AMERICAN UNIVERSITY OF BEIRUT

# THE ONE CHILD POLICY AND OLD AGE DEPENDENCY EFFECT ON THE CHINESE PROVINCIAL ECONOMIC GROWTH

by
MALAK IBRAHIM MORTADA

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MALAK IBRAHIM MORTADA

Approved by:

Dr. Simon Neaime, Professor
Economics
Advisor

Dr. Samir Makdisi, Professor Emeritus
Economics
Member of Committee

Dr. Pierre Mouganie, Assistant Professor
Economics
Member of Committee

Date of thesis defense: December 1, 2015

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# AN ABSTRACT OF THE THESIS OF

Malak Mortada for Master of Arts
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Title: The One Child Policy and Old Age Dependency Effect on the Chinese Provincial Economic Growth.

This thesis discusses the One Child Policy (OCP) that has been put in effect since 1979 in China. It concentrates on understanding its effect on the provincial economic growth by adopting the Classical Solow model since 1954 till 2004. Then, it focuses on the relaxation of this policy since the end of 2013, and one of the reason of this loosening: the increasing in the old age dependency ratio that plays a role in affecting the household per-capita saving rate on the regional level.

This thesis is divided into five chapters: Chapter 1 is an introduction that gives a brief history of the OCP and mentions its relaxation. Chapter 2 is a literature review that includes what previous researchers conclude about the impact of OCP on growth in China, the importance of Solow model as a population model, in addition to the impact of old ageing on the channels that affect the economic growth. Chapter 3 is about theoretical frameworks. In this section, Solow model is theorized .Chapter 4 is the empirical part of the thesis where two regressions based on the panel data approach are adopted. The first regression treats the regional GDP growth as the dependent variable while the population growth and capital stock (including varying depreciation rates across the provinces) growth rates are considered as independent variables. The OCP is treated as a dummy variable and is found to affect positively and significantly the dependent variable. The second regression considers the household per-capita saving rate as the dependent variable, and it is- according to the literature- one of the channels that affects the economic growth while the old age and young dependency ratio, real interest rates, life expectancy and regional GDP per capita are the explanatory variables. The conclusion derived is that the old age dependency ratio affects negatively the saving rate, but it is insignificant. Chapter 5 concludes and summarizes what has been mentioned before. It includes recommendations

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# CHAPTER 1

# INTRODUCTION

China has undergone outstanding economic growth in the past three decades. According to the World Development Indicators (WDI), China’s annual GDP growth rate was around 9.88% between 1978 and 2013 compared with 2.22% for the United Kingdom, 2.76% for United States, 5.91% for India and 2.28 % for Japan. The chief driving factors behind this experience have been extensively debated. In fact, some argued that the improvement in total factor productivity played a key part in this phenomenon (Bosworth & Collins, 2008; Perkins, et al., 2008) while others consider that the central reason behind this achievement is the population growth. The Chinese population has surpassed 1.3 billion in 2013 and it was twice more than that in 1949. The one child policy implemented since 1979 had influenced population growth pattern significantly. In fact, China's National Health and Family Planning Commission confirms that it has prevented about 400 million births. However, ever since its launch, the one-child policy has been extremely controversial. Supporters of the policy contend that without such an exacting measure, sustained population growth would have doomed China’s faith for rapidly raising per capita income, a political mandate of post-Mao Chinese leadership. Proponents also claim that uncontrolled population growth will end in further depletion of natural resources and irreversible damage of the environment. So, they were in line with the pessimistic Malthusian theory of population growth. On the other hand, opponents of the policy, both inside and outside of China, draw attention to the fact that major fertility decline was already achieved by the late 1970s under a less tough policy. They also alert of the high costs and critical results of such an exceptional policy such as human rights violations, particularly regarding women; the forceful modification of China's traditional family structure; an imbalanced sex ratio, due to a partiality for sons; and a rapidly increasing number of ageing residents.

On November 15, 2013, and more than 33 years after its introduction, China took a historic step by further relaxing the infamous one-child fertility policy as the government announces that couples are allowed to have a second child if one spouse is an only child. It is important to note that some groups are already exempt from the one-child regulation in China, such as ethnic minorities, rural families whose first child is a girl, and couples in which both parents are only children. Then, on October 29, 2015, the government announces that all couples will be allowed to have two children. Nevertheless, Yadan Ouyang states that experts and particularly demographers are divided over the likely impact of the reform. As a matter of fact, some of the latter group- who have been demanding for several years for wider changes, arguing that the decades-old policy has led to the demographic challenges that China faces today such as an ageing population, increasing in the old age dependency ratio, skewed sex ratio at birth, and shrinking labor force- believe that this step signals the beginning of the end of China's fertility restrictions. Indeed, according to the Paulson Institute in Chicago, the fertility rate has dropped underneath the replacement level of 2.1 since the early 1990s, to around 1.5 births per woman in 2013. The labor force started to shrink in 2012 for the first time in decades, and the ratio of workers to retirees is projected to drop from 4.9 to 1 in 2013 to 1.6 to 1 by 2050. On the other hand, another group of professionals and policy makers believe that the loosening won't have a considerable impact on the country's demographic situation, which is comforting to conservatives but concerning to

