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Population Growth and Planned Birth Policy

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POPULATION GROWTH AND PLANNED BIRTH POLICY

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ABSTRACT

China's planned birth policy is based on "population pessimism", which states population growth affects the income level negatively, though the role of population growth in cross-country growth regressions is ambiguous. There are "population pessimism", "population optimism", and "population neutralism". Also, a new concept "demographic dividend" was raised in recent years, which states a rise in the rate of economic growth can be induced because of a rising share of working age people in a population while still holding "population neutralism". The planned birth policy results in a decreasing fertility rate, which slows down the population growth and changes the age structure of population. In this paper whether population pessimism holds and whether China grasps "demographic dividend" are tested. An overlapping generation (OLG) model is developed to introduce the dependency ratio into the growth regression. The claim of demographic dividend and the role of population growth are first examined in the cross-country data and sensitivity analyses are followed for the robustness test. Throughout the sensitivity analyses, dependency ratio is proved to be robust in cross-country growth regressions while still holding "population neutralism". Later, using the provincial level data of China the case study on China's planned birth policy is conducted where two instrumental variables, sex ratio at birth and minority proportion, are introduced to handle the endogeneity problems and policy suggestions based on the predicted China's demographic structure are provided.

DEDICATION

This paper is dedicated to my wife, Xuanwen Wang, and to my parents, Jinshun Zhang and Xiuhong Huang, for their love and support all these years.

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Chapter 1: Introduction and Background

Population growth shows up in almost every cross-country regression in explaining economic growth. Levine and Renelt (1991) examine over 50 papers published in 1980's on the cross-country study of economic growth and review all the explanatory variables used in those papers. From the list of explanatory variables, it can be seen that population growth shows up in every single paper. In Sala-i-Martin, Doppelhofer and Miler (2004)'s recent search for "determinants of long-term growth", authors selected 67 independent variables as the possible candidates for the determinants of long-term growth, among which population growth is included. Researchers use different sets of variables in cross-country growth regressions. As in Levine and Renelt (1992), "for example, many authors who examine the relationship between measures of fiscal policy and growth ignore the potential importance of trade policy, while those authors who study the empirical ties between trade and growth commonly ignore the role of fiscal policy." Among those different sets of variables, however, population growth shows up almost in every single set. Population growth is categorized in "a set of variables *always* included in the regression" in Levine and Renelt (1992)'s sensitivity analysis. Despite its omnipresence, the role of population growth is ambiguous. There are "population pessimism", which claims population growth will bring negative effect on income level and economic growth, "population optimism", which claims population growth will bring positive effect on economic growth, and "population neutralism", which claims population growth in itself insignificantly correlates with economic growth. Recent empirical results support "population neutralism". For example, Levine and Renelt (1992) and Sala-i-Martin et al (2004) are the two most comprehensive papers in the sensitivity analysis over the explanatory variables for economic growth and both conclude population growth insignificantly correlates with economic growth.

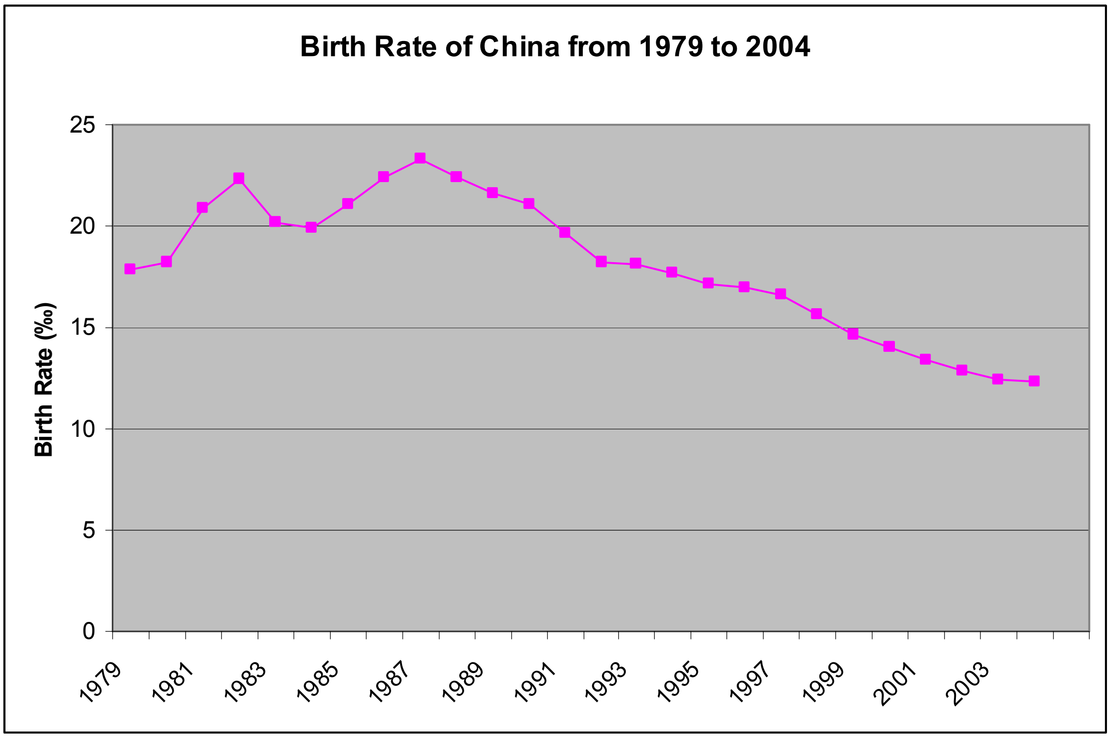
Also, there is a subgroup under population neutralism, which focuses on the effect from the age structure of population to economic growth. The term "demographic dividend" rises after scholars' attempt in separating age structure of population from the population in recent years. The demographic dividend is a rise in the rate of economic growth due to a rising share of working age people in a population. The age structure of population has been applied frequently in cross-country growth regressions in the last ten years and shows its significance in explaining economic growth, while still holding population neutralism. That is, population growth itself might not significantly correlate with economic growth while a component of population growth may. Demographic dividend is still not widely accepted by economists though and there isn't any sensitivity analysis being conducted over its significance. This paper will try to fill the gap.

The issue of demographic dividend is especially meaningful for me, a Chinese, because of the planned birth policy. China has carried out the planned birth policy since 1979, which restricts most couples[1] to a single child. The policy has been widely criticized within and outside China since the first day it was enforced while people come to support

[1] Couples of minority are not restricted.

it now[2], which is partly because the Chinese government claims the policy greatly benefits economic growth. The planned birth policy starts at 1979 and almost at the same time China's economic reform took place. That is, the effect of the planned birth policy might mingle with the effect of the economic reform. Later on, the economy did take off, which provides a superficial evidence for the government statement. The real per capita GDP growth for China averages at 8.36%[3] from 1979 to 2004 and the fertility rate from 1979 to 2004 is presented in **Figure 1.1**.

Figure 1.1: Birth Rate of China from 1979 to 2004



Source: China Statistical Yearbook 2005 (National Bureau of Statistics of China)

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[2] According to *The 2008 Pew Global Attitudes Survey in China*, 76% of Chinese support the planned birth policy.
[3] Data is based on Penn World Table 6.2.

Based on the population pessimism, the government statement does make sense. Besides population pessimism, though, there is another argument can lead the decreasing fertility rate to economic growth given the age structure of China's population since 1980s. That is the argument of demographic dividend, which is a subgroup of population neutralism. The explanation till now from population pessimism in the relationship between the decreasing fertility rate and economic growth may consist with the explanation from demographic dividend, but the application differs greatly in the future. If abiding "population pessimism", the planned birth policy should be carried on forever; while if abiding "population neutralism" and realizing the effect of the age structure of population, the planned birth policy would only benefit the economic growth for a short period (when the share of working age population is rising) and should be stopped in the near future. The huge welfare effect[4] behind this issue cautions everyone and makes the sensitivity analysis a must before giving any statement. "*The consequences for human welfare involved in questions like these are simply staggering: once one starts to think about them, it is hard to think about anything else.*"[5]

The overall goal of this paper is to identify whether the "demographic dividend" exists in China and, if yes, how long this period lasts and at what magnitude. The rest of the paper is organized as follows. Literature review in the relation between population growth and economic growth is summarized in Chapter 2. The concept of demographic dividend is

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[4] The planned birth policy has helped to prevent an extra 400 million births since 1979 according to *Wikipedia: Demographics of the People's Republic of China*.

[5] See: Lucas (1988).

introduced in Chapter 3. Chapter 4 presents the statistical analysis of the relationship between the dependency ratio and economic growth from 1970 to 2004. Chapter 5 sets up the theoretical model to introduce the dependency ratio into the growth regression. Chapter 6 builds the empirical model and applies two different approaches in robustness test. Section 6.1 and section 6.2 apply the first approach, a variant of extreme bound analysis (EBA), to test the robustness of the newly introduced dependency ratio in the growth regression; section 6.3 and section 6.4 apply the second approach, Bayesian Averaging of Classical Estimates (BACE), to perform the robustness test for the dependency ratio. Data and variables used for this study are summarized in Chapter 7. Chapter 8 presents the estimation results with sensitivity analysis. Chapter 9 presents the case study on China. Chapter 10 concludes and provides policy implications.

Chapter 2: Literature Review

Malthus started to look at the relation between population and economic growth in 1798 (Malthus, 1798). In the Malthusian model, people give birth to more children and at earlier age when the income grows, while larger population will decrease the income because of diminishing marginal productivity. The diminishing marginal productivity will drive down the income and end at so-called "*Malthusian catastrophe*". Although Malthus' "higher income higher fertility" argument was not appropriate in 18th century Europe (and neither now nor at any other time; actually fertility rate falls sharply when income grows), his argument on diminishing marginal productivity does make sense. For a natural resource (land, water, etc.) augmented economy (a mainly agricultural economy), as population grows the per capita share of natural resource decreases. Hence the marginal product of labor goes down. The lower productivity and larger population size will end at the *Malthusian catastrophe*. Malthus predicted continuing famines in Europe, which had been proved false mainly due to the improper "higher income higher fertility" argument. Malthusianism is categorized as "population pessimism" because in the Malthusian model population growth will only bring a negative effect on income.

The opposite view is "population optimism". Population optimists claim population growth can bring a scale effect[6] in production, rather than a diminishing marginal product.

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[6] See: Boserup (1981).

Furthermore, population growth can enhance specialization during industrialization[7], which will improve human capital accumulation; also larger population increases the population density, which can generate a bigger spillover in learning. All of the above will positively affect the income. The Boserupian School in 1980s could be regarded as the representative for the "population optimism"[8].

The third school is "population neutralism", which actually emerged from the empirical study. Kelley (1988) conducts a survey of past empirical studies on the relation between population growth and economic growth and claims there is no definite conclusion from the body of empirical tests. Levine and Renelt (1992) also conclude population growth rate is not robust in the sensitivity analysis of cross-country growth regressions. Temple (1999) brings a similar result. Later, Becker, Glaeser and Murphy (1999) combines both the negative effect (diminishing marginal productivity) and the positive effect (human capital accumulation, spillover effect, etc.) and conclude "the net relation between greater population and per capita incomes depends on whether the inducements to human capital and expansion of knowledge are stronger than diminishing returns to natural resources".

Recently a subgroup of population neutralism is raised, which aims at the effect of the age structure of population. The term "demographic dividend" is created, in which population growth *per se* may still not relate to economic growth, while the change of age

[7] See: Kuznets (1967).
[8] Notice that the economy in population pessimism is a mainly agricultural economy, while the economy in population optimism is a mainly industrial economy.

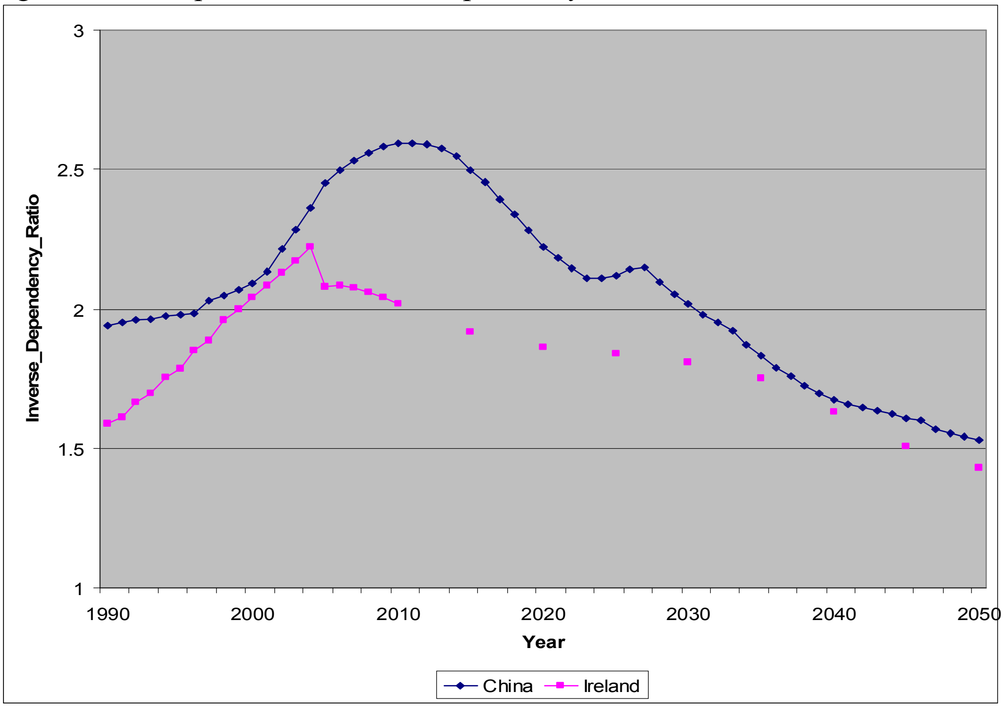
structure will affect economic growth. "Demographic dividend" is applied in explaining the economic growth in Bloom and Williamson (1998), Bloom, Sachs, Collier, and Udry (1998), Bloom, Canning and Malaney (2000), Bloom and Canning (2003), and Bloom, Canning, and Sevilla (2003). And in Bloom, Canning, Fink and Finlay (2007), the authors conclude "the addition of age structure significantly improves the forecasts" in future economic growth.

Bloom and Williamson (1998) examine 78 Asian and non-Asian countries from 1965 to 1990 to identify the effect of the demographic transition on economic growth, especially the contribution of demographic transition on the East Asia's "economic miracle". The authors argue that demographic transition accounts for between one forth and two fifths of the East Asian "miracle". Bloom, Sachs, Collier, and Udry (1998) argue that geography, demography and public health can be attributed to two third of Africa's growth shortfall. Although the magnitude is too high to be accepted and the geography effect[9] is widely criticized, the causality test shows the causal relation from the demography aspects to economic growth. Bloom and Canning (2003) argue that the legalization of contraception in Ireland in 1979 resulted in sharp decrease in the fertility rate and hence a substantial increase in female labor participation rate, which boosts economic growth. The authors claim over a quarter of Ireland's economic growth from 1965 to 1995 should be attributed to the demographic transition.

[9] Mainly the geography effect here can be translated as "Africa is poor because it locates in Africa".

China's planned birth policy started in 1979 nationwide; coincidentally Ireland legalized contraception also in 1979. Both policies result in decrease in fertility rate and more interestingly the two countries' demographic transition path resembles each other (see **Figure 2.1**).

Figure 2.1: Comparison of Inverse Dependency Ratio between China and Ireland



Source: World Population Prospects: The 2006 Revision, United Nations Population Division

Since 1979, both countries have experienced rapid economic growth. Ireland's growth rate of real GDP per capita averaged 4.12%[10] from 1979 to 2004, which is over twice the average growth rate for the entire Europe at the same time and results in the end of a

[10] Data is based on Penn World Table 6.2.

relatively poor country image of Ireland[11]; China's growth rate of real GDP per capita averaged 8.36%[12] during the same period, which is considered as another "miracle". Given the similar demographic transition paths and the similar economic take-off, a practical question would be: does the contribution from demographic transition to economic growth also apply to China? Also in Bloom and Canning (2003), the authors claim after 2006, when the dependency ratio cycles to the increasing period, Ireland's demographic dividend will turn into demographic drag and would slow down the economic growth according to the same reasoning. China's dependency ratio will cycle to the increasing period after 2012[13]. If the same reasoning also applies in China, the planned birth policy should be stopped no later than 2012 to lessen the forthcoming demographic drag.

