025)	(0.048)
West Asian Dummy				0.037	-0.062
				(0.025)	(0.049)
East Asian Dummy				0.044*	-0.056
				(0.024)	(0.048)
Constant	0.039**	0.025	-0.069		
	(0.019)	(0.021)	(0.048)		
Observations	176	176	176	176	176
R^2	0.281	0.293	0.320	0.320	0.359
Adjusted R ^{2}	0.268	0.278	0.300	0.300	0.330
F Statistic	9.369 *** (df = 7; 168)	8.669*** (df = 8; 167)	7.777*** (df = 10; 165)	7.044*** (df = 11; 165)	6.479*** (df = 14; 162)
Note:	*p<0.1; **p<0.05; ***p<0.01				

7. Conclusion

Population aging is a challenge of Asia. According to the results of this paper, considerable demographic transformation has been restrained the economic growth from 1960 to 2014. Based on the projection of Lutz, Sanderson and Scherbov (2007)[26] , the issues of population aging will become increasingly serious by 2050. With significant and pervasive social, economic and political implications, planning for the future merits priority consideration of the aging of societies. The the elderly (age 65+) in Asia is estimated to increase rapidly, being 6.38 millions in 1960, almost 901 millions in 2050, and 1.22 billion by 2100[14]. The estimated ratio of the old population to total population in 2050 is greater than that of Japan in 2010 (23%). Indeed, in Japan, along with China and other countries in East Asia, approximately 30% of the population is expected to be over the age of 65 years by 2050. The factors that we discussed in section 6 related to population aging show challenges to governments and relative departments across Asia. The proposals for governments are to empower the elderly and promote their rights in order to increase participation rate in social, economic and other fields, and to rigorously enact relevant laws to not only control the population growth but also enhance the needs of older persons. Appropriate policies and laws are required to meet the needs of the elderly, and the society wide ramifications of an aging population and the requisite socio-economic adjustments to accommodate transition to an aging society.

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