reformers. In keeping with official estimations,  and before the final decision of terminating the OCP in 2015, the policy will permit 10-15 million couples in China to bear a second child, forming an increase of 1-2 million more births every year, on top of the 15 million births a year at present day. But then again that estimate is founded on a notion that about more than half of the qualified couples would really have babies.
As the same time, critics depicts a more pessimistic view as they announce that the new policy is not only useless, but it is much challenging to implement than a universal two-child policy due to the fact that it is unfeasible to prove if someone is an only child with the presence of a large migrant population. GuBaochang indicates that it would also intensify the threat of corruption as family-planning officials still have the authority to curb people's reproductive freedoms.

When studying economic growth, labor growth is an essential element in the Solow Growth Model (Solow, 1956). Hence, focusing on the One Child Policy (OCP) in China is necessary to examine its economic development as it had slowed down the population growth since 1980s, and its long-run impact progressively appeared after 30 years where the number of working aged population approaches its peak (Park et al, 2007). As mentioned previously, an implicit factor in relaxing the OCP is the increase in the old age dependency ratio that is considered a direct consequence of this policy and an important element in affecting negatively the working force.

All at once, China's age structure is worsening.For instance, based on the UN figures, in 2011, 9.1% of the Chinese were aged 65 or over, up from 7.0% in 2000 and 5.2% in 1980, while the percentage of youngsters (0 to 14) deteriorated to 16.5% in 2011 from 22.9% in 2000 and 35.5% in 1980. The share of ageing people could further increase to 17.4% in 2030 and 29.3% in 2050, while the share of young may decline to 10.8% in 2030 and 9.1% in 2050.

The baby boom in early 1960s and the one-child policy have meaningfully lowered the dependency ratio in the past three decades - from 62.6% in 1982 to 34.4% in 2011. This low dependency ratio has given China the opportunity to save more and grow its capital base in the past. However, this ratio has likely already bottomed out and could start rising on aging population According to the UN, It could increase to 39.2% in 2030 and 62.3% in 2050. The old-age dependency ratio is projected to increase to 24.2% in 2030 and 47.6% in 2050 from 11.3% in 2010 and 8.7% in 1980. This can be translated as 40 years from now, only two workers will support one retiree, vs nine workers supporting one now.

This phenomenon of population's aging gathers wide attention, largely because the accelerating aging of the population affects the long-term economic growth in China by playing a role in decreasing the labor participation rate as it upgrades the cost of labor and reduces the competitiveness of the products. Also, it presents big challenges to China's pension system. Typically, Chinese families largely depended on their children after their retirement. However, after a 33-year implementation of the one-child policy, every only-child will need to give provision to two parents and four grandparents, which is considered a large liability. In this case, the retirees will have to depend on the national pension system. China needs to quickly catch up its pension system coverage to ensure social security, as presently only about a third of the population is covered. Additionally, how to fund the pension system remains a big question as the Chinese workforce shrinks.

In this thesis, the impact of theone child policy and population growth on regional economic growth would be investigated using the basic Solow Model. The regression will include the capital stock as an explanatory variable, but unlike previous research papers, it is going to encompass depreciation rates that differ across the Chinese provinces. These depreciation rates were calculated by Professor Yanrui Wu using the simulation technique for the first time in the literature.Moreover, following the relaxation of the OCP in 2013, the old age dependency ratio –as a factor leading to this loosening-will be examined to see whether it plays a significant role in affecting the regional Chinese household saving rate as the latter is considered to be one of the channels that affect the economic growth.

The research is presented as follows: a brief history of China's one child policy followed by its relaxation and a literature review of the papers that investigate the influence of the OCP on the Chinese economic growth, in addition to the importance of the Solow model and the impact of the old age dependency ratio on the different channels that have an effect on the growth are reported in chapter 2. In chapter 3, the Solow Growth Model as a theoretical framework is punctiliously examined. Chapter 4 is the empirical part of the thesis where data and empirical panel regression analysis and results are presented. In the final chapter, a conclusion is presented.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Overview of the One-Child Policy in China