The U.S. didn't experience a dramatic decrease in fertility rate as Ireland and China, on the contrary, the most considered change in demographic structure in U.S. is a dramatic increase in fertility rate, the Post-World War II baby boom. Recently, scholars (Poterba, 2001; Abel, 2001; etc) have tried to speculate upon whether the stock prices will melt down when the baby boomers retire. It is claimed that when the baby boomers started entering their "prime saving years" (40 to 64) in 1990s, the demand for the assets increased dramatically, which drove up the stock prices. Hence a decline in the stock prices is expected when the baby boomers retire and begin liquidating their stocks.

[11] Ireland's GDP per capita in PPP value in 2006 reaches $44500, which is slightly over U.S.'s $43800;
[12] Data is based on Penn World Table 6.2.
[13] The data for predicted population is from *World Population Prospects: 2006 Revision, United Nations*, using medium variant.

Poterba (2001) uses the term "asset market meltdown hypothesis" to refer to this conjecture. Poterba (2001) concludes the "asset market meltdown hypothesis" is incorrect "because asset decumulation in retirement takes place much more gradually than asset accumulation during working years" and people in the real world usually do not deplete their wealth before they die while theoretical models typically assume people consume all of their wealth before they die. In response to Poterba (2001), Abel (2001) builds bequest motives into a general equilibrium model and concludes "the continued high demand for assets by retired baby boomers does not attenuate the fall in the price of capital" because of rational expectation. Despite that the conclusions are conflicting, the literature shows that population age structure plays an important role in asset prices and asset returns and hence certainly also in economic growth. In other words, when the baby boomers enter their prime saving years, they are facing a relatively lower youth dependency ratio compared to their parents. The lower youth dependency ratio would not only free more labor (women) into the labor market as argued in Bloom and Canning (2003), it would also induce a higher demand for investment, which will result in the increase of the marginal product of capital. Hence, the two components in the growth model, capital and labor, are both affected by the demographic structure.

In summary, the literature shows age structure of population can affect the economic growth and the demographic dividend did emerge and partly explained the economic growth in some regressions. The question for the paper would be whether the demographic dividend is robust and specifically whether the demographic dividend partly explained China’s economic growth. Relating the planned birth policy, the question could be whether the planned birth policy did contribute to China’s economic growth and (if yes) how long this contribution would last and in what magnitude.

Chapter 3: Concept: Demographic Dividend

The demographic dividend is a rise in the rate of economic growth due to an increasing share of working age people in a population. This usually occurs late in the demographic transition when the fertility rate falls and the youth dependency rate declines. The term comes to economists' concern when people's life cycle is integrated into the economic growth model. People's economic needs and contributions are different over the life cycle. Children and youth are mostly net consumers, working-age people are net-producers and savers, and the elderly fall somewhere in between. It implies large youth and elderly cohorts may slow down the pace of economic growth, while large working-age cohorts may speed it up. This follows because a lower youth dependency ratio will bring up more saving, which is the major factor in explaining economic growth in the Solow growth model and is empirically proved to be a major factor in explaining the "*economic miracle*" of east Asia newly industrialized countries (*NIC*)[14].

Furthermore, lowering the fertility rate will free more women into the labor market. And fewer babies per household imply that each baby could get more parental investment, including education, which will boost the human capital of the babies and help the economic growth in the next generation.

14 *NIC* are Hong Kong, South Korea, Singapore and the Republic of China (Taiwan), not including mainland China.

Chapter 4: Statistical Evidence

The dependency ratio is the ratio of the economically dependent part of the population to the productive part. Children and elders are normally regarded as the dependent part while people in working age are regarded as the productive part. Mathematically,

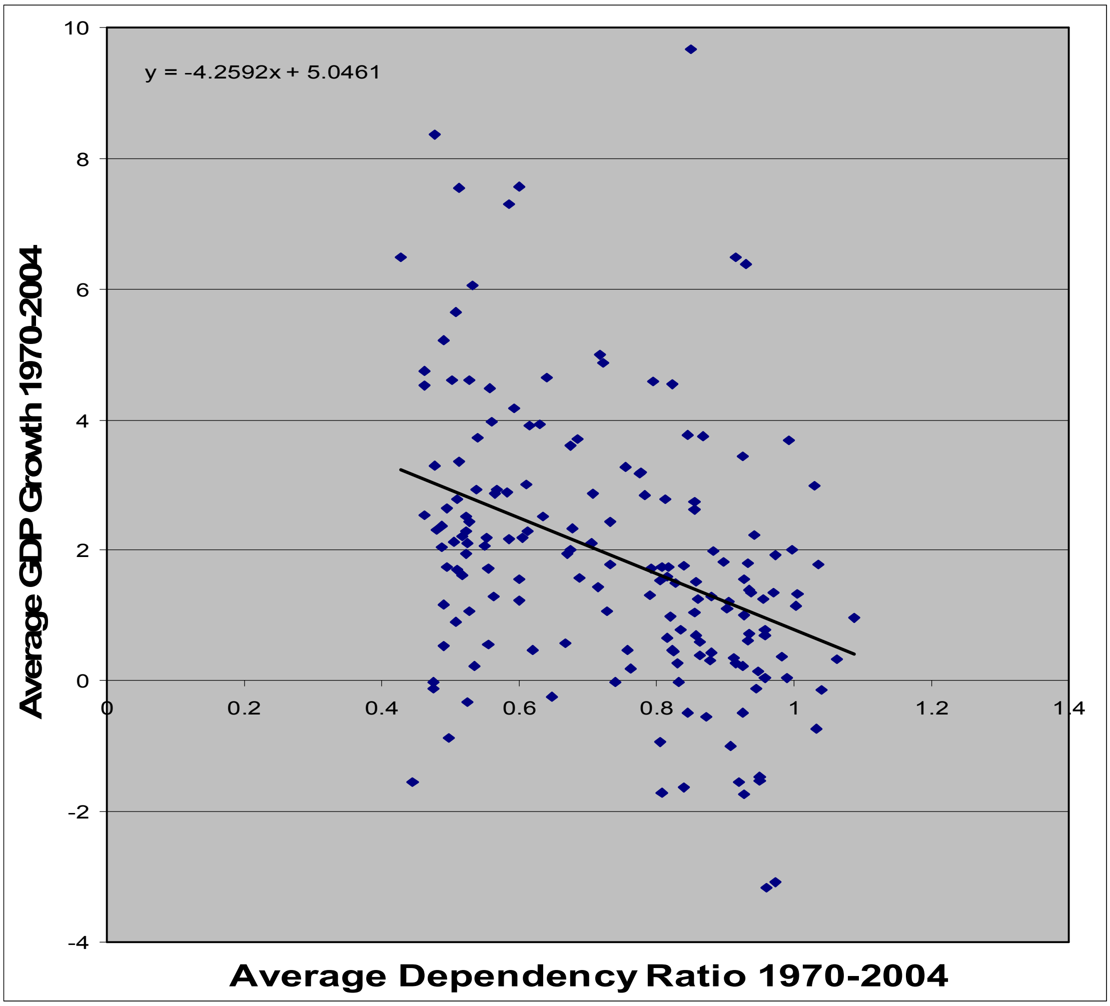
$$Dependency\_Ratio = \frac{number\_of\_people\_aged\_0-14 + number\_of\_people\_aged\_65\_and\_over}{number\_of\_people\_aged\_15-64};$$

The higher the dependency ratio, the more number of dependants a working-age adult has to support.

The dependency ratio is calculated from variables "Population", "Population aged 0-14, total", and "Population aged 15-64, total" from *World Bank Education Statistics Version 5.3* and the growth rate of real per capita GDP is calculated from variable "GDP per capita (constant 2000 US$)" from the same source. **Figure 4.1** presents the scatter plot with a trend line of 170[15] countries on the correlation between the average real per capita GDP growth and the average dependency ratio from 1970 to 2004. In this set of correlations, each dot represents a country, whose average dependency ratio is valued at x-axis and average real per capita GDP growth is valued at y-axis.

[15] 39 countries/regions are dropped due to incomplete data either in growth rate or in dependency ratio.

Figure 4.1: Correlation between Average GDP Growth Per Capita and Average Dependency Ratio for 170 countries from 1970 to 2004

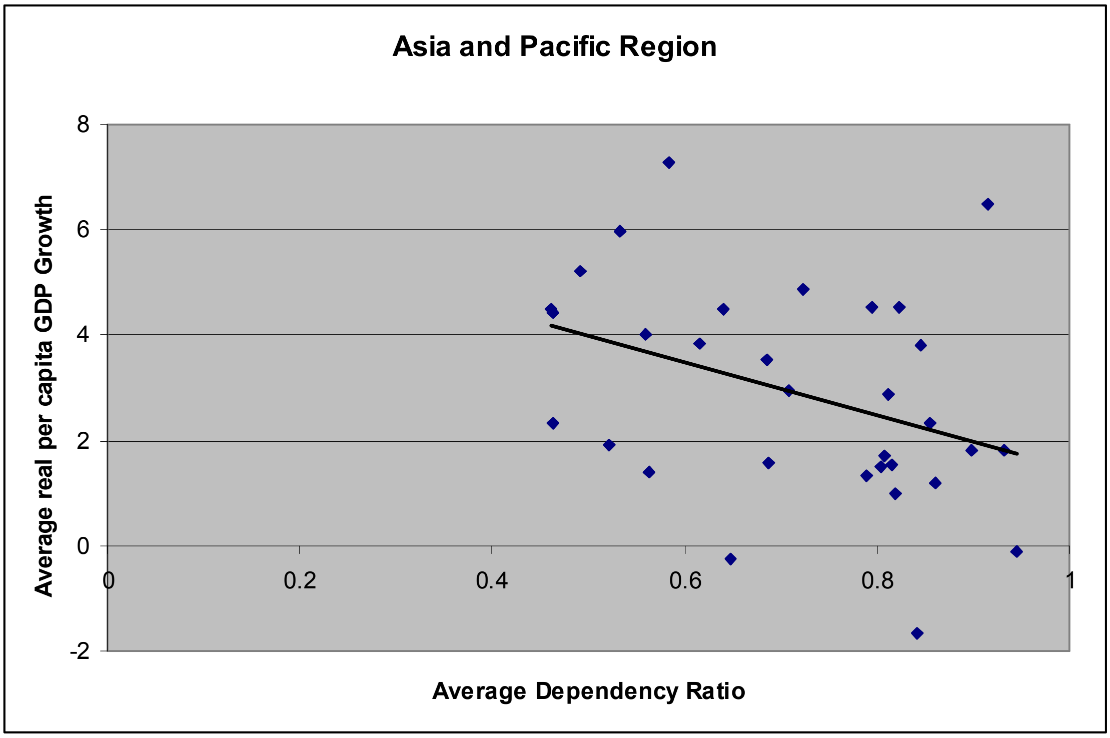


Source: Penn World Table Version 6.2 and World Bank Education Statistics Version 5.3

Figure 4.1 shows a downward trend-line with a -0.37 correlation coefficient, that is, at the 35 years average, a higher dependency ratio country is associated with a lower GDP growth and a lower dependency ratio country is associated with a higher GDP growth.

If divided the world into five[16] regions (Asia and Pacific, Europe and Central Asia, Latin American and Caribbean, Middle East and North Africa, and Sub-Saharan) as in the data, the negative correlations show up in every region. **Figure 4.2** to **Figure 4.6** present the scatter plots with trend lines for these five regions during the same period.

Figure 4.2: Correlation between Average GDP Growth Per Capita and Average Dependency Ratio for *Asia and Pacific Region*



Source: Penn World Table Version 6.2 and World Bank Education Statistics Version 5.3

[16] In World Bank data set, the world is divided into seven regions. North American is combined into Europe and Central Asia and South Asia is combined into East Asia and Pacific in this paper because there are only two countries in North American and only seven countries in South Asia.

Figure 4.3: Correlation between Average GDP Growth Per Capita and Average Dependency Ratio for *North American, Europe and Central Asia*

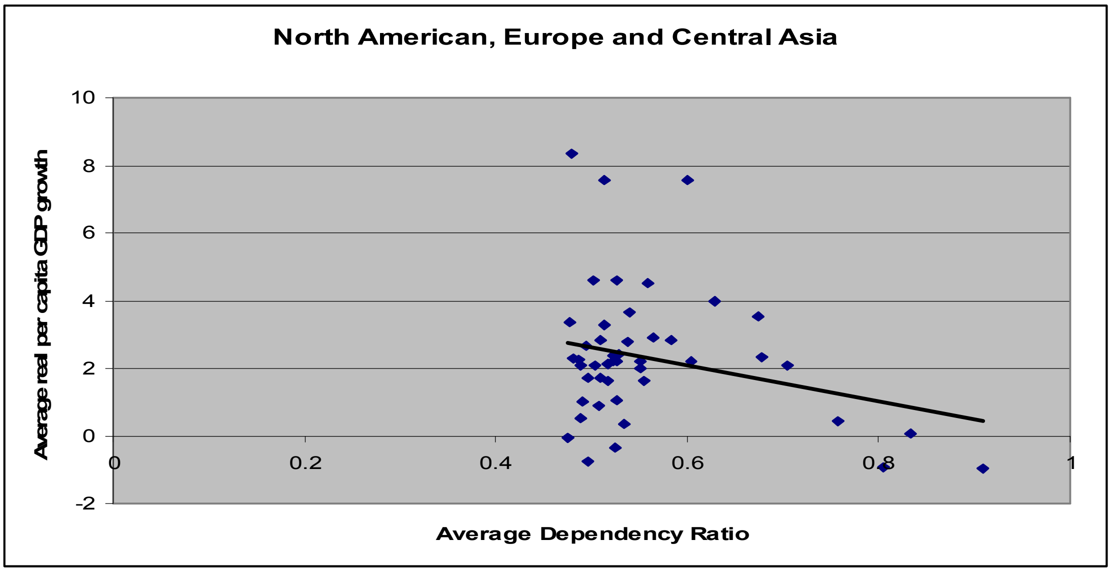
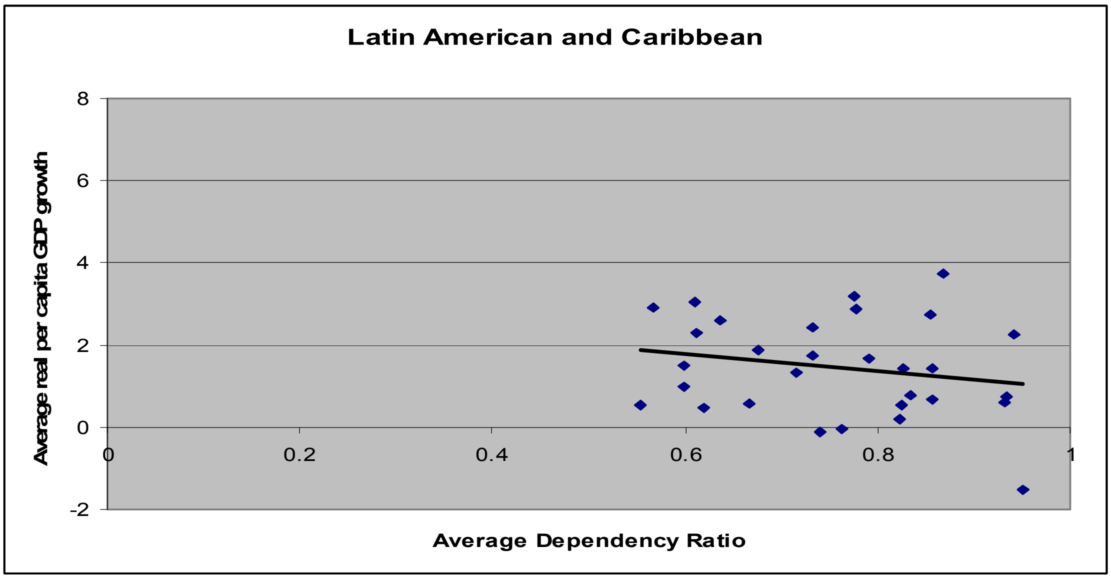


Figure 4.4: Correlation between Average GDP Growth Per Capita and Average Dependency Ratio for *Latin American and Caribbean*



Source: Penn World Table Version 6.2 and World Bank Education Statistics Version 5.3

Figure 4.5: Correlation between Average GDP Growth Per Capita and Average Dependency Ratio for Middle East and North Africa

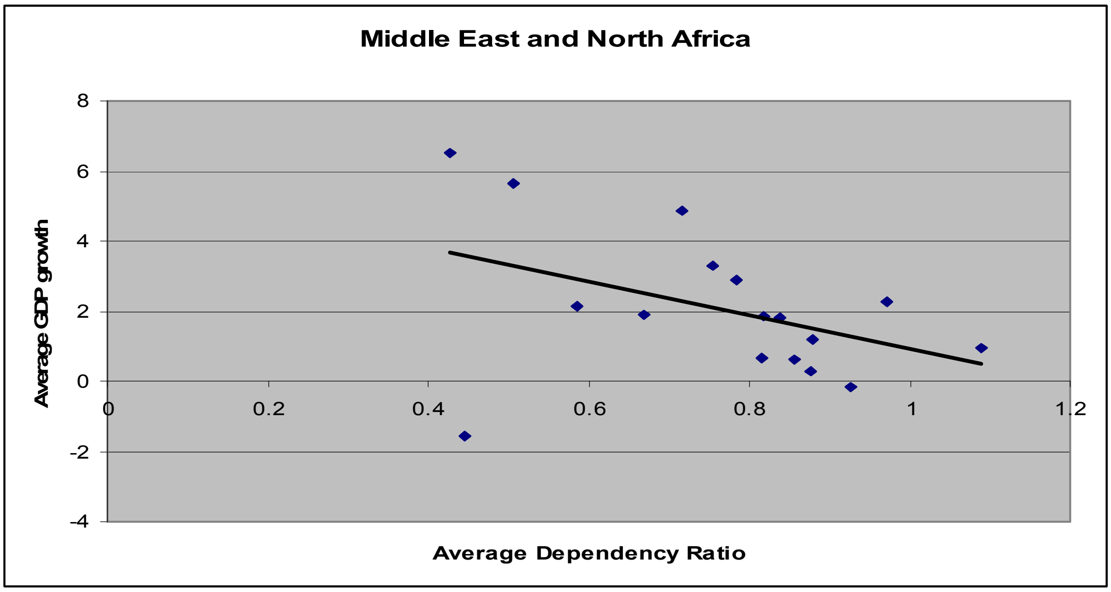
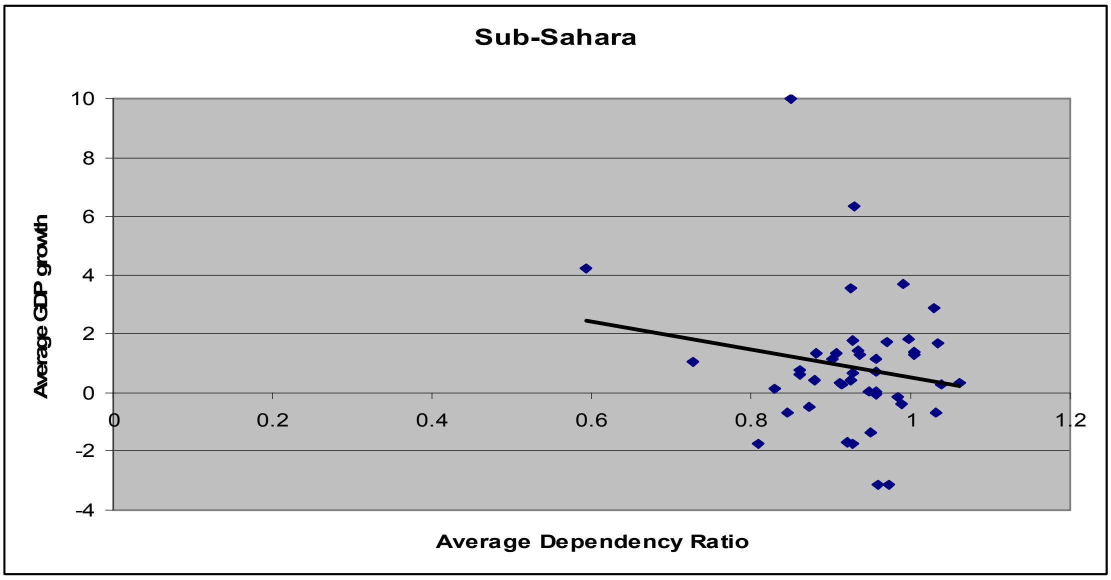


Figure 4.6: Correlation between Average GDP Growth Per Capita and Average Dependency Ratio for *Sub-Saharan*



Source: Penn World Table Version 6.2 and World Bank Education Statistics Version 5.3

That is, at the 35 years average, the negative correlation between the dependency ratio and real per capita GDP growth pertains across the five regions.

From the statistical evidence, a negative correlation between the dependency ratio and real per capita GDP growth can be observed. The theoretical support for this correlation and the significance of the correlation after including necessary controls for economic growth and the robustness of the correlation would be addressed in the latter part of the paper.

Chapter 5: Theoretical Model

The model is a transformed overlapping generations (OLG) model. The representative individual lives for three periods: youth (0-14), worker (15-64), and retiree (65 and over). The youth is a net consumer, with C_t^0 consumption. The worker is self-supporting and raises children and saves for the retirement. The retiree spends all the saving, assuming no bequest.

The budget constraint for the worker at time period *t* is:

$$f_t * C_t^0 + C_t^1 + S_t = w_t \qquad (5.1)$$

, where f_t is the representative fertility rate whose replacement rate is roughly 1.0 rather than 2.0 since the representative individual here is nonsexual; C_t^0 is the consumption of the youth and C_t^1 is the consumption of the worker; superscript *0* stands for the youth and superscript *1* stands for the worker and superscript *2* would stand for the retiree; S_t is the saving and w_t is the wage rate.

The budget constraint for the retiree is:

$$C_{t+1}^2 = (1 + r_{t+1})S_t \qquad (5.2)$$

, where variable C_{t+1}^2 is the consumption of the retiree and r_{t+1} is the real interest rate. The retiree's consumption is decided both by how much he had saved at the worker period and how much the real interest rate is at period *t+1,* which is the return to the capital at period *t+1* and reflects the productivity at period *t+1*. The concerned asset market meltdown hypothesis provides a good example; the retired baby boomers' consumption (or income) is determined not only by how much they had saved, but also by how well their children generation performs.

The utility function is assumed with constant elasticity of substitution (CES) and additive. Hence, the expected lifetime utility of a representative worker at period *t* is:

$$U_t = f_t * \frac{(C_t^0)^{1-\theta}}{1-\theta} + \frac{(C_t^1)^{1-\theta}}{1-\theta} + \beta * \frac{(C_{t+1}^2)^{1-\theta}}{1-\theta} \qquad (5.3)$$

, where coefficient β is the subjective discount factor with $0 < \beta < 1$ and $\frac{1}{\theta}$ is the constant elasticity of substitution between consumption today and consumption tomorrow.

The production function is in the Cobb-Douglas functional form with constant return to scale (CRS):

$$Y_{t+1} = K_t^{\alpha} * (A_{t+1} L_{t+1})^{1-\alpha} \qquad (5.4)$$

The capital comes from the savings of the workers at *last period*, whose number is L_t as seen at the below overlapping age structure table.

$$K_t = L_t * S_t \qquad (5.5)$$

The age structure is overlapping as follows:

Table 5.1: Over lapping of the age structure

Period	Youths	Workers	Retirees
… …			
t-2	L_{t-1}	L_{t-2}	L_{t-3}
t-1	L_t	L_{t-1}	L_{t-2}
t	L_{t+1}	L_t	L_{t-1}
t+1	L_{t+2}	L_{t+1}	L_t
t+2	L_{t+3}	L_{t+2}	L_{t+1}
… …			

The representative fertility rate f_t can be expressed as $f_t = L_{t+1} / L_t$ since it states as how many children a representative worker raises. Literally $\frac{L_{t+1}}{L_t}$ is the child dependency ratio at time period *t*. The child dependency ratio and the aged dependency ratio add up to the (total) dependency ratio.

$$Child\_Dependency\_Ratio = \frac{number\_of\_people\_aged\_0-14}{number\_of\_people\_aged\_15-64};$$

$$Aged\_Dependency\_Ratio = \frac{number\_of\_people\_aged\_65\_\&\_over}{number\_of\_people\_aged\_15-64};$$

$$Dependency\_Ratio = Child\_Dependency\_Ratio + Aged\_Dependency\_Ratio;$$

The aged dependency ratio $\frac{L_{t-1}}{L_t}$ at time period t can also be expressed in the form of the representative fertility rate.

$$\frac{L_{t-1}}{L_t} = 1/\frac{L_t}{L_{t-1}} = \frac{1}{f_{t-1}} \tag{5.6}$$

Besides, the capital and the labor are rewarded at their marginal products at equilibrium:

$$r_{t+1} = MPK = \frac{\partial Y_{t+1}}{\partial K_t} = \alpha * K_t^{-(1-\alpha)} * (A_{t+1}L_{t+1})^{1-\alpha} = \alpha * (\frac{K_t}{A_{t+1}L_{t+1}})^{-(1-\alpha)} \tag{5.7}$$

$$w_{t+1} = MPL = \frac{\partial Y_{t+1}}{\partial L_{t+1}} = (1-\alpha) * A_{t+1} * K_t^{\alpha} * (A_{t+1}L_{t+1})^{-\alpha} = (1-\alpha) * A_{t+1} * (\frac{K_t}{A_{t+1}L_{t+1}})^{\alpha} \tag{5.8}$$

By substituting in $K_t = L_t * S_t$ and applying $f_t = L_{t+1} / L_t$, the above two equations can be transformed as:

$$r_{t+1} = \alpha * (\frac{K_t}{A_{t+1}L_{t+1}})^{-(1-\alpha)} = \alpha * (\frac{L_t S_t}{A_{t+1}L_{t+1}})^{-(1-\alpha)} = \alpha * (\frac{S_t}{A_{t+1}f_t})^{-(1-\alpha)} \tag{5.9}$$

$$w_{t+1} = (1-\alpha) * A_{t+1} * (\frac{K_t}{A_{t+1}L_{t+1}})^{\alpha} = (1-\alpha) * A_{t+1} * (\frac{S_t}{A_{t+1}f_t})^{\alpha} \tag{5.10}$$

In this model the decision-making involves only the worker cohort since the youth cohort simply consumes what is provided and the retiree cohort consume what had been saved. The worker distributes his wage income among his own consumption and the saving for retirement and the children's consumption. The decision over children's consumption will be decomposed into the decision over the representative fertility rate and the worker's own consumption since the utility function is assumed additive as explained later. Therefore, the three choice variables for the worker would be his own consumption, saving, and the representative fertility rate.

Since the utility function is additive and both the representative child's consumption C_t^0 and the worker's consumption C_t^1 occur at the same time period (not subject to the discount factor), utility maximization will lead to the equality between the representative children's consumption and the representative's consumption.

$$C_t^0 = C_t^1 \tag{5.11}$$

Then the utility function can be transformed as:

$$U_t = f_t * \frac{(C_t^0)^{1-\theta}}{1-\theta} + \frac{(C_t^1)^{1-\theta}}{1-\theta} + \beta * \frac{(C_{t+1}^2)^{1-\theta}}{1-\theta} = (1+f_t) * \frac{(C_t^1)^{1-\theta}}{1-\theta} + \beta * \frac{(C_{t+1}^2)^{1-\theta}}{1-\theta} \tag{5.12}$$

And substitute the budget constraint facing the retiree $C_{t+1}^2 = (1+r_{t+1})S_t$ into the utility function, there is:

$$U_t = (1+f_t) * \frac{(C_t^1)^{1-\theta}}{1-\theta} + \beta * \frac{((1+r_{t+1})S_t)^{1-\theta}}{1-\theta} \tag{5.13}$$

Substitute in equation (5.9): $r_{t+1} = \alpha * (\frac{S_t}{A_{t+1} f_t})^{-(1-\alpha)} = \alpha A_{t+1}^{1-\alpha} f_t^{1-\alpha} S_t^{-(1-\alpha)}$

$$U_t = (1+f_t) * \frac{(C_t^1)^{1-\theta}}{1-\theta} + \beta * \frac{(S_t + \alpha A_{t+1}^{1-\alpha} f_t^{1-\alpha} S_t^{\alpha})^{1-\theta}}{1-\theta} \tag{5.14}$$

Here it is. The utility function is now with the three choice variables: f_t, C_t^1, and, S_t.

Now the budget constraint for the worker should also be transformed:

$$f_t * C_t^0 + C_t^1 + S_t = w_t \tag{5.15}$$

By substituting in $C_t^0 = C_t^1$:

$$(1+f_t)C_t^1 + S_t = w_t \tag{5.16}$$

By applying equation (5.10) $w_{t+1} = (1-\alpha) * A_{t+1} * (\frac{S_t}{A_{t+1} f_t})^{\alpha} = (1-\alpha) A_{t+1}^{1-\alpha} f_t^{-\alpha} S_t^{\alpha}$:

$$(1+f_t)C_t^1 + S_t = (1-\alpha) A_t^{1-\alpha} f_{t-1}^{-\alpha} S_{t-1}^{\alpha} \qquad (5.17)$$

Combining the transformed utility function in equation (5.12) and the transformed budget constraint in equation (5.17), the LaGrange function is set up as follow:

$$L(f_t, C_t^1, S_t) = (1+f_t) * \frac{(C_t^1)^{1-\theta}}{1-\theta} + \beta * \frac{(S_t + \alpha A_{t+1}^{1-\alpha} f_t^{1-\alpha} S_t^{\alpha})^{1-\theta}}{1-\theta} + \lambda((1-\alpha) A_t^{1-\alpha} f_{t-1}^{-\alpha} S_{t-1}^{\alpha} - (1+f_t)C_t^1 - S_t) \qquad (5.18)$$

Notice that in the LaGrange function besides the three choice variables and the coefficients $\alpha, and, \beta, and, \theta$ and the exogenous labor-augmented technology indexes A_t, and, A_{t+1}, there are two more unknown variables f_{t-1}, and, S_{t-1}. Therefore, the solutions for the utility-maximizing consumption and saving will be both related with f_t, and, f_{t-1}. Remember that the child dependency ratio is expressed here as $\frac{L_{t+1}}{L_t} = f_t$ and the aged dependency ratio is expressed as $\frac{L_{t-1}}{L_t} = 1/\frac{L_t}{L_{t-1}} = \frac{1}{f_{t-1}}$ and the total dependency ratio is the sum of the child dependency ratio and the aged dependency ratio, which is a function of both f_t, and, f_{t-1}:

$$\delta_t = f_t + \frac{1}{f_{t-1}} \qquad (5.19)$$

That is, the solutions for the utility-maximizing consumption and saving will relate the dependency ratio δ_t.

Chapter 6: Empirical Model

In Barro (1997) an extended version of neoclassical economic growth model (Ramsey-Cass-Koopmans) is introduced as:

$$D_y = f(y, y^*) \qquad (6.1)$$

, where D_y is the growth rate of per capita output, y is the current level of per capita output, and y^* is the steady state level per capita output. In this set-up D_y is decreasing in y given y^* which reflects the conditional convergence; and given y D_y is increasing in y^*, the steady state level per capita output, which depends on a full set of variables conventionally regarded to affect the economic growth, such as growth of population, education level, investment share of GDP, trade, etc. These explanatory variables enter the model independently and linearly based on the influential works of Kormendi and Meguire (1985), Grier and Tullock (1989) and Barro (1991).

A similar model is deducted as followed, including the dependency ratio as an explanatory variable.

Production function is at Cobb-Douglas functional form and with constant return to scale.

$$Y_t = K_t^{\alpha} * L_t^{1-\alpha} \qquad (6.2)$$

Differentiate the production function with respect to time:

$$\frac{dY_t}{dt} = \frac{\partial Y_t}{\partial K_t} * \frac{dK_t}{dt} + \frac{\partial Y_t}{\partial L_t} * \frac{dL_t}{dt} \tag{6.3}$$

Divide both sides by Y_t:

$$\frac{dY_t / dt}{Y_t} = \frac{\partial Y_t}{\partial K_t} * \frac{K_t}{Y_t} * \frac{dK_t / dt}{K_t} + \frac{\partial Y_t}{\partial L_t} * \frac{L_t}{Y_t} * \frac{dL_t / dt}{L_t} \tag{6.4}$$

Given $Y_t = K_t^{\alpha} * L_t^{1-\alpha}$, there is $\frac{\partial Y_t}{\partial K_t} * \frac{K_t}{Y_t} = \alpha * K_t^{\alpha-1} * L_t^{1-\alpha} * \frac{K_t}{Y_t} = \alpha$. (6.5)

And similarly, there is $\frac{\partial Y_t}{\partial L_t} * \frac{L_t}{Y_t} = (1-\alpha) * K_t^{\alpha} * L_t^{-\alpha} * \frac{L_t}{Y_t} = 1-\alpha$. (6.6)

Hence, equation (6.4) can be transformed as:

$$\frac{dY_t / dt}{Y_t} = \alpha * \frac{dK_t / dt}{K_t} + (1-\alpha) * \frac{dL_t / dt}{L_t} \tag{6.7}$$

That is, the GDP growth is decomposed as a weighted average of capital growth and labor growth, where the weights are defined as capital share of output and labor share of output respectively.