In the early 1970s, the Chinese government was inspired by the work of the Club of Rome in the 1970s about the scarcity of resources (Greenhalgh 2003) and stirred by the Malthusian catastrophe (which warns that given limited resources, nonstop population growth impedes economic growth). During this period, China's central government started to control its rapid population growth with the "Later, Longer, and Fewer" family planning program. It is a campaign that promotes and encourages later marriage, longer intervals between births, and fewer children. This undertaking proved to be very successful and reduced birth rates considerably according to Yu (2011). However, these policies did not fruitfully achieve the ultimate and ideal population growth rate as  the reigning party found  it was not enough because  even though the birth rate decreases sharply, the fertility rate was only slightly affected ,and so, out of fear of re-increasing birth rates (for the reason that the baby-boomers born after the Great Leap Forward were getting into childbearing-age), they reinforced the population-control procedures by introducing a population control-policy, generally acknowledged as the  "One-Child-Policy" -for simplicity reasons henceforth called OCP- together with other extreme economic and societal reforms in 1979 (Li and Zhang 2007). In fact, the one-child policy that aims to  directly target the number of children per family by stating that each couple is allowed to have only one child, was instigated by the central government. However, the implementation of thepolicy, comprising benefits and penalties, was formalized by local governments and officials.

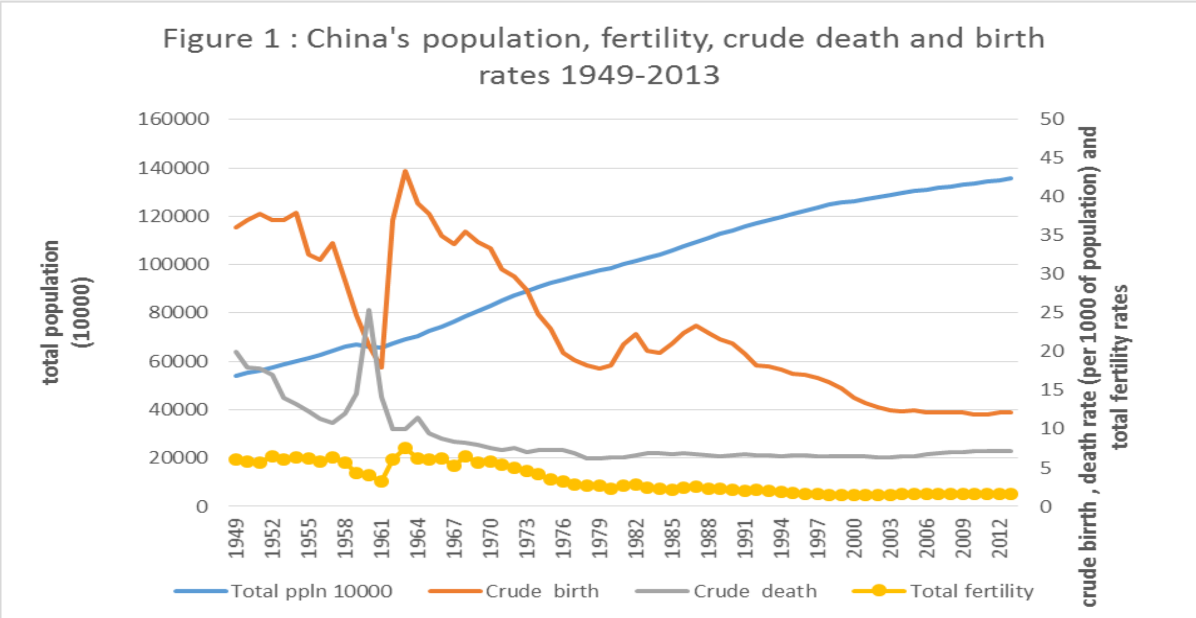
Consequently, local policies unavoidably varied between provinces, regions whether they are urban or rural, and ethnic groups (Han population and ethnic minorities). For instance, urban couples were allowed to have one child and rural parents two children with exceptions.

The implementation of the OCP was regarded as very effective in almost all urban areas and yet less successful in rural areas. Consequently, in order to appreciate the real impact of the OCP on China's demographic transition, it is crucial to reassess China's population policies since 1949, and in particular, the causes behind the steady decline of the birth rates in the 70s.

Former efforts in decreasing the accelerating growth rate of the Chinese population had considerable impacts on Chinese's demographic transition. The post-1949s were the starting point of a new period.  As a matter of fact, Chinese government had a view that a large and big population is judged as an asset keeping up with traditional Chinese values and culture. But soon, after the first consensus in 1953, China started to become aware of the liabilities of a large and rapidly growing population. Indeed, government representatives were astounded by the already high number of population that reaches around 600 million in the mainland and was increasing at a rate of above 2%. Following this, they began the first family planning program in 1956, which was disturbed shortly after by the Great Leap Forward (it is a campaign undertaken by the Chinese communists between 1958 and early 1960 to organize its vast population, especially in large-scale rural communities in order to find a solution to China's industrial and agricultural problems) and the subsequent famine. It is important to remark that the 1956 campaign was- to some extent- fruitful in decreasing the birth rate, but it was the famine that really brought down the birth rate between 1958 and

1960. But neither the Great Leap Forward nor the famine essentially had any noteworthy impact on fertility as right after the beginning of the 1960s, the birth rate soared back to, and even exceeded in some years, the former levels in the early 50s, and so, a new baby-boomer cohort in China was born just after the starvation. This increase in birth rates is a common occurrence after a famine or a fighting campaign during which people generally postpone their childbearing decisions.