Further decompose the labor growth to introduce the dependency ratio, which is the interested variable in this paper. First, denote the dependency ratio as δ_t.

By definition, $\delta_t = \frac{N_t - L_t}{L_t} \Leftrightarrow N_t = (1+\delta_t) * L_t \Leftrightarrow L_t = \frac{1}{1+\delta_t} * N_t$ (6.8)

, where N_t is the total population.

Let $\rho_t = \frac{1}{1+\delta_t}$, equation (6.8) can be transformed as $L_t = \rho_t * N_t$ (6.9)

Differentiate equation (6.9) with respect to time:

$$\frac{dL_t}{dt}=\frac{\partial L_t}{\partial \rho_t}*\frac{d\rho_t}{dt}+\frac{\partial L_t}{\partial N_t}*\frac{dN_t}{dt}=N_t*\frac{d\rho_t}{dt}+\rho_t*\frac{dN_t}{dt} \qquad (6.10)$$

Divide both sides by L_t:

$$\frac{dL_t/dt}{L_t}=\frac{N_t}{L_t}*\frac{d\rho_t}{dt}+\frac{\rho_t}{L_t}*\frac{dN_t}{dt}=\frac{d\rho_t/dt}{\rho_t}+\frac{dN_t/dt}{N_t} \qquad (6.11)$$

Substitute equation (6.11) into equation (6.7):

$$\frac{dY_t/dt}{Y_t}=\alpha*\frac{dK_t/dt}{K_t}+(1-\alpha)*(\frac{d\rho_t/dt}{\rho_t}+\frac{dN_t/dt}{N_t}) \qquad (6.12)$$

Subtract both sides by the population growth:

$$\frac{dY_t/dt}{Y_t}-\frac{dN_t/dt}{N_t}=\alpha*\frac{dK_t/dt}{K_t}+(1-\alpha)*\frac{d\rho_t/dt}{\rho_t}-\alpha*\frac{dN_t/dt}{N_t} \qquad (6.13)$$

Applying $\rho_t=\frac{1}{1+\delta_t}$:

$$\frac{dY_t/dt}{Y_t}-\frac{dN_t/dt}{N_t}=\alpha*\frac{dK_t/dt}{K_t}-(1-\alpha)*\frac{d(1+\delta_t)/dt}{1+\delta_t}-\alpha*\frac{dN_t/dt}{N_t} \qquad (6.14)$$

In equation (6.14), the left hand side variable is the per capita GDP growth, which is the dependant variable in the growth regression, and the right hand side variables include capital growth, growth rate of dependency ratio plus 1, and population growth. That is, dependency ratio enters the growth regression in a transformed expression.

Then, decompose the capital growth to bring out the conditional convergence and the steady state level per capita output. First, decompose the output as the uses of fund, also called as the goods market clearing condition: $Y_t = C_t + I_t = C_t + S_t$ (6.15)

, where C_t is the consumption, I_t is the investment, and S_t is the saving. And denote saving as a proportion of output: $S_t = s * Y_t$ (6.16)

Also notice that investment is indeed the change in capital stock as: $I_t = \frac{dK_t}{dt}$ when no depreciation is assumed. Divide equation (6.15) by L_t to obtain per effective labor amount of output: $\frac{Y_t}{L_t} = \frac{C_t}{L_t} + \frac{I_t}{L_t} = \frac{C_t}{L_t} + \frac{dK_t / dt}{L_t}$ (6.17)

Denote the effective labor amount of output as $y_t \equiv \frac{Y_t}{L_t}$ and the effective labor amount of consumption as $c_t \equiv \frac{C_t}{L_t}$ and the effective labor amount of capital as $k_t \equiv \frac{K_t}{L_t}$. Then equation (6.17) can be transformed as: $y_t = c_t + \frac{dK_t / dt}{L_t}$ (6.18)

Differentiate $k_t \equiv \frac{K_t}{L_t}$ with respect to time:

$$\frac{dk_t}{dt} = \frac{1}{L_t}\frac{dK_t}{dt} - \frac{K_t}{L_t^2}\frac{dL_t}{dt} = \frac{dK_t / dt}{L_t} - k_t \frac{dL_t / dt}{L_t} \Leftrightarrow \frac{dK_t / dt}{L_t} = k_t \frac{dL_t / dt}{L_t} + \frac{dk_t}{dt} \quad (6.19)$$

Recall that in equation (6.11), the labor growth can be decomposed as population growth minus the growth of dependency ratio plus 1. Denote population growth rate as n_t and the growth rate of dependency ratio plus 1 as φ_t, then equation (6.19) can be transformed as:

$$\frac{dK_t/dt}{L_t} = k_t*(n_t - \varphi_t) + \frac{dk_t}{dt} \tag{6.20}$$

Substitute equation (6.20) into equation (6.18):

$$y_t = c_t + \frac{dK_t/dt}{L_t} = c_t + k_t(n_t - \varphi_t) + \frac{dk_t}{dt} \tag{6.21}$$

Applying $Y_t = C_t + S_t$ and $S_t = s*Y_t$:

$$C_t = Y_t - S_t = (1-s)Y_t \Leftrightarrow \frac{C_t}{L_t} = (1-s)\frac{Y_t}{L_t} \Leftrightarrow c_t = (1-s)y_t \tag{6.22}$$

Then transform equation (6.21) as:

$$\frac{dk_t}{dt} = s*y_t - (n_t - \varphi_t)k_t \tag{6.23}$$

Then by $Y_t = K_t^{\alpha} * L_t^{1-\alpha}$, there is $\frac{Y_t}{L_t} \equiv y_t = K_t^{\alpha} * L_t^{-\alpha} = (\frac{K_t}{L_t})^{\alpha} \equiv k_t^{\alpha}$ (6.24)

Substitute equation (6.24) into equation (6.23) and divide both sides by k_t:

$$\frac{dk_t}{dt} = s*k_t^{\alpha} - (n_t - \varphi_t)k_t \Leftrightarrow \frac{dk_t/dt}{k_t} = \frac{d\ln k_t}{dt} = s*k_t^{\alpha-1} - (n_t - \varphi_t) \tag{6.25}$$

Let $z_t = \ln k_t \Leftrightarrow k_t = e^{z_t}$, the equation (6.25) can be transformed as:

$$\frac{dz_t}{dt} = s*\exp((\alpha-1)z_t) - (n_t - \varphi_t) \tag{6.26}$$

Take a first order Taylor series around the steady state:

$$\frac{dz_t}{dt}\Big|_{z_t=z_{ss}} = s*\exp((\alpha-1)z_{ss}) - (n_t - \varphi_t) + s*(\alpha-1)\exp((\alpha-1)z_{ss})(z_t - z_{ss}) \tag{6.27}$$

Applying $z_{ss} = \ln k_{ss} = \ln(\frac{s}{n_t - \varphi_t})^{1/(1-\alpha)}$, the equation (6.27) would be simplified as:

$$\frac{dz_t}{dt} = (1-\alpha)(n_t - \varphi_t)(z_{ss} - z_t) \Leftrightarrow \frac{dk_t / dt}{k_t} = (1-\alpha)(n_t - \varphi_t)(k_{ss} - k_t) \quad (6.28)$$

$$\Rightarrow \frac{dK_t / dt}{K_t} = \frac{dk_t / dt}{k_t} + \frac{dL_t / dt}{L_t} = (1-\alpha)(n_t - \varphi_t)(k_{ss} - k_t) + (n_t - \varphi_t) \quad (6.29)$$

Applying $y_t = k_t^{\alpha}$,&, $y_{ss} = k_{ss}^{\alpha}$:

$$\frac{dK_t / dt}{K_t} = (1-\alpha)(n_t - \varphi_t)(y_{ss}^{1/\alpha} - y_t^{1/\alpha}) + (n_t - \varphi_t) \quad (6.30)$$

Substitute equation (6.30) into equation (6.14):

$$\frac{dY_t / dt}{Y_t} - \frac{dN_t / dt}{N_t} = \alpha * [(1-\alpha)(n_t - \varphi_t)(y_{ss}^{1/\alpha} - y_t^{1/\alpha}) + (n_t - \varphi_t)] - (1-\alpha) * \varphi_t - \alpha * n_t \quad (6.31)$$

That is the conditional convergence, where the growth rate is positively correlated with the steady state level given the previous income level and negatively correlated with the previous income level given the steady state. The conditional convergence is predicted in the Solow model as in Mankiw et al (1992) and it is thoroughly tested in empirics by Barro (1991). On the variables affecting the steady state or conventionally the long-run growth, however, almost every scholar uses a different set of explanatory variables. As in Levine and Renelt (1992), “many authors who examine the relationship between measures of fiscal policy and growth ignore the potential importance of trade policy, while those authors who study the empirical ties between trade and growth commonly ignore the role of fiscal policy.” Over 70 variables have been considered for the determinants of economic growth and more than 50 variables have shown significance in at least one regression. The results from different regressions are mixed-up and even conflicting with each other sometimes. Two papers are essential in clearing up this mist.

One is Levine and Renelt (1992) and the other is Sala-i-Martin et al (2004). Levine and Renelt (1992) test over 50 variables for the robustness using a variant of Edward Leamer's (1983) extreme-bounds analysis (EBA) and conclude "very few economic variables are robustly correlated with cross-country growth rates or the ratio of investment expenditures to GDP." Aside from the four variables always included in the cross-country regression, the investment share of GDP, the initial level of real GDP per capita, the initial secondary-school enrollment rate and the average annual rate of population growth, the only robust correlations found in Levine and Renelt (1992) are "a positive and robust correlation between average growth rates and the average share of investment in GDP" and "a positive and robust correlation between the share of investment in GDP and the average share of trade in GDP". The too few robust correlations found in Levine and Renelt (1992) drive researchers to believe that the criterion used in Levine and Renelt (1992) is too strict, as commented by authors in Sala-i-Martin et al (2004), "the test is too strong for any variable to pass: any one regression model (no matter how well or poorly fitting) carries a veto." In the more recent study, Sala-i-Martin et al (2004) apply a different method, a Bayesian Averaging of Classical Estimates (BACE) approach, in examining the robustness of explanatory variables in the cross-country regression. The BACE approach results in "about one-fifth of the 67 variables used in the analysis can be said to be significantly related to growth while several more are marginally related". Population growth is one of the four "always included variables" in Levine and Renelt (1992) and it is insignificant before the robustness test[17] and after the robustness test. Population growth is also included in Sala-i-Martin et al (2004) and it is also insignificant[18] before and after the robustness test. That is, “population neutralism” holds in these two sensitivity analysis papers. Below these two sensitivity analysis approaches will both be applied in the cross-country growth regression when the population growth is decomposed to bring up the effect of age structure of the population. Two questions are under concern: does “population neutralism” still hold after the decomposition and does the negative correlation between the dependency ratio and the growth rate significantly show up and prove its robustness in the sensitivity analysis?

[17] Indeed, population growth is marginally significant at 10% level when only the four always included variables are regressed on. In Levine and Renelt (1992) 5% is taken as statistically significant. That is, 10% is insignificant.
[18] The marginal significant level for population growth in Sala-i-Martin et al (2004) is .95.

Chapter 7: Data and Variables

Since the criterion in Levine and Renelt (1992) is claimed to be “too strict”, the four always included variables: the investment share of GDP ($IShare_{it}$), the initial level of real GDP per capita ($Y_{i,t-1}$), the initial secondary-school enrollment rate ($Enroll_{i,t-1}$), and the average annual rate of population growth ($GPOP$) are first considered. These four variables are all fitted in this study. The initial level of real per capita GDP correlates with the dependency ratio in the sense that the income level reversely and negatively affects the fertility rate because richer couple value the quality of children over the quantity of children; the education level is also regarded negatively correlated with fertility rate because higher educated couple face a higher opportunity cost in rearing children; as for the investment share, the investment equals saving in the OLG model in **Chapter 5** and saving can be solved as a function of dependency ratio; population growth is surely correlated with dependency ratio since the dependency ratio is a component of population growth. Data for GDP per capita and the investment share of GDP comes from *Penn World Table 6.2* under “constant price entries” and data for the population growth and the secondary-school enrollment rate comes for *World Bank Education Statistics Version 5.3*. The GDP is calculated by adding up consumption, investment, government spending and net exports in any given year using the Laspeyres price index where the reference year is 1996. The secondary student enrollment includes enrollment in general programs as well as enrollment in technical and vocational programs, which makes the secondary enrollment rate possibly exceed 100%. The data set covers 170 countries and ranges from 1970 to 2004. A five-year average of the data is taken to reduce business-cycle effects and measurement error as in most cross-country growth regressions. The comparative statistics is presented in **Table 7.1**. All the values are at five-year average and the 35-year interval is decomposed into seven observations. Number of observations reaches the maximum at 1190, which equals 170 multiplying 7.

The fifth variable is the only robust variable out of the four always included variables in Levine and Renelt (1992): the average share of trade in GDP *(Openness)*. Trade share correlates with the dependency ratio in the sense that the trade would lead the labor and the capital to be better allocated and hence increase the marginal product of labor and marginal product of capital, which shows up in the utility maximization consumption and saving in **Chapter 5** and hence correlates with the dependency ratio. This variable also comes from *Penn World Table 6.2* under "constant price entries" and is calculated from dividing exports **plus** import by GDP. Notice that in GDP calculation, $GDP = C + I + G + NE = C + I + G + EX - IM$ while in the trade share calculation, $Openness = \frac{EX + IM}{GDP}$ which makes the trade share of a small country with great trade opportunity exceed 100% when $EX + IM > C + I + G + EX - IM$.
Or equivalently, $2 * IM > C + I + G$. Other variables obtained from *Penn World Table 6.2* include consumption share of GDP ($CShare_{it}$) and government spending share of GDP ($GShare_{it}$), both of which are under "constant price entries". Consumption share

measures the consumption level and it could be solved as a function of dependency ration in **Chapter 5**; government share is not accounted for in **Chapter 5**, though if included it could be treated similarly as investment, competing the consumption as in the equation $Y = C + I + G$, rather than $Y = C + I$. Consumption share also contains values over 100%, which happens when the unfavorable balance of trade is huge.

Mathematically, $\frac{C}{GDP} > 1 \Leftrightarrow C > C + I + G + NE \Leftrightarrow -NE > I + G$ .The descriptive statistics for these three variables: $Openness, CShare_{it}, and, GShare_{it}$ is enclosed in **Table 7.1**. Again, the values are at five-year average.

Table 7.1: Descriptive Statistics for Dependent Variable and Independent Variables

Variables	Obs.	Mean	Std. Dev.	Min	Max
Dependent Variable					
Growth Rate of GDP per capita (%)	1078	1.78	4.7486	-27.68	52.15
Independent Variables					
Population Growth (%)	1190	1.83	1.5066	-5.05	16.17
Growth Rate of (1+δ) (%)	1190	-0.31	0.5080	-2.83	1.19
Lag Secondary Enrollment	859	51.06	33.4109	0.00	151.34
Lag GDP per capita	912	7264.07	8112.7160	242.37	75186.65
Investment Share (%)	1082	14.42	8.4911	1.02	91.97
Consumption Share (%)	1082	69.17	18.7223	10.39	199.84
Government Spending Share (%)	1082	22.67	10.8050	2.55	79.57
Openness (%)	1084	77.78	51.2984	2.17	426.67

Source: Penn World Table Version 6.2 and World Bank Education Statistics Version 5.3

Besides, the region dummies from *World Bank Education Statistics Version 5.3* are also included. They are: dummy for East Asia & Pacific, dummy for Europe & Central Asia, dummy for Latin America & Caribbean, dummy for Middle East & North Africa, dummy for North America, dummy for South Asia, and dummy for Sub-Saharan Africa. The region dummies try to control region-specific culture and/or religion. As argued in Bloom and Canning (2003), the religion could greatly affect the fertility rate. No other variables are included mainly because of the data deficiency of China from 1970 to 2004. If some other variables are included, such as political right index, China will always be dropped out. As seen in the two papers on sensitivity analysis, China isn't included in the 119-country sample of Levine and Renelt (1992) and isn't included in the 88-country sample of Sala-i-Martin et al (2004). For the discussion over the planned birth policy though, the statement would be less creditable if China is excluded in the regressions. Besides, in conducting sensitivity analyses over cross-country growth regressions, an equal number of observations for all regressions is needed, which also eliminates the chance to be included for some variables.

Chapter 8: Estimation Results

The first regression contains only the four always included variables as in Levine and Renelt (1992). The result is shown in **Table 8.1** including the comparison with the result from Levine and Renelt (1992). Also included in **Table 8.1** is the second regression, which replaces the population growth by growth rate of (1+δ), where δ is the (total) dependency ratio. Growth rate of (1+δ) is a component of population growth as shown in below.

The dependency ratio is the ratio of the population defined as dependent (the population age 0-14 and 65 and over) divided by the population defined as working-age (age 15-64). Hence, the Dependency Ratio δ is given by:

$$\delta = \frac{POP - WA}{WA} = \frac{POP}{WA} - 1 \qquad (8.1)$$

where POP is the total population in the economy; WA is the total working age people in the economy. Rearrange the equation:

$$\frac{POP}{WA} = 1 + \delta \qquad (8.2)$$

$$POP = WA * (1 + \delta) \qquad (8.3)$$

Let $\rho = 1 + \delta$ and take log on both sides of the equation:

$$\ln(POP_t) = \ln(WA_t) + \ln(\rho_t) \qquad (8.4)$$

Then take the lag of all variables for one period:

$$\ln(POP_{t-1}) = \ln(WA_{t-1}) + \ln(\rho_{t-1}) \tag{8.5}$$

Subtract these two equations and get the growth rate of population:

$$\ln(POP_t) - \ln(POP_{t-1}) = \ln(WA_t) - \ln(WA_{t-1}) + \ln(\rho_t) - \ln(\rho_{t-1}) \tag{8.6}$$

$$\because gr(z) \equiv \ln(z_t) - \ln(z_{t-1}) \tag{8.7}$$

$$\therefore gr(POP) = gr(WA) + gr(1+\delta) \tag{8.8}$$

As shown in **Table 8.1**, results of regression (I) are consistent with the result in Levine and Renelt (1992) and as expected. Population growth is insignificant [19] in both regressions. That is, "population neutralism" holds in both regressions. Lag secondary enrollment is significant and positive, which states higher education associates with higher economic growth. Lag GDP per capita is significant and negative, which complies with the convergence theory. Investment share is significant and positive, which states higher investment share associates with higher economic growth.

[19] Population growth is marginally significant at 10% level in the only-four-always-included-variables regression of Levine and Renelt (1992), but it is regarded as insignificant because 5% significant level is taken as statistically significant in Levine and Renelt (1992) and in the follow-up sensitivity analysis of Levine and Renelt (1992) population growth is fragile and is the only fragile variable among the four always included variables.

Table 8.1: Cross-country Growth Regressions

(Dependent Variable: Growth Rate of Real GDP per capita)

	Regression [Period] # of countries [Data Source]		
Independent Variables	Levine and Renelt (1992) [1960-1989] 119 countries [WB/IMF]	(I) [1970-2004] 170 countries [WB/PWT]	(II) [1970-2004] 170 countries [WB/PWT]
Population Growth (%)	-0.38* (0.22)	0.0621 (0.1065)	
Growth of (1+δ) (%)			-0.6702*** (0.2538)
Lag Secondary Enrollment	3.17** (1.29)	0.0276*** (0.0062)	0.0232*** (0.0050)
Lag GDP per capita	-0.35** (0.14)	-0.0001*** (0.00002)	-0.0001*** (0.00002)
Investment Share (%)	17.49*** (2.68)	0.1199*** (0.0170)	0.1194*** (0.0169)
Constant	-0.83 (0.85)	-0.4794 (0.4264)	-0.4370 (0.2671)
Number of Observations	101	811	811
R-Square	0.46	0.12	0.13

Notes: Standard deviations are reported in the parenthesis and *, ** and *** represent significant level of 10%, 5% and 1% respectively.

Regression (II) differs from regression (I) by replacing population growth with growth rate of (1+δ). The descriptive statistics of growth rate of (1+δ) can be found in **Table 7.1**. Results on the other three variables: lag secondary enrollment, lag GDP per capita, and investment share, are similar. Growth rate of (1+δ) is significant and negative, differing from the insignificant population growth. The negative sign states that higher growth rate of dependency ratio associates with lower economic growth. That is, after decomposing population growth, the factor inside population growth and affecting economic growth pops out. The following part will focus on the sensitivity analysis of this pop-out factor: growth rate of dependency ratio.

The sensitivity analysis conducted in Levine and Renelt (1992) is categorized as Extreme Boundary Analysis (EBA), which is a variant of the EBA discussed in Leamer (1983, 1985) and Leamer and Leonard (1983). The EBA examines the boundaries of the coefficient for the interested variable by adding other variables and varying the combination of added variables. The highest coefficient value obtained plus two standard deviations will be the upper bound and the lowest coefficient value obtained minus two standard deviations will be the lower bound, if 5% significant level is chosen. When the upper bound and the lower bound remain significant and of the same sign, the interested variable would be regarded as robust. A good feature of the EBA in the cross-country growth regression is that the explanatory variables enter the regression independently and linearly according to Kormendi and Meguire (1985), Grier and Tullock (1989) and Barro (1991), which makes the added variables combine only linearly and much simpler.

Table 8.2 presents the results with adding one variable from $Openness, CShare, GShare$. **Table 8.3** presents the results with adding two variables and with the combination from $Openness, CShare, GShare$. The results for adding all these three variables are also enclosed in **Table 8.3**. Throughout these regressions, growth rate of (1+δ) is significant everywhere at 10% level and of the same sign, while not all significant at 5% level. In Levine and Renelt (1992), population growth is marginally significant at 10% level when only four variables are included and insignificant and of *different* sign after adding up to three variables from a subset of seven variables: “the average rate of government consumption expenditures to GDP (GOV), the ratio of exports to GDP (X), the average inflation rate (PI), the average growth rate of domestic credit (GDC), the standard deviation of inflation (STDI), the standard deviation of domestic credit growth (STDD), and an index for the number of revolutions and coups (REVC).” Other findings are consistent with Levine and Renelt (1992), trade share and the other three always included variables are all robust. Additional regressions are presented in **Table 8.4** and **Table 8.5** when the region dummies are included. The seven dummy variables are added, while counted as one added variable, and the linear combination with $Openness, CShare, GShare$ is presented in **Table 8.4** and **Table 8.5**. Throughout these regressions, growth rate of (1+δ) is significant everywhere at 5% level and of same sign. That is, by adding region dummies, the robustness of growth rate of (1+δ) improves. In summary, the Extreme Boundary Analysis leads to a robust result for growth rate of (1+δ).

Table 8.2: Sensitivity Analysis with Adding One Variable

(Dependent Variable: Growth Rate of Real GDP per capita)

	Regression			
	(II)	(III)	(IV)	(V)
Basic Variables				
Growth of (1+δ) (%)	-0.6702*** (0.2538)	-0.6192** (0.2573)	-0.6694*** (0.2539)	-0.5533** (0.2535)
Lag Secondary Enrollment	0.0232*** (0.0050)	0.0227*** (0.0050)	0.0235*** (0.0050)	0.0228*** (0.0050)
Lag GDP per capita	-0.0001*** (0.00002)	-0.0001*** (0.00002)	-0.0001*** (0.00002)	-0.0001*** (0.00002)
Investment Share (%)	0.1194*** (0.0169)	0.1151*** (0.0173)	0.1186*** (0.0170)	0.1118*** (0.0169)
Added Variables				
Consumption Share (%)		-0.0101 (0.0084)		
Government Spending Share (%)			-0.0102 (0.0122)	
Openness (%)				0.0093*** (0.0024)
Constant	-0.4370 (0.2671)	0.4347 (0.7760)	-0.1885 (0.3989)	-0.9076*** (0.2921)
Number of observations	811	811	811	811
R-square	0.13	0.13	0.13	0.15

Notes: Standard deviations are reported in the parenthesis and *, ** and *** represent significant level of 10%, 5% and 1% respectively.

Table 8.3: Sensitivity Analysis with Adding Two and Three Variables

(Dependent Variable: Growth Rate of Real GDP per capita)

	Regression			
	(VI)	(VII)	(VIII)	(IX)
Growth of (1+δ) (%)	-0.6116** (0.2574)	-0.4796* (0.2574)	-0.5446** (0.2534)	-0.4549* (0.2574)
Lag Secondary Enrollment	0.0230*** (0.0050)	0.0220*** (0.0050)	0.0233*** (0.0050)	0.0225*** (0.0050)
Lag GDP per capita	-0.0001*** (0.00002)	-0.0002*** (0.00002)	-0.0001*** (0.00002)	-0.0002*** (0.00002)
Investment Share (%)	0.1136*** (0.0174)	0.1058*** (0.0173)	0.1100*** (0.0169)	0.1024*** (0.0174)
Consumption Share (%)	-0.0114 (0.0085)	-0.0136 (0.0084)		-0.0162* (0.0085)
Government Spending Share (%)	-0.0127 (0.0123)		-0.0181 (0.0123)	-0.0221* (0.0124)
Openness (%)		0.0097*** (0.0024)	0.0099*** (0.0025)	0.0105*** (0.0025)
Constant	0.8572 (0.8776)	0.2451 (0.7704)	-0.4970 (0.4026)	0.9652 (0.8688)
Number of observations	811	811	811	811
R-square	0.13	0.15	0.15	0.15

Notes: Standard deviations are reported in the parenthesis and *, ** and *** represent significant level of 10%, 5% and 1% respectively.

Table 8.4: Sensitivity Analysis with Region Dummies, Part I

(Dependent Variable: Growth Rate of Real GDP per capita)

	Regression			
	(X)	(XI)	(XII)	(XIII)
Growth of (1+δ) (%)	-0.7463*** (0.2719)	-0.7261*** (0.2733)	-0.7371*** (0.2720)	-0.6366** (0.2702)
Lag Secondary Enrollment	0.0150** (0.0063)	0.0149** (0.0063)	0.0153** (0.0063)	0.0115* (0.0063)
Lag GDP per capita	-0.0001*** (0.00002)	-0.0001*** (0.00002)	-0.0001*** (0.00002)	-0.0001*** (0.00002)
Investment Share (%)	0.1041*** (0.0178)	0.1023*** (0.0180)	0.1032*** (0.0179)	0.0957*** (0.0178)
Consumption Share (%)		-0.0065 (0.0087)		
Government Spending Share (%)			-0.0132 (0.0124)	
Openness (%)				0.0108*** (0.0025)
East Asia & Pacific	-0.5331 (0.6835)	-0.5332 (0.6837)	-0.5584 (0.6839)	-0.8369 (0.6800)
Europe & Central Asia	-0.0894 (0.7092)	-0.0601 (0.7105)	-0.0791 (0.7092)	-0.0592 (0.7017)
Latin America & Caribbean	-1.5230** (0.6518)	-1.4786** (0.6547)	-1.5470** (0.6521)	-1.5401** (0.6449)
Middle East & North Africa	-0.9542 (0.7043)	-0.9223 (0.7058)	-0.8926 (0.7066)	-1.3323* (0.7024)
North America	0.1031 (1.1995)	0.2078 (1.2080)	0.0638 (1.1999)	0.6600 (1.1938)
South Asia	(dropped)	(dropped)	(dropped)	(dropped)
Sub-Saharan Africa	-1.3224** (0.6341)	-1.2437* (0.6430)	-1.3459** (0.6344)	-1.6040** (0.6308)
Constant	1.0351 (0.6501)	1.5223* (0.9231)	1.3743* (0.7238)	0.7632 (0.6463)
Number of observations	811	811	811	811
R-square	0.15	0.15	0.15	0.17

Notes: Standard deviations are reported in the parenthesis and *, ** and *** represent significant level of 10%, 5% and 1% respectively.

Table 8.5: Sensitivity Analysis with Region Dummies, Part II

(Dependent Variable: Growth Rate of Real GDP per capita)

	Regression			
	(XIV)	(XV)	(XVI)	(XVII)
Growth of (1+δ) (%)	-0.7109*** (0.2735)	-0.5963** (0.2718)	-0.6148** (0.2701)	-0.5605** (0.2719)
Lag Secondary Enrollment	0.0152** (0.0063)	0.0111* (0.0063)	0.0118* (0.0062)	0.0114* (0.0062)
Lag GDP per capita	-0.0001*** (0.00002)	-0.0002*** (0.00002)	-0.0001*** (0.00002)	-0.0002*** (0.00002)
Investment Share (%)	0.1008*** (0.0180)	0.0922*** (0.0180)	0.0937*** (0.0178)	0.0889*** (0.0180)
Consumption Share (%)	-0.0080 (0.0088)	-0.0115 (0.0087)		-0.0145* (0.0088)
Government Spending Share (%)	-0.0149 (0.0125)		-0.0216* (0.0124)	-0.0251** (0.0126)
Openness (%)		0.0112*** (0.0025)	0.0115*** (0.0025)	0.0121*** (0.0026)
East Asia & Pacific	-0.5617 (0.6840)	-0.8494 (0.6797)	-0.8968 (0.6800)	-0.9223 (0.6795)
Europe & Central Asia	-0.0415 (0.7105)	-0.0060 (0.7025)	-0.0406 (0.7009)	0.0294 (0.7014)
Latin America & Caribbean	-1.4952** (0.6547)	-1.4620** (0.6472)	-1.5803** (0.6445)	-1.4886** (0.6462)
Middle East & North Africa	-0.8453 (0.7086)	-1.2912* (0.7027)	-1.2551 (0.7029)	-1.1907* (0.7032)
North America	0.1884 (1.2078)	0.8685 (1.2036)	0.6302 (1.1925)	0.8879 (1.2014)
South Asia	(dropped)	(dropped)	(dropped)	(dropped)
Sub-Saharan Africa	-1.2514* (0.6429)	-1.4758** (0.6379)	-1.6595*** (0.6308)	-1.5071** (0.6369)
Constant	2.0202** (1.0136)	1.6163* (0.9128)	1.2996* (0.7155)	2.4615** (1.0048)
Number of observations	811	811	811	811
R-square	0.15	0.17	0.17	0.17

Notes: Standard deviations are reported in the parenthesis and *, ** and *** represent significant level of 10%, 5% and 1% respectively.

The other robustness test is introduced in Sala-i-Martin etc (2004), called Bayesian Averaging of Classical Estimates (BACE). Since the BACE is a response to the "too strict" robustness test in Levine and Renelt (1992), which concludes only one variable (trade share) out of over 50 variables except for the four-always-included variables is robust in cross-country growth regression, and the BACE concludes 18 out of 67 variables are robust, it is expected the growth rate of the dependency ratio would also be robust in BACE based on its robustness in EBA. Anyhow, the BACE is followed.

The BACE test differs from the EBA test first in the "always-included" variables. There is no variable being "always-included" in the BACE test. All variables face a binary choice: to be included or not to be included. 67 variables are examined in Sala-i-Martin et al (2004), which can be translated as the total number of possible regressions is $2^{67}=1.48*10^{20}$. As stated in Sala-i-Martin et al (2004), the estimates converge after 89 million regressions. Then, based on the 89 million regressions, a posterior inclusion probability for each of these 67 variables is calculated. "The posterior inclusion probability is the sum of the posterior probabilities of all of the regressions including that variable. Thus, computationally, the posterior inclusion probability is a measure of the weighted average goodness-of-fit of models including a particular variable, relative to models not including the variables." Third, a prior inclusion probability is set based on the expected model size. In Sala-i-Martin et al (2004) the expected model size is believed to include 7 variables[20], which concludes the prior inclusion probability is 0.104=7/67. In

[20] Different model sizes, varying from 5 to 28, are tested in the later part of Sala-i-Martin et al (2004).

the end, the prior inclusion probability is compared to the posterior inclusion probability. If the posterior inclusion probability for a specific variable is greater than the prior inclusion probability, it says this variable has "high marginal contribution to the goodness-of-fit of the regression model" and belongs in the regression for explaining the economic growth. 18 variables out of the 67 variables carry a posterior inclusion probability higher than the prior inclusion probability (=0.104) and are claimed as "significant". Later on, the sign certainty is tested over these 18 variables and the result confirms the robustness of these 18 variables. For this paper, the posterior inclusion probability for the growth rate of (1+δ) is 0.8587 when all variables (including the region dummies) are taken into account, which is certainly higher than any possible prior inclusion probability. As expected, the growth rate of dependency ratio shows its robustness under BACE.