Figure 1: China's population, fertility, crude death and birth rates 1949-2013




Source: China Statistical Yearbook, Beijing, years: 1949-1999 and World Bank Data (WDI): years: 2000-2013.

Figure 1 displays plainly how the population increased every year since 1949 except between 1958 and 1961. Those years left a sharp mark in the history of China, as it was the only time when the crude death rate was higher than the crude birth rate as a result of the famine during the Great Leap Forward. There was even a slight population decline during these crisis years. This graph displays just national averages, but in the most relentlessly affected provinces, the increase in mortality and the drop in births was much higher. With these and other statistics demographers could reconstruct the number of famine-related deaths. Their estimations alternate between 25 to more than 40 million premature deaths caused by famine and famine-related maladies.

During the early 1960s, China started the second birth-control campaign that emphasized the virtues and advantages of late marriage. The second campaign again soon came to a halt when the "Cultural Revolution" started in 1967 but the revolution itself was responsible for later marriage sending young people from urban areas to rural regions and as a result, many suspended their marriage and childbearing decisions (which had nothing to do with the birth control campaign).

In 1971, China started to revitalize its frozen campaign on birth control but this time under a new slogan, "later, longer, and fewer" with the intention of a more overall approach. This campaign turned out to be very successful and reduced birth rates radically according to Yu (2011). In effect, between 1971 and 1979, the campaign decreased the birth rate by as much as 50%. But in contrary to the birth rate, the fertility rate was only marginally affected through all the programs as even though the earlier programs lowered the fertility rate by delaying marriages and decisions on childbearing, the long-term effect was limited. For example, in the mid-1970s, a married couple could still have two children in cities, and three or four in the provinces. Without significantly decreasing the number of children each couple has, the suspending policies can work only in the short-run and remain effective for 10-15 years at most.

Furthermore, in 1979, China was precisely at this precarious point where the previous delaying strategy on birth control turned out to be much less effective. To make the matter worse, the postponing effect on childbearing of the 10-year long Cultural Revolution halted when a large number of those who were sent to the rural areas started to return to their original cities in 1978-79. In addition to that, the baby-boomers born after the famine would have started having children in 1979 and a new boost in population growth rates was anticipated. That's why the government implemented the OCP, trying to necessarily decrease fertility rates and hence everlastingly change demographic trends.

Figure 1 shows explicitly the increase in the birth rates during the 1980s, and specifically during 2 years: 1982 and 1987. The first peak should not be linked to the baby boomers because the peak of the baby boomers dated back to 1963 and the peak age-at-birth for Chinese women is in their 20s. It is in reality the bouncing-back effect as a result of the delaying strategies of the earlier population-control policies and a decade of Cultural Revolution. The peak birthrate in 1987 matches up with the peak of the baby boomers of 1963 perfectly, and it marks the appearance of the second generation of those baby boomers. In the event that the one-child policy had not been executed, the birthrates would have surged back much higher during the 1980s. The one-child policy significantly restrained the increase of the birthrates in the 1980s and, more significantly, has permanently altered the demographic trend and the total fertility rate in China.

### *2.1.1 Benefits, penalties and amendments of the OCP*

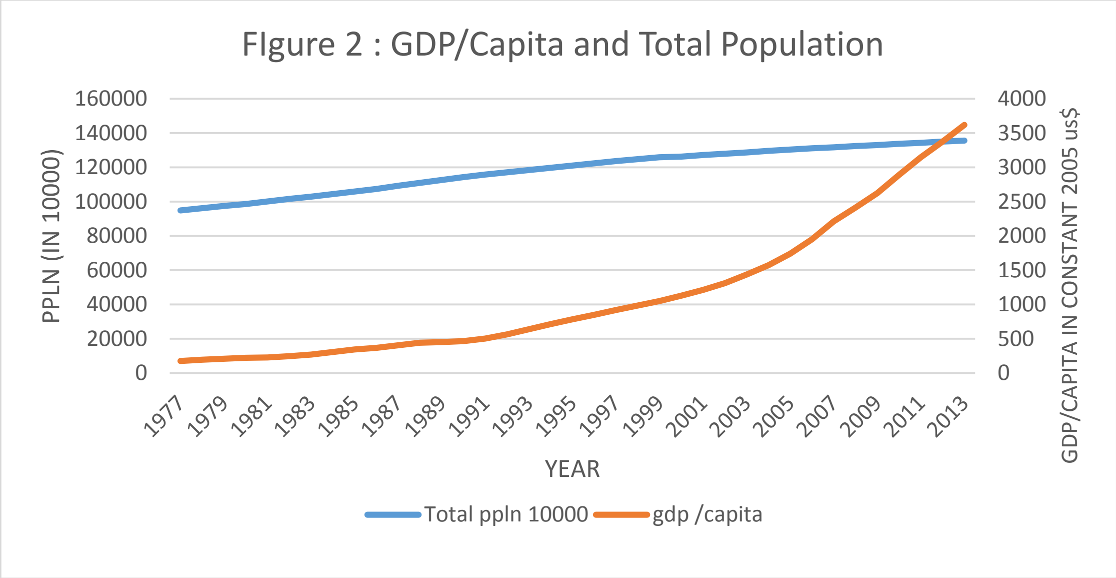
Overall, families that give birth to a single child can gain benefits and monetary recompenses such as a child allowance that continues until the child reaches age 14, precedence access to schools, priority in college admittance, employment, health care, and accommodating. In rural provinces, single-child families are permitted to pay lower taxes and can get a larger area of land. The penalties on above-quota births in cities include 10-20 percent of both parents' wages that last for 3 to14 years. To impose the One-Child Policy, the Chinese government uses a quota reward system for Planning Officials who carry out the birth control policies.  If they do not meet these quotas, they are either penalized or lose the chance to receive promotions. Along the same lines, parents who breach the OCP will be demoted or will not be entitled for promotion if they are employed in government sectors. Also, the "above-quota" children are prohibited of attending public schools. Though, in rural regions, the most familiar sentence is a considerable one-time fine, which may make up a large fraction of a worker's annual revenue. Demotions in the place of work and consent to attend public schools are typically not as central in rural areas as they are in urban regions.