Throughout the EBA regressions, the upper bound for the coefficient of growth rate of (1+δ) is -0.4549 at regression (IX) and the lower bound is -0.7463 at regression (X). Mathematically, say, a country's dependency ratio decreases from 0.50 to 0.49, that is the growth of the (1+δ) is -0.67%, the country would expect to have a (0.30%, 0.50%)[21] economic boost from the change in the age structure of population. Specifically, for the twenty-five years from 1980[22] to 2004, Ireland's economic growth averages at 4.14% and its growth rate of (1+δ) averages at -0.65%. If applying the upper bound and the lower bound, the contribution from the growth rate of (1+δ) to the economic growth ranges

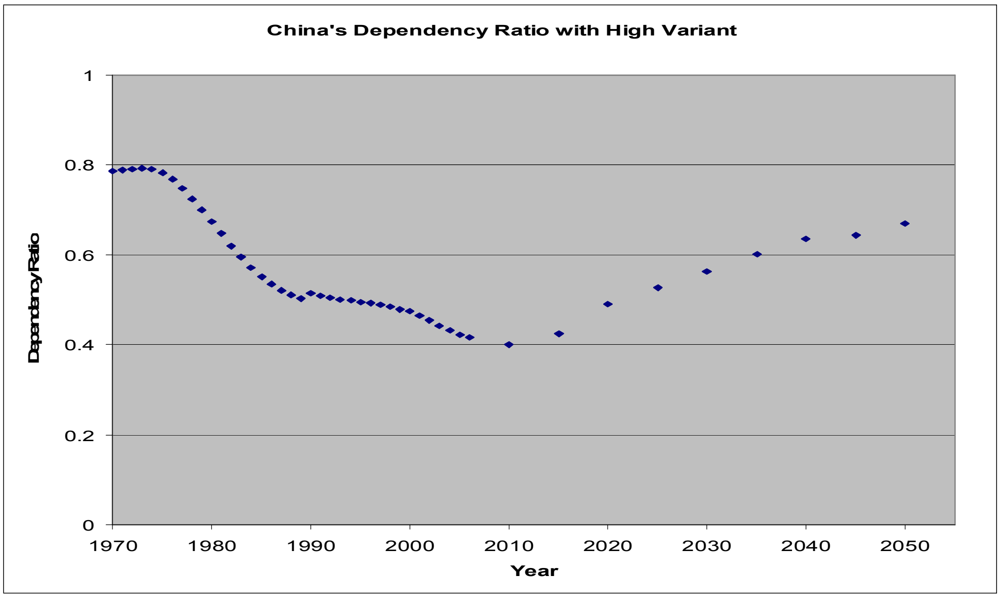
[21] 0.30% = -0.67% * (-0.4549); 0.50% = -0.67% * (-0.7463).
[22] Ireland legalized contraception in 1979.

from 7.10% to 11.65%, which is much smaller than the a-quarter contribution in Bloom and Canning (2003). That is, the paper echoes the contribution from the growth rate of dependency ratio to the economic growth in Ireland, but with a much lower magnitude. As for China, a country carried out the planned birth policy in 1979, the economic growth averages at 8.36% and the growth rate of $(1+\delta)$ averages at -0.72% since 1980 to 2004. If applying the upper bound and the lower bound, the contribution from the growth rate of $(1+\delta)$ to the economic growth ranges from 3.92% to 6.43%. That is, the planned birth policy results in the negative growth rate of dependency ratio and contributes to economic growth in this sense, but the magnitude is small, even when all kinds of normative judgments (such as human rights) are ignored.

The compelling planned birth policy is criticized all the time inside and outside China. However, most Chinese come to tolerate it and be supportive partly because it is believed that the policy helps improve the economy, which was based on "population pessimism" or "Malthusianism" and is lack of comprehensive theoretical support. All these sacrifice will only be a bit meaningful when a "shrinking" population size in China did help the economic growth. The planned birth policy results in lower population growth and change in the age structure of the population. Given the "population neutralism", the lower population growth would not benefit the economic growth, while the change in the age structure may benefit the economic growth when the growth rate of dependency ratio is decreasing. As shown in the above estimation results, from 1980 to 2004 the growth rate of dependency ratio in China did decrease and benefit the economic growth.

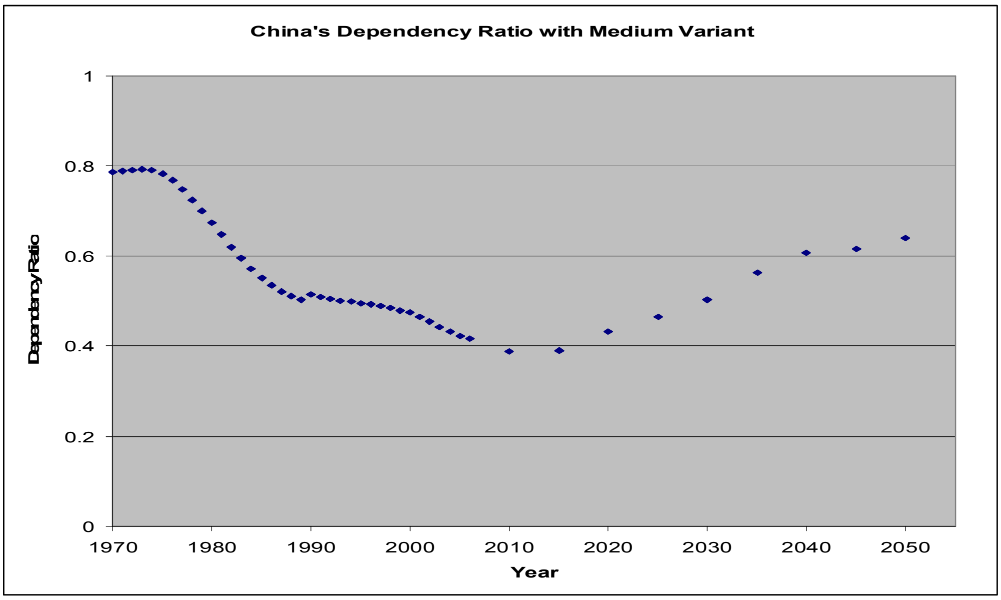
However, differing from a continually decreasing population growth due to the planned birth policy, the growth rate of dependency would not continually decrease along with the decreasing population growth. The dependency ratio cycles overtime. Right now due to the lower fertility rate, the child dependency ratio reduces dramatically which contributes to the decreasing growth rate of (total) dependency ratio; while when next period comes, the children in this period become the working-age population and the dependency ratio will cycle to an increasing period. The cycle of dependency ratio is presented in **Figure 8.1** through **Figure 8.4**. The population is projected to 2050 based on *World Population Prospects: The 2006 Revision, United Nations Population Division*, which makes projections with high variant, medium variant, low variant and constant-fertility variant. Through these different projections, the dependency ratio in China will all cycle to the increasing period during 2015 to 2020; and if the projection with high variant is assumed, the increasing period would come during 2010 to 2015. That is, from 1979 to 2010 the decreasing population growth accretes with a decreasing growth of dependency ratio, while the population growth is neutral on economic growth, the growth of dependency ratio is negative and robust which practically benefits the economic growth and creates an illusion of a benefit from lower population growth to economic growth. After 2010, though, the decreasing population growth will come along with an increasing growth rate of dependency ratio, which will hinder the economic growth, rather than boost the economic growth.

Figure 8.1: China's Dependency Ratio with Population Projection (I)



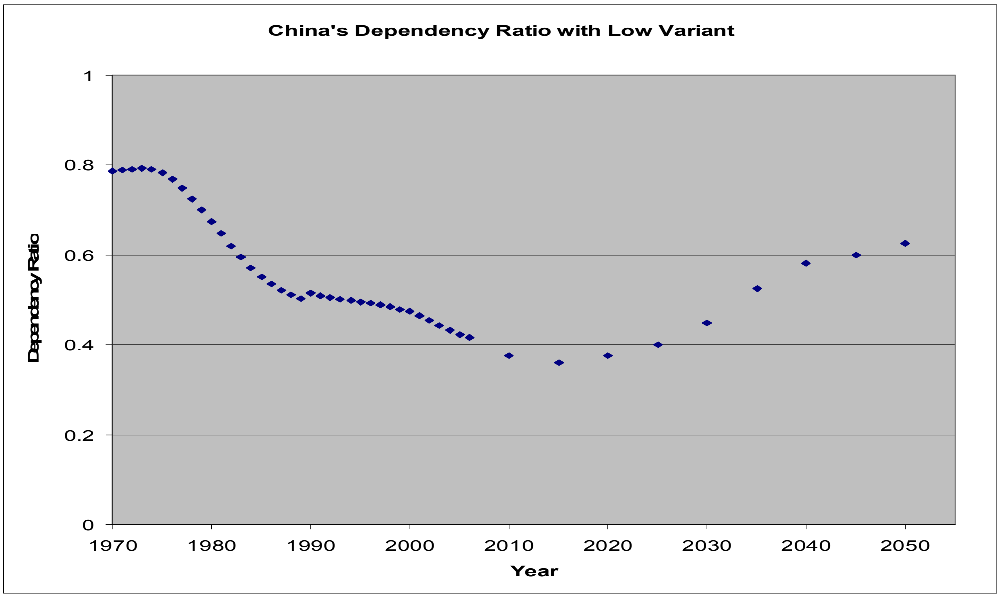
Source: *World Population Prospects: The 2006 Revision, United Nations Population Division*

Figure 8.2: China's Dependency Ratio with Population Projection (II)



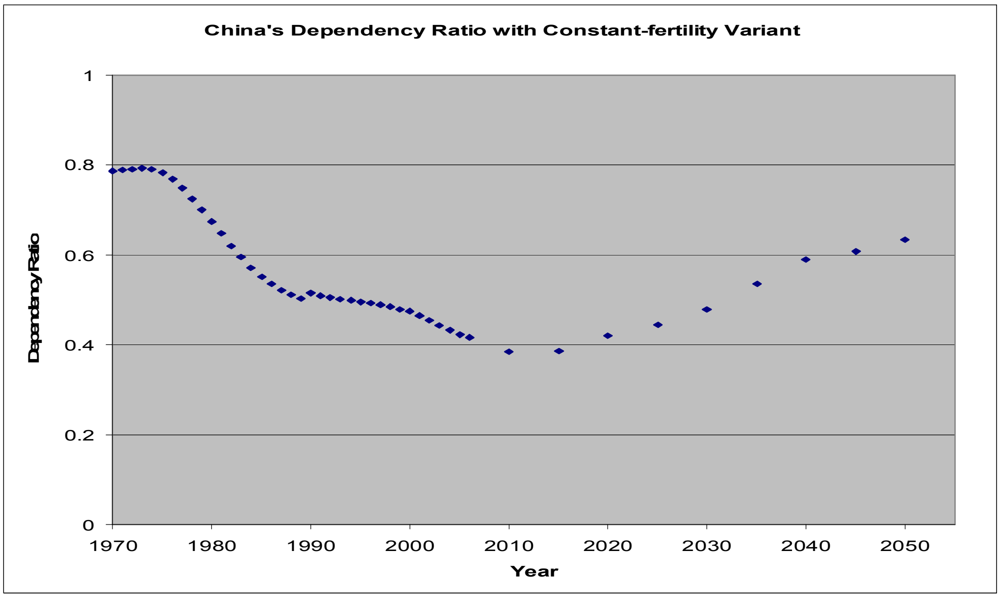
Source: *World Population Prospects: The 2006 Revision, United Nations Population Division*

Figure 8.3: China's Dependency Ratio with Population Projection (III)



Source: *World Population Prospects: The 2006 Revision, United Nations Population Division*

Figure 8.4: China's Dependency Ratio with Population Projection (IV)



Source: *World Population Prospects: The 2006 Revision, United Nations Population Division*

Chapter 9: Case Study of China

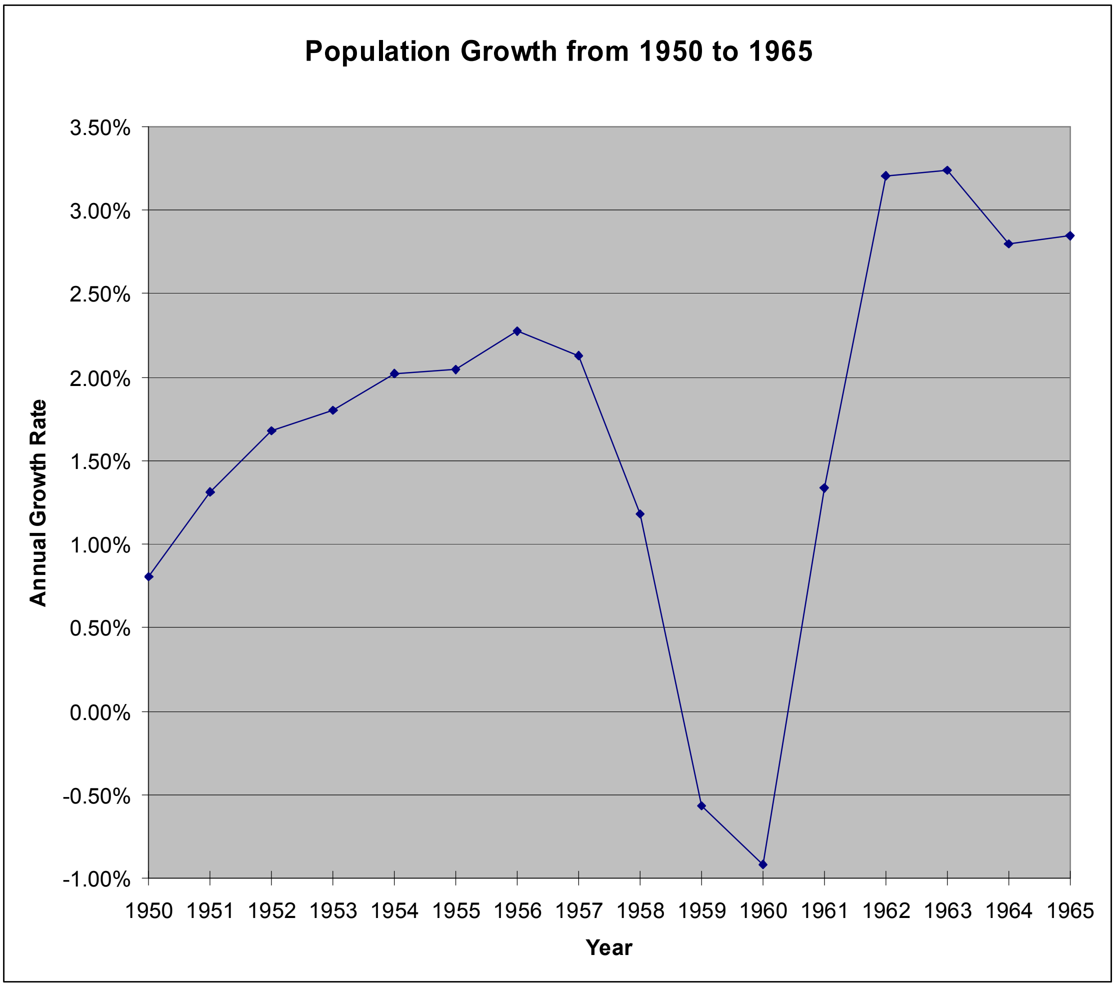
On the study based on the cross-country data, researchers (Barro, 1991; Romer, 1989; etc.) concern the consistency and the comparability of the cross-country data. Different countries may use different statistical methods and define variables differently. For this concern, data from inside a country is favored, which is one reason for conducting the case study of China in the following section. The other reason for this case study would be the possible endogeneity problems on the population growth and hence the growth rate of dependency ratio since the growth rate of dependency ratio is a component of population growth. The population growth and the growth rate of dependency ratio are assumed independent from the error terms in the above cross-country regressions, which is required for an unbiased estimate in OLS. However, this might not be true. Two types of endogeneity problems, omitted variable bias and simultaneity, are both possible for the population growth. One candidate for the omitted variables in the above cross-country regressions could be the religious belief, which clearly correlates with the fertility rate and the population growth as discussed in Bloom and Canning (2003) and also correlates with the economic growth. The simultaneity problem was concerned back in Malthus' "higher income higher fertility"[23] argument: fertility rate affects income level while at the same time income level will reversely affects fertility rate. A popular method in dealing with the endogeneity problems is to introduce instrumental variables. Instrumental

[23] Although the opposite of "higher income higher fertility" is indeed closer to the reality, the reverse causal relation between the income level and the fertility is already raised by Malthus.

variables are variables correlated with the endogenous explanatory variables and by themselves not correlated with the dependent variable (or not correlated with the errors). That is, instrumental variables only correlate with the dependent variable through their correlation with the endogenous explanatory variables. “Finding such instrumental variables is a formidable task” in the cross-country data as claimed in Mankiw, Romer, and Weil (1992), while it is possible in data from inside a country, especially when a natural experiment happens after conducting certain policies. The planned birth policy induces a natural experiment and some variables could be used as the instrumental variables for the population growth, which is ideal for the endogeneity problems and makes this case study valuable.