In 1984, the policy was marginally relaxed, with rural families and other demographic groups qualified to receive permits for a second child. The latter is allowed under special circumstances, such as the first child is disabled, a spouse returns from abroad, the first child is a girl and the couple has real teething troubles, or one spouse is a deep-sea fisherman or works in underground mining for more than five years. Provinces have flexibility in determining under which conditions couples may have a second child, with the proviso that they do not gainsay the guiding principles of the one-child policy and exceed the province's population target. As a result, those new exemptions varied dramatically from province to province, and no longer applied if rural families migrated to urban centers. For instance, the residents in the urban areas of Shanghai are sanctioned to have another child if one spouse or both spouses are single children; but under the same stipulation, a second birth in the urban areas of Beijing is not permitted.

The one-child policy is strictly applied to Han Chinese, while ethnic subgroups are usually given the permission to have more than one child.

**Figure 2: GDP/Capita and Total Population**

Source: World Bank Indicators.

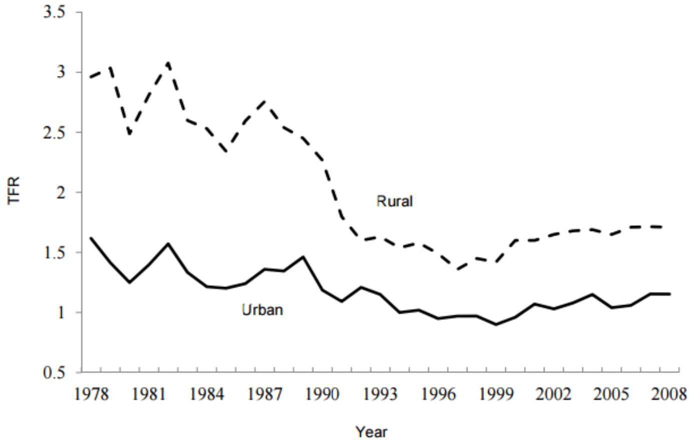



When the OCP was announced, the régime decides on a target population of 1.2 billion by the year 2000. The census of 2000 calculates the population at 1.27 billion, although some demographers view this number as underestimated. The authorities in China contend that the policy has prevented 250 to 300 million births. Figure 2 represents a graph of both GDP/capita in constant 2005 US$ and the total population in China. In 1978, just before the implementation of the OCP, the population was about 962590000 and GDP/capita was only 195.22$.Total population increases in 2013 by approximately 41% to reach 1.3 billion people and GDP/capita follows the same pattern, but by a dramatic percentage of +1753%.

### 2.2 Fertility Rates

China's total fertility rate (TFR) dropped from 2.78 in 1978 to 1. 7 in 2004 and it reaches 1.47 in 2008, with a rate of 1.3 in urban areas and just under 2.0 in rural areas. The TFR decreased to sub-replacement levels sometime during the early 1990s (Feeney and Yuan 1994). As seen clearly in figure 3, around 1991, fertility in urban and rural areas started to converge. The pace of this decline is notable bearing in mind that the TFR was over 5.0 until the 1970s (Gu 2007). The decline in total fertility rate is normally successive to a drop in infant mortality (which as stated by Wei and Hao (2010) decreased from 2% in 1960 to 0.66% in 1990, which is a level analogous to developed countries) because of better health conditions. The OCP forced an additional exogenously change to the total fertility rate by charging fines to couples who do not respect the policy. On the other hand, many believe that the OCP policy itself is most likely only to some extent responsible for the reduction in the total fertility rate. In fact, the most striking decrease in the fertility rate in fact happened before the policy was enacted (Figure 1). Between 1970 and 1979, the "late, long, few" campaign had already resulted in a reducing by half the total fertility rate, from 5.9 to 2.9. After the one-child policy was introduced, there was a gradual fall in the rate until 1995, and it has more or less steadied at around 1.7 since then. Additionally, many countries have had considerable declines in fertility during the last 25 years, and China's neighbors in East Asia region are characterized by having ones of the lowest total fertility rates in the world: 1.04 in Singapore, 1.38 in Japan, and 0.91 in the Hong Kong Special Administrative Region. Even allowing for the fact that these countries are more advanced and urbanized than China, the parallels are hard to disregard.

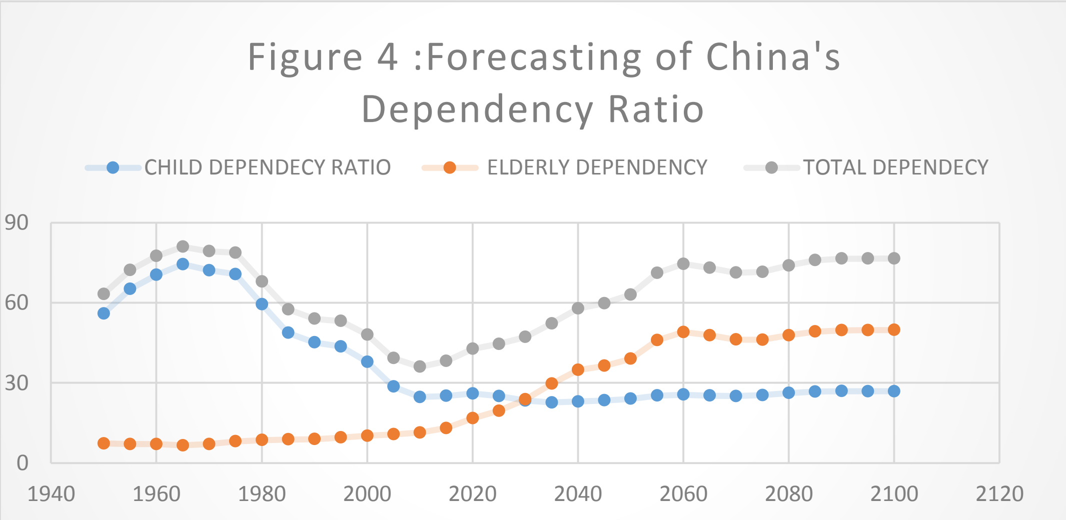
**Figure 3: Trends of TFRs in Urban and Rural Areas between 1978 - 2008**




Sources: The 1978-1987 data are from the 2/1000 Fertility and Contraceptive Use Survey conducted in 1988; the 1988-1992 data are from the National Fertility Survey done in 1992; the 1993-2000 data are from the 2001 National Fertility and Reproductive Health Survey; and the 2001-2008 data are from the Annual Population Monitoring Surveys.

### 2.3 Old Age Dependency Ratio

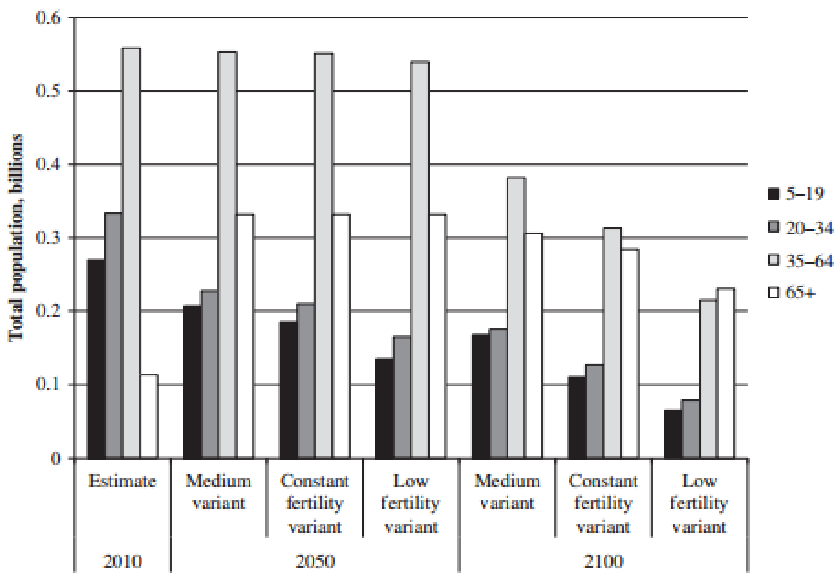
**Figure 4: Forecasting of China's Dependency Ratio**




Source: United Nations Population Division. World Population Prospects.

As seen in figure 4, total and child dependency ratio started to decrease in the mid-1970s, however this reduction is more pronounced after the implementation of the OCP during late 1979. Nevertheless, this steady decline in the total dependency ratio experiences a reversal after 2010 where it jumps from 36% to reach around 38 % in 2014. This occurs basically because the old age dependency ratio that seems to be relatively stable until the beginning of the 21st century, starts to increase until it reaches 13% in 2015. According to the data forecasted by the United Nations Population Division and under the UN's medium fertility scenario (which takes into consideration a regular rise in total fertility rate (TFR) from 1.63 in 2010 to 1.88 by 2100), this rate isexpected to further increase in the future until it reaches 39% in 2050 and about 49.8% by 2100. So, As a result of very minimal fertility rates and minor international immigration, China is evidently ageing very rapidly. Another way to explicate this phenomenon is by looking at the effect in the changing relative size of the populations aged 20–34 and 65 and over, which can viewed in figure 5. The 20–34 age group is the critical one to observe since it comprises the population that gives birth and its members are skilled, and this acquired and flexible skill that they have is necessary to ensure a capable labor force. Presently, this age group outstrips the population aged 65 and over by around three to one. Under the UN’s medium fertility scenario, this relationship will turn around, so that by 2050, the ratio of the younger group to the elder will be approximately two to three, and will keep increasing until 2100. However, the long term prospects of continued low fertility would head into a ratio of more than one to two within a couple of generations. Indeed, some accept as true that even these predictions could be optimistic, partially because of doubts about the baseline assumptions used in constructing them. This transition will present a wide array of economic, social, and political burdens to policymakers. For instance, in spite of a shrinking labor force and additional wage inflation, resources will have to be found to arrange for suitable care for the senior population and support those who are poor.

**Figure 5: Projected Total Population Size by Key Age Groups in China**




Note: The constant variant implies a fixed TFR of 1.63 to 2100, while the low variant involves a stabilized TFR at around 1.3–1.4. Source: Based on the UN World Population Prospects: The 2012 Revision (UNPD 2013).

### 2.4 Relaxation of the OCP

During 2012–13, several developments indicated that further relaxations in the family planning policy were potential. In 2012, the China Development Research Foundationproposed a ‘three-step’ policy transition: some provinces ought to implement a two-child policy promptly, while a national two-child policy has to be in effect by 2015, and allrestrictions on births eliminated by 2020 (Waldmeir 2013). In early 2013, China’s Population and Family Planning Commission was merged into the new Public Health and Family Planning Commission—an important happening that indicates a potential for further reform by unsettling deep-rooted bureaucracies (Jiang et al. 2013). In November 2013, the Third Plenary Session of the Eleventh CentralCommittee of the Communist Party of China restated that family planning was a prime national policy, but altered the policy so that a couple in which one spouse was an only child would be eligible to have a second child (NHFPC 2013). Following the pronouncement, provinces gradually implemented the policy, with nearly all regions amenable by the summer of 2014 (Gu 2014). Bai (2014) guesstimated that about 15–20 million couples have now become qualified for a second child as a consequence of the relaxation. It is important to notice that under the family planning regulations, couples must submit an application for special dispensation to give birth to a second child if they are entitled to do so, or else, it is going to be regarded - in principle- as a breach of the policy. This new amendment was regarded as both beneficial and detrimental since experts acknowledged that while the ensuing baby boom would make the rapid pace of ageing better, it would at the same time, place an ever greater demand on public services. It was officially estimated that couples are going to give birth to about 10 million extra births over the following 5 years. These predictions are founded on a significantly common outlook that there was a curbed and restrained demand for children which only a thorough process of gradual policy amendment could manage. Zhuang (2014) reported the comment made by ZhaiZhenwu, a demographer who lectures at Renmin University and who believes that: ‘A universal two-children policy will introduce a serious baby boom in a short period of time and put a lot of pressure on public services such as health and education’. To confirm these worries or anticipations is premature, but there is a number of statistics that give an idea about the number of applications for a second child and the extra birth that begins to materialize. For instance, In Xuanwei Area which is located in Yunnan Province, and is populated with about 1.25 million people, the number of applications for a second child was only limited to 36 within the first 3 months of the relaxation of the OCP. According to Liu et al. (2014), this small figure was credited by local family planning officials to economic burden on young couples. In order to figure out this phenomenon, several new studies have studied fertility preferences in both urban and rural China. A number of research papers were for instance studies of couples qualified to bear a second child, while others used rely on surveys and ask respondents to express their intents under future settings of policy relaxation. As Hou et al. (2014) inform, the mean wanted number of children in 63 studies of urban fertility preferences in the period 2000–10 was only 1.50 with a Standard deviation of 0.25  while the mean in 52 studies in rural areas over the same period was 1.82 (SD 0.36).