First, the background for the planned birth policy is narrated, which is necessary for understanding why some variables could be identified as instruments for population growth. Chinese worship the ancestors and believe the ancestors are always connected with the direct descendants. The ancestors can benefit from the prayer and sacrifice from the direct descendants and the direct descendants can be blessed by the ancestors. Therefore, a responsibility for a family is to carry on the family line (*Chuan Zong Jie Dai*) because only the direct descendants can provide prayer and sacrifice to the ancestors. A transformed expression is “more sons more happiness” (*Duo Zi Duo Fu*) because the chance of a family line being carried on is bigger when there are more sons. Based on this tradition, the fertility rate is usually high through China’s history if without wars or natural disasters. As shown in **Figure 9.1 s**ince the end of the civil war in 1949, China's population increased steadily until the three-year-long drought starting from 1959 to 1961.

Figure 9.1: Population Growth Rate of China from 1950 to 1965



The drought led millions of people to death due to the lack of food. From the tragedy, policy makers came to believe that the most important challenge for Chinese (at least at that time) was the conflict between the limited rice production and the enormous population size. The government in the 1960's and the 1970's focused in all means to increase the rice production and to reduce (or regulate) the population size. For the rice production section, the hybrid rice was successfully bred in 1973, which increased the rice yield by about 20% given same level of inputs (Lin, 1994). In addition, the Household Responsibility System was introduced in 1978, which redefined the property right and provided the farmers the first time the right to claim the residual of the yield. Household Responsibility System greatly enhanced farmers' incentive and with the aid of the newly-bred hybrid rice the rice production jumped sky-high at a sudden, which gradually liberated the rural farmers from the land and later on emerged the economic reform. For the population regulation section, on Dec. 18th, 1962 the government issued the first document which aimed at regulating the urban area population. Urban people were chosen as the experimental group due to a better fit comparing rural people. First, urban people do not produce any crop (and hence the regulation wouldn't deteriorate the severe food shortage then). Second, urban people inherited the same "more sons more happiness" tradition as the rural people and they accounted for 17% of the total population in 1962 (and hence the sample size is just right to serve as the experimental group). Third, urban people were more organized and were almost all employed by the government then, either in the state-owned enterprises or in the government departments (and hence the regulation could be better carried out). Fourth, urban people were better educated (and hence they could possibly be more supportive for the policy). However, inheriting the "more sons more happiness" belief few people voluntarily chose to have only one child. Therefore, the government forced to implement the one child policy. A certificate was issued to women who were bearing the first child. Without the certificate pregnant women might not be treated in the hospital and sometimes the hospital would even force pregnant women without the certificate to take abortion. The second child would not only be bereaved the hospital treatment, but also bring punishment, both pecuniary and non-pecuniary[24], toward the family. In short, the cost of having a second child was prohibitive. Usually after giving the first birth, women (sometimes, men) would take a surgery to prevent future pregnancy. And facing the conflict between the traditional "more sons more happiness" belief and the planned birth policy, some parents choose to selectively abort the female fetus with the aid of type-B ultrasonic inspection. On Dec. 31st, 1974 the government issued a second document on the population regulation, which credited the success of the first document and stated the policy would be further carried on. On Oct. 26th, 1978 the third document was issued and the population regulation is no longer only applied in the urban area, it is applied all over the country. However, the policy is not enforced over every Chinese. Only the majority Chinese (the Han Chinese) are subject to the policy. The minority Chinese are not restricted partly because the minority population is relatively small[25] and the minority Chinese are mostly residing in the remote area where the population size is not regarded as a problem by the policy makers. Mainland China is composed of 4 municipalities, 22 provinces, and 5 autonomous regions and the Minority Chinese reside clustering in the five autonomous regions (Tibet, Xinjiang, Ningxia, Inner Mongolia, and Guangxi) and the three other provinces close to the autonomous regions (Qinghai, Guizhou, and

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[24] The pecuniary punishment could be up to one year's income of the family and the non-pecuniary punishment includes fewer chances to be promoted for the parents because the parents are not supportive to the government policy. Generally the non-pecuniary punishment is more critical.

[25] There are total 55 minority ethnicities in China and the total minority Chinese account for about 10% of the population.

Yunnan). **Table 9.1** presents the sorted minority population percentage by region based on the fifth (and latest) National Population Census conducted in 2000.

Table 9.1: Sorted Minority Percentage by Region in 2000

Region	Total Population (unit: 10,000)	Han Percentage %	Minority Percentage %
Tibet	262	5.93	94.07
Xinjiang	1925	40.61	59.39
Qinghai	518	54.49	45.51
Guangxi	4489	61.66	38.34
Guizhou	3525	62.15	37.85
Ningxia	562	65.47	34.53
Yunnan	4288	66.59	33.41
Inner Mongolia	2376	79.24	20.76
Hainan	787	82.71	17.29
Liaoning	4238	83.98	16.02
Hunan	6440	89.79	10.21
Jilin	2728	90.97	9.03
Gansu	2562	91.31	8.69
Chongqing	3090	93.58	6.42
Heilongjiang	3689	94.98	5.02
Sichuan	8329	95.02	4.98
Hubei	6028	95.66	4.34
Hebei	6744	95.69	4.31
Beijing	1382	95.74	4.26
Tianjin	1001	97.36	2.64
Fujian	3471	98.33	1.67
Guangdong	8642	98.58	1.42
Henan	9256	98.78	1.22
Zhejiang	4677	99.15	0.85
Shandong	9079	99.32	0.68
Anhui	5986	99.37	0.63
Shanghai	1674	99.40	0.60
Shaanxi	3605	99.51	0.49
Jiangsu	7438	99.67	0.33
Shanxi	3297	99.71	0.29
Jiangxi	4140	99.73	0.27

Source: China Statistical Yearbook 2001 (National Bureau of Statistics of China)

Based on the background for the planned birth policy, at least two variables could be identified as the instrumental variables for the population growth. The first would be the sex ratio (male-to-female) at birth. Over the human history, the sex ratio at birth averages at 103[26] and generally the range from 102 to 107 is regarded as normal. This normal range is clearly broken in recent years China. **Table 9.2** presents the sex ratio at birth by region in 1990, 1995, and 2000. As shown in the table, the highest sex ratio at birth in 2000 is 135.64 and the highest sex ratio in 1995 is 131.63, which are clearly abnormal. The abnormal sex ratio at birth is resulted from the selective abortion. Hence a region with a higher sex ratio at birth indicates the preference on a son is higher and the "more sons more happiness" belief is stronger in this region, which should positively correlate with the fertility rate and the population growth. On the other hand, there is hardly any evidence that the sex ratio at birth would directly correlate with the regional economic growth (the dependent variable)[27]. Therefore, the sex ratio at birth could be identified as an instrumental variable.

[26] That is, there are 103 male babies per 100 female babies at birth. More male babies at birth are balanced by higher male baby mortality rate so that the male-to-female ratio is kept roughly at one-to-one over time.
[27] Only when the sex ratio becomes extremely unnatural, it may negatively affect economic growth.

Table 9.2: Sex Ratio at Birth by Region in 1990, 1995, 2000 in China

Region	Sex Ratio at Birth in 2000	Sex Ratio at Birth in 1995	Sex Ratio at Birth in 1990
Beijing	110.56	122.54	106.21
Tianjin	112.51	110.56	110.65
Hebei	113.43	115.2	112.32
Shanxi	112.52	111.83	109.66
Inner Mongolia	108.45	111.36	107.37
Liaoning	112.83	111.61	110.1
Jilin	111.23	109.84	108.11
Heilongjiang	109.71	109.7	107.44
Shanghai	110.64	105.34	104.35
Jiangsu	116.51	123.88	114.5
Zhejiang	113.86	115.35	117.82
Anhui	127.85	118.14	110.48
Fujian	117.93	124.42	110.49
Jiangxi	114.74	119.81	110.56
Shandong	112.17	118.94	115.97
Henan	118.46	127.44	116.64
Hubei	128.18	131.63	109.49
Hunan	126.16	116.96	110.49
Guangdong	130.3	123.3	111.76
Guangxi	125.55	124.57	117.73
Hainan	135.64	125.87	115.6
Chongqing	115.13		
Sichuan	116.01	110.01	111.53
Guizhou	107.03	100.35	101.77
Yunnan	108.71	109.53	106.84
Tibet	102.73	98.91	103.05
Shaanxi	122.1	124.26	111.12
Gansu	114.82	110.13	110.29
Qinghai	110.35	106.58	104.62
Ningxia	108.79	106.77	110.04
Xinjiang	106.12	101.26	103.7

Source: China Population Statistics Yearbooks

The second instrumental variable would be the minority proportion. As discussed in the background for the planned birth policy, the minority Chinese are not subject to the policy, which makes the minority proportion positively correlate with the fertility rate. Though the minority proportion also correlates with the education level, which correlates with the economic growth, since the native language for the minority Chinese is not Chinese while Chinese is the only official language used in the education. Hence, to ensure the minority proportion being a proper instrumental variable, the education should be controlled.

Although these two variables could be identified as the instrumental variables, whether they can serve as good instruments need to be tested. The usual tests for endogeneity and the over-identification[28] would be invalid if heteroskedasticity is present according to Hansen (1982) and Baum, Schaffer, and Stillman (2003). To handle heteroskedasticity of unknown form, the Generalized Method of Moments (GMM) is called for. Hence, empirically the case study would be carried out following the same neoclassical economic growth model with two instrumental variables and in GMM approach.

Table 9.3 presents the descriptive statistics for data used in the case study. The provincial-level data is collected from China's Statistical Yearbooks 1996-2008 and includes all 31 provinces. Variable "Graduates with Degrees or Diplomas" is used for the measurement of the education level, which as discussed above is crucial for ensuring the

[28] Here there are two excluded instruments (sex ratio at birth and the minority proportion) and one endogenous explanatory variable.

minority percentage as a valid instrumental variable. Lag secondary enrollment rate is not selected as the measurement of the education level as in the cross-country data because there is little variance in secondary enrollment rate across provinces in China due to the nine-year compulsory education system. Variable "International Trade Share" is used as the proxy for the trade share since the trade share is not reported in the yearbooks[29]. Other variables are the counterpart for the variables used in the cross-country data. The variable "Growth Rate of Sex Ratio" is used as the proxy for the instrumental variable "Sex Ratio at Birth" since the sex ratio at birth is only reported for the National Population Census, which uses a different population sampling method as used in China Statistical Yearbooks, and the growth rate of sex ratio is indeed the sum of sex ratio at birth and the sex ratio at mortality. The other instrumental variable "Minority Proportion" is also included.

[29] Only the net export is reported in the yearbook which is export **minus** import, while the trade share is calculated from dividing export **plus** import to GDP.

Table 9.3: Descriptive Statistics for Data in the China Case Study

Variables	Obs.	Mean	Std. Dev.	Min	Max
Dependent Variable					
Growth Rate of real GRP per capita (%)	401	10.37	3.34	-8.05	23.72
Independent Variables					
Graduates with Degrees or Diplomas (10000 persons)	401	9.42	7.14	0.17	44.65
GRP per capita in 1995 (10000 Yuan)	403	0.51	0.32	0.18	1.74
Investment Share (%)	401	47.89	10.56	29.70	90.10
International Trade Share (%)	401	0.31	0.42	0.03	2.22
Population Growth (%)	401	0.85	2.11	-10.38	18.87
Growth Rate of (1+δ) (%)	370	-0.73	1.84	-7.82	7.91
Growth Rate of Sex Ratio (%)	340	0.005	2.19	-9.58	8.57
Minority Percentage (%)	403	15.02	21.34	0.27	94.07
Added Variables					
Consumption Share (%)	401	41.01	7.55	24.45	70.06
Government Spending Share (%)	401	19.18	2.67	11.68	24.94
Primary Industry Share (%)	401	17.52	8.42	0.80	46.03
International Tourism Earning (billion Yuan)	401	4.62	8.83	0.007	66.20

Source: China Statistical Yearbooks (National Bureau of Statistics of China, 1996-2008)

Table 9.4 presents the GMM estimation when population growth is used as the endogenous explanatory variable to check the population neutralism argument, where all the robust variables concluded in Levine and Renelt (1992) are included. As shown in the result for the first-stage regression, the two instruments show significant correlation with population growth. The p-value of the joint significance tests for the two instruments is smaller than 0.01. The minority percentage is positively correlated with population growth as expected and significant at the 5% level. The growth rate of sex ratio, the other instrument, is also positively correlated with population growth as expected and significant at the 5% level. The F-Stat and the Anderson-Rubin test state that the regression is heteroskedasticity-robust. For the second-stage regression, education level is positively correlated with economic growth at 1% significant level as expected, the conditional convergence is insignificant, the investment share is positively correlated with economic growth at 1% significant level as expected, and the international trade share is also positively correlated with economic growth at 5% significant level as expected. As for the test of population neutralism, however, the regression supports population pessimism. The population growth is negatively correlated with the economic growth at 1% significant level. The Anderson canon corr. LR statistic (with a less than 0.01 p-value) and the Hansen J statistic (with a higher than 0.10 p-value) state that the instruments are valid.

Table 9.4: GMM Estimation with Population Growth

First-Stage Dependent Variable: **Population Growth**		**Second-Stage** Dependent Variable: **GRP Growth**	
	Independent	**Variables**	
		Population Growth	-1.4225*** (0.2705)
Graduates with Degrees or Diplomas	-0.0183* (0.0110)		0.1380*** (0.0145)
GRP per capita in 1995	0.1352 (1.3122)		-0.5849 (0.7104)
Investment Share	-0.0064 (0.0132)		0.1228*** (0.0137)
International Trade Share	1.7147 (1.1294)		1.9930** (0.8431)
Growth of Sex Ratio	0.1559** (0.0742)		
Minority Percentage	0.0143** (0.0058)		
Constant	0.5115 (0.8501)		3.8776*** (0.7063)
Obs.	340		340
Shea Partial R-Square	0.0377	*Anderson canon. corr. LR statistic*	13.081
Partial R-Square	0.0377		
F Value	4.99	Chi-sq(2) P-value	0.0014
Anderson-Rubin test of joint significance:		*Hansen J statistic*	2.088
F Value	6.06		
Chi-Square Value	12.38	Chi-sq(1) P-value	0.1485

Note: Robust standard errors are reported in the parentheses and *, **, and *** represent significant level of 10%, 5%, and 1% respectively.

Table 9.5, **Table 9.6**, **Table 9.7,** and **Table 9.8** present the sensitivity analysis (EBA) on the GMM estimation with population growth. Four variables[30] are added for the sensitivity analysis and they are consumption share, government spending share, primary industry (agriculture) share, and international tourism earning. Variable "consumption share" and variable "government spending share" are already introduced in the cross-country regressions. Variable "primary industry share" is included because as in the literature review population growth correlates with economic growth differently between in a mainly agricultural economy and in a mainly industrial economy. Variable "international tourism earning" is included because both in the empirical growth literature focusing developing countries and in the regional development literature tourism earnings have proved to be a significant contributor in economic growth. The descriptive statistic for "primary industry share" and "international tourism earning" could also be found in **Table 9.3**. Throughout the regressions with the combination of these four added variables, the population growth is always negative and significant at 1% level in economic growth. The p-values for Anderson canon corr. LR statistics are all less than 0.01 and the p-values for Hansen J statistics are all greater than 0.10, which state that the instruments are valid.

[30] The fifth variable added is foreign direct investment and the sixth variable added is transportation routes. The results don't differ qualitatively.

Table 9.5: Sensitivity Analysis on GMM Estimation with 2 added variables

(Dependent Variable: GRP Growth)

Regression	**(I)**	**(II)**	**(III)**
Population Growth	-1.4235***	-1.5124***	-1.3794***
	(0.2540)	(0.3008)	(0.2486)
Graduates with Degrees or Diplomas	0.0978***	0.1332***	0.0955***
	(0.0183)	(0.0154)	(0.0182)
GRP per capita in 1995	-1.8504**	-0.5035	-2.0308**
	(0.8545)	(0.8368)	(0.8225)
Investment Share	0.0899***	0.1094***	0.0922***
	(0.0132)	(0.0157)	(0.0142)
International Trade Share	2.0847**	1.9604**	2.1058***
	(0.8620)	(0.9660)	(0.8177)
Consumption Share	-0.1076***		-0.1180***
	(0.0234)		(0.0252)
Government Spending Share		0.0997*	-0.0456
		(0.0559)	(0.0549)
Constant	10.8348***	2.6584***	12.1046***
	(1.6504)	(1.0066)	(2.0470)
Obs.	340	340	340
Anderson canon. corr. LR statistic	13.069	12.634	12.722
Chi-sq(2) P-value	0.0015	0.0018	0.0017
Hansen J statistic	1.537	0.793	2.744
Chi-sq(1) P-value	0.2150	0.3732	0.0976

Note: Robust standard errors are reported in the parentheses and *, **, and *** represent significant level of 10%, 5%, and 1% respectively.