## 2.5 Literature Review

### *2.5.1Literature Review on Population Growth Models*

The relationship between population and economic growth has been subject to debate for hundreds of years. It started back in 1798 when Thomas Robert Malthus explored the issue of population and its effect on economic growth in his essay entitled "An Essay on the Principle of Population" and came up with the famous poverty trap of rapid growth. According to him, natural resource was limited and high population growth would be a burden on the resources especially for economic development. He argued that human population grows at a geometrical rate, while food production grows at an arithmetic rate.  Consequently, there will be shortages of food supplies and the situation will finally results in wars and starvation since there will be great competition for food. In his view, population needs to be controlled in other to sustain a healthy human race. His theory was partially accurate under the assumption of low productivity, limited international trade and stagnation of technology. However, his view regarding technology stagnation was later on challenged by the concept of industrialization as the second industrial revolution in 1800s with machinery manufacturing changed the traditional low productivity system. This pessimistic attitude was reinforced by scholars from Roma Club (1972) who focused on the limits to growth under the assumption of rapid population growth. This club is a group of industrialists, economists and statesmen who published ‘The Limits to Growth’ in 1972 in which they reached the fundamental inference that if current growth trends in world population carry on and if associated industrialization, pollution, food production and resource exhaustion stay unchanged, the limits to growth on this planet will happen in the next 100 years.Another economist named Ester Boserup (1981) offers an alternative theory to that of Malthus. She was optimistic and believed that population growth is not a problem as we only need to intensify the land to support more output which will be able to sustain people. She believed that under pressure of more mouths to feed, people will put more labor and more strong efforts into feeding themselves and find way to get more manure, water, etc. to improve their crops. She also held the belief that there are enough resources to feed the people and digging deeper into the environment is the way to do this. Boserup was concerned about overcoming the limits inflicted by the environment through intensive agriculture and technology. In 1967, Simon Kuznets put forward a neutral argument whereby rapid population growth has no beneficial or detrimental effects on economic growth. Later in the end of 20thcentury, Bloom and Williamson (1998) demonstrated the same result from the research based on East Asia economic miracle using the convergence model which take demographic structure as a variable. One of their discoveries was that rapid growth in the population of working age had a considerably positive impact on economic growth. On the other hand, the effect of total population growth was irrelevant and negative. Then, Bloom, Canning and Malaney (2000) claimed that one third to a half of the growth of the East Asia Miracle was supported by the demographic transition during 1965-1990. In this period, countries have shifted from having high birth rate and low death rate to low birth rate and death rate. Zheng and Rui (2010) collected Chinese provincial data in order to illustrate the positive correlation between the economic growth and the change of dependency ratio (caused by the one child policy) since 1989. Several empirical studies and papers depict the ambiguous relationship between population and economic growth. For instance, Tsen&Furuoka, 2005 show that in Asia, there is no relation between population and economic growth in the long run. In fact, in the short run, they demonstrate that Japan, Korea and Thailand have bidirectional granger causality between population and economic growth, while China, Singapore and Philippines have unidirectional granger causality that runs from population to economic growth. This settles that low population growth dampens economic growth. In the same way, the increase in an ageing population also diminishes economic growth. For example, S. H. Lee & Mason, 2007 establish that, in Taiwan, the effect of demographic transformation by an increase of elderly people affects income growth through the lowest income among three generations. Peng, 2008 illustrates that in China, the ageing population leads to lower economic growth through a decrease in the labor force and a decline in new demand for investment.

### *2.5.2 Literature Review on Solow Growth Model*

Recently, there is an increasing number of empirical works on cross country growth and convergence. Within the theoretical and empirical growth literature, the

Solow model (Solow, 1956) is being apprehended as the foundation of basic endogenous growth models. Another two notable papers by Cass (1965) and Koopmans (1963) also delivered a focus on the issue of convergence. Allowing for a set of assumptions, the main pattern of Solow growth model emphasized that long run rate of growth is exogenously determined. More evidently, economies converge towards a steady state level of growth, which mainly rests on the level of technological progress and work force growth. There are numerous directions of research that empirically consider the validity of Solow's paradigm.For instance, the most quoted and influential paper by Mankiw, Romer and Weil (Mankiw et al., 1992), henceforth MRW, scrutinizes the consistency of Solow's model with international variation of living standard. Using a large set of cross-section data, they plainly confirm what the augmented Solow model predicts. Solow accepted diminishing marginal returns of capital, exogenous population growth and savings rate, no depreciation and technological progress. The model foretells that steady state level of income per capita is exogenously determined by savings and population growth rate, which lead to the understanding of convergence. In testing Solow model, the theoretical and empirical outline provided by MRW has been very significant for the cross-section growth empirics in literature. By supposing that the rates of saving and population growth are independent of the residual term, MRW tested both the textbook and augmented Solow model using OLS in a single cross-section regression framework. They demonstrated that an augmented Solow