Table 9.6: Sensitivity Analysis on GMM Estimation with 3 added variables

(Dependent Variable: GRP Growth)

Regression	**(IV)**	**(V)**	**(VI)**	**(VII)**
Population Growth	-1.4396***	-1.4523***	-1.5427***	-1.4207***
	(0.2763)	(0.2612)	(0.3120)	(0.2586)
Graduates with Degrees or Diplomas	0.1329***	0.0870***	0.1264***	0.0844***
	(0.0159)	(0.0207)	(0.0176)	(0.0203)
GRP per capita in 1995	-0.3354	-1.4845*	-0.1864	-1.6613**
	(0.7388)	(0.8416)	(0.8501)	(0.8165)
Investment Share	0.1245***	0.0905***	0.1099***	0.0922***
	(0.0139)	(0.0133)	(0.0158)	(0.0143)
International Trade Share	1.3281	0.9470	1.1221	0.9800
	(1.0799)	(1.0274)	(1.1541)	(1.0086)
Consumption Share		-0.1136***		-0.1229***
		(0.0247)		(0.0258)
Government Spending Share			0.1093*	-0.0372
			(0.0577)	(0.0552)
International Tourism Earning	0.0285	0.0489	0.0365	0.0499
	(0.0338)	(0.0328)	(0.0371)	(0.0320)
Constant	3.8022***	11.1000***	2.4541**	12.2027***
	(0.7117)	(1.7133)	(1.0161)	(2.0412)
Obs.	340	340	340	340
Anderson canon. corr. LR statistic	12.995	12.968	12.490	12.590
Chi-sq(2) P-value	0.0015	0.0015	0.0019	0.0018
Hansen J statistic	1.841	1.101	0.512	1.953
Chi-sq(1) P-value	0.1748	0.2940	0.4744	0.1623

Note: Robust standard errors are reported in the parentheses and *, **, and *** represent significant level of 10%, 5%, and 1% respectively.

Table 9.7: Sensitivity Analysis on GMM Estimation with 4 added variables, Part I

(Dependent Variable: GRP Growth)

Regression	**(VIII)**	**(IX)**	**(X)**	**(XI)**
Population Growth	-1.3990***	-1.4366***	-1.5121***	-1.3891***
	(0.2792)	(0.2741)	(0.3256)	(0.2743)
Graduates with Degrees or Diplomas	0.1328***	0.0966***	0.1303***	0.0911***
	(0.0141)	(0.0178)	(0.0148)	(0.0174)
GRP per capita in 1995	-0.8050	-1.8648**	-0.6043	-2.1452**
	(0.7132)	(0.8754)	(0.8684)	(0.8503)
Investment Share	0.1197***	0.0906***	0.1097***	0.0931***
	(0.0152)	(0.0144)	(0.0165)	(0.0149)
International Trade Share	1.8786**	2.1026**	1.9328*	2.1121**
	(0.8327)	(0.9073)	(0.9955)	(0.8679)
Consumption Share		-0.1084***		-0.1212***
		(0.0242)		(0.0253)
Government Spending Share			0.0953	-0.0530
			(0.0590)	(0.0557)
International Tourism Earning				
Primary Industry Share	-0.0195	-0.0005	-0.0081	-0.0060
	(0.0212)	(0.0218)	(0.0227)	(0.0220)
Constant	4.5347***	10.8699***	2.9565*	12.5531***
	(1.0876)	(1.7054)	(1.5210)	(2.1099)
Obs.	340	340	340	340
Anderson canon. corr. LR statistic	11.850	11.751	10.981	11.064
Chi-sq(2) P-value	0.0027	0.0028	0.0041	0.0040
Hansen J statistic	2.648	1.603	1.077	3.355
Chi-sq(1) P-value	0.1037	0.2055	0.2993	0.0670

Note: Robust standard errors are reported in the parentheses and *, **, and *** represent significant level of 10%, 5%, and 1% respectively.

Table 9.8: Sensitivity Analysis on GMM Estimation with 4 added variables, Part II

(Dependent Variable: GRP Growth)

Regression	**(XII)**	**(XIII)**	**(XIV)**	**(XV)**
Population Growth	-1.4199***	-1.4729***	-1.5528***	-1.4460***
	(0.2866)	(0.2851)	(0.3419)	(0.2905)
Graduates with Degrees or Diplomas	0.1282***	0.0863***	0.1240***	0.0805***
	(0.0153)	(0.0203)	(0.0167)	(0.0195)
GRP per capita in 1995	-0.5401	-1.4602*	-0.2520	-1.7208**
	(0.7619)	(0.8795)	(0.9045)	(0.8662)
Investment Share	0.1217***	0.0917***	0.1104***	0.0932***
	(0.0157)	(0.0146)	(0.0167)	(0.0152)
International Trade Share	1.2281	0.9637	1.1082	0.9742
	(1.0476)	(1.0518)	(1.1654)	(1.0373)
Consumption Share		-0.1151***		-0.1264***
		(0.0258)		(0.0260)
Government Spending Share			0.1076*	-0.0405
			(0.0617)	(0.0569)
International Tourism Earning	0.0284	0.0502	0.0377	0.0528
	(0.0329)	(0.0337)	(0.0376)	(0.0332)
Primary Industry Share	-0.0179	0.0031	-0.0046	-0.0012
	(0.0215)	(0.0222)	(0.0233)	(0.0226)
Constant	4.4026***	11.0563***	2.6079*	12.4618***
	(1.1141)	(1.7615)	(1.5738)	(2.1005)
Obs.	340	340	340	340
Anderson canon. corr. LR statistic	11.729	11.594	10.772	10.862
Chi-sq(2) P-value	0.0028	0.0030	0.0046	0.0044
Hansen J statistic	2.336	1.074	0.662	2.224
Chi-sq(1) P-value	0.1264	0.3000	0.4159	0.1359

Note: Robust standard errors are reported in the parentheses and *, **, and *** represent significant level of 10%, 5%, and 1% respectively.

Aside, for the robust growth rate of dependency ratio in the cross-country data, it faces the same endogeneity problems as the population growth and the two instruments could also be used as the excluded instruments with the same reasoning as for the population growth. **Table 9.9** presents the two-stage GMM regression with growth rate of (1+δ). Notice that the minority proportion doesn't significantly correlate with the growth rate of (1+δ) in the first-stage regression, which rules out the minority proportion as a valid instrument for growth rate of dependency ratio.

Table 9.9: GMM Estimation with Growth of (1+δ)

First-Stage Dependent Variable: **Growth of (1+δ)**		**Second-Stage** Dependent Variable: **GRP Growth**	
	Independent	**Variables**	
		Growth of (1+δ)	1.3814*** (0.4693)
Graduates with Degrees or Diplomas	-0.0176 (0.0111)		0.1974*** (0.0191)
GRP per capita in 1995	0.3512 (0.7610)		-1.1286 (0.9626)
Investment Share	0.0080 (0.0103)		0.1067*** (0.0201)
International Trade Share	-0.5619 (0.6571)		0.3287 (0.7906)
Growth of Sex Ratio	-0.2023*** (0.0569)		
Minority Percentage	-0.0055 (0.0074)		
Constant	-0.8413 (0.6329)		4.6199*** (1.1349)
Obs.	340		340
Shea Partial R-Square	0.0607	*Anderson canon.*	21.285
Partial R-Square	0.0607	*corr. LR statistic*	
F Value	6.67	Chi-sq(2) P-value	0.0000
Anderson-Rubin test of joint significance:		*Hansen J statistic*	0.059
F Value	6.06		
Chi-Square Value	12.38	Chi-sq(1) P-value	0.8075

Note: Robust standard errors are reported in the parentheses and *, **, and *** represent significant level of 10%, 5%, and 1% respectively.

To summarize, the GMM estimations show that population growth in China is significantly and negatively correlated with the economic growth and the follow-up sensitivity analysis shows the significant correlation is indeed robust. The reasons for conflicting results between using cross-country data and using provincial data of China might be: (1) the unsolved endogeneity problems biased the regression results using cross-country data; (2) the significance of population growth cancels out across countries. As in the literature review for population growth, in the natural resources augmented economy population growth negatively correlates with economic growth while in the industrialized economy population growth positively correlates with economic growth. The negative effect and the positive effect cancel out when both natural resources augmented economies and industrialized economies are included in the cross-country regressions, which empirically appears as population neutralism.

Chapter 10: Conclusions and Policy Implications

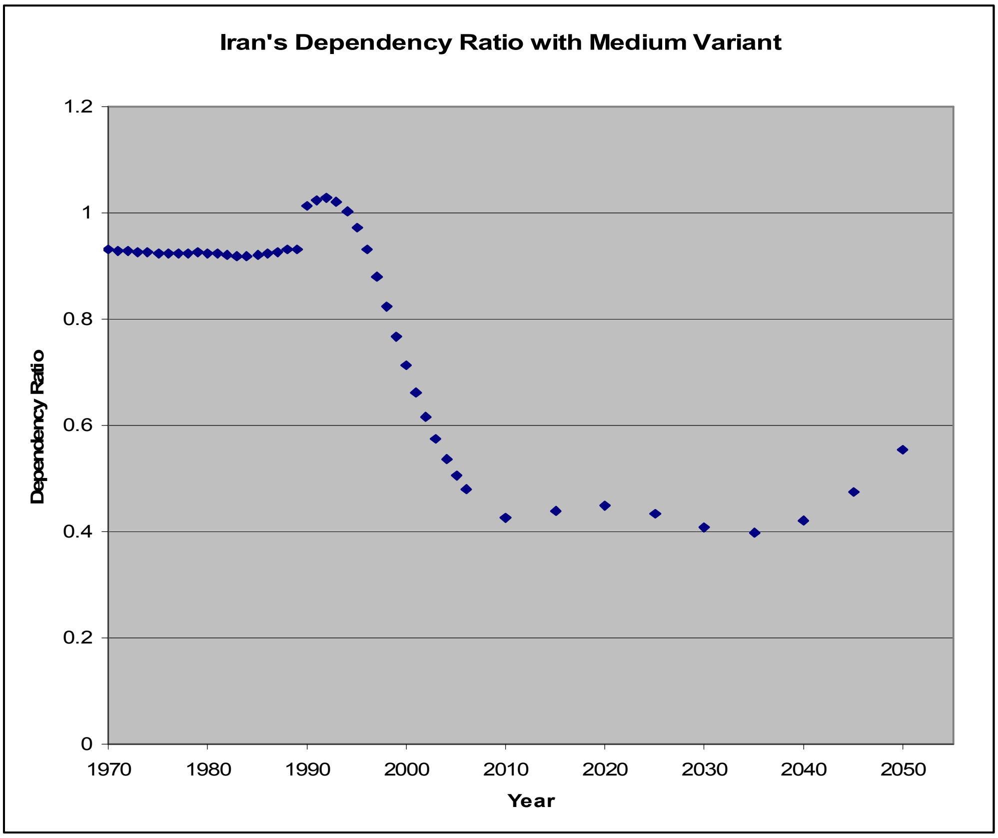
Population growth is always included in cross-country growth regressions and doesn't show its significance at most times, which is categorized as "population neutralism". In this paper the population growth is decomposed and the age structure of population, rather than population itself, is distilled to be the factor associating economic growth. Sensitivity analyses are conducted to test the robustness of the growth rate of dependency ratio and prove that the growth rate of dependency ratio is negative and robust in affecting the economic growth in cross-country growth regressions. Later the result is applied in explaining the coincidence of China's high economic growth rate and low population growth rate since 1979 and evaluating the planned birth policy in mere efficiency sense. The policy suggestion from this paper would be that a country will benefit from the population control policy only when the policy decreases the growth rate of the dependency ratio. Lowering the population growth itself would not boost the economic growth. As for China, the country conducting the most rigorous population control policy, the benefit from the decreasing growth rate of dependency ratio will end at the latest in 2020[31] and if continuing the planned birth policy after 2020 what follows would be the drag, rather than the benefit.

Recently more and more countries start to practice various sorts of population control policies. For example, now in India only people with two or fewer children are eligible

[31] It is inferred based on the population projection by United Nations Population Division.

for election to a Gram panchayat (village councilor) and in Iran mandatory contraceptive courses are required for both males and females before a marriage license can be obtained. It is believed that these recent practices in population control are influenced by China's "successful" experience. But if focusing the growth rate of dependency ratio, rather than the growth rate of population, not all these practices will reach their goal, to boost the economic growth. Iran, for instance, actually faces an increasing growth rate of dependency ratio in the near future as shown in **Figure 10.1**.

Figure 10.1: Iran's Dependency Ratio with Population Projection



Source: World Population Prospects: The 2006 Revision, United Nations Population Division

In summary, the paper identifies a robust variable in explaining cross-country growth regressions: the growth rate of dependency ratio while holding “population neutralism” and suggests determining whether a population control practice is feasible should focus on the growth rate of the dependency ratio, rather than the growth rate of population.

As for the limitations, the most concerned is the non-fully-developed case study of China. The data used in the case study only covers from 1995 to 2007, while the planned birth policy started in 1979. Also, variable “growth rate of sex ratio” is used as the proxy for the instrumental variable “sex ratio at birth”, which may not be appropriate. And the abnormal sex ratio at birth in China due to the selective abortion may already start affecting the economic growth, associating with the violence and instability, which is not accounted yet in the case study. These limitations are expected to be addressed in the future research.

APPENDIX

List of Countries in the Cross-Country Model

Albania	Dominican Republic	Lithuania	Saudi Arabia
Algeria	Ecuador	Luxembourg	Senegal
Argentina	Egypt, Arab Rep.	Macao, China	Sierra Leone
Armenia	El Salvador	Macedonia, FYR	Singapore
Australia	Equatorial Guinea	Madagascar	Slovak Republic
Austria	Eritrea	Malawi	Slovenia
Azerbaijan	Estonia	Malaysia	Solomon Islands
Bahamas, The	Ethiopia	Maldives	Somalia
Bahrain	Fiji	Mali	South Africa
Bangladesh	Finland	Malta	Spain
Barbados	France	Mauritania	Sri Lanka
Belarus	Gabon	Mauritius	St. Lucia
Belgium	Gambia, The	Mexico	Vincent and the Grenadines
Belize	Georgia	Micronesia, Fed. Sts.	Sudan
Benin	Ghana	Moldova	Suriname
Bhutan	Greece	Mongolia	Swaziland
Bolivia	Guatemala	Morocco	Sweden
Bosnia and Herzegovina	Guinea	Mozambique	Switzerland
Botswana	Guinea-Bissau	Namibia	Syrian Arab Republic
Brazil	Haiti	Nepal	Tajikistan
Brunei Darussalam	Honduras	Netherlands	Tanzania
Bulgaria	Hong Kong, China	Netherlands Antilles	Thailand
Burkina Faso	Hungary	New Zealand	Togo
Burundi	Iceland	Nicaragua	Tonga
Cambodia	India	Niger	Trinidad and Tobago
Cameroon	Indonesia	Nigeria	Tunisia
Canada	Iran, Islamic Rep.	Norway	Turkey
Cape Verde	Ireland	Oman	Turkmenistan
Central African Republic	Israel	Pakistan	Uganda
Chad	Italy	Panama	Ukraine
Chile	Jamaica	Papua New Guinea	United Arab Emirates
China	Japan	Paraguay	United Kingdom
Colombia	Jordan	Peru	United States
Congo, Dem. Rep.	Kazakhstan	Philippines	Uruguay
Congo, Rep.	Kenya	Poland	Uzbekistan
Costa Rica	Korea, Dem. Rep.	Portugal	Vanuatu
Cote d'Ivoire	Korea, Rep.	Puerto Rico	Venezuela, RB
Croatia	Kyrgyz Republic	Qatar	Vietnam
Cuba	Lao PDR	Romania	Yemen, Rep.
Cyprus	Latvia	Russian Federation	Zambia
Czech Republic	Lebanon	Rwanda	Zimbabwe
Denmark	Lesotho	Samoa	
Djibouti	Liberia	Sao Tome and Principe	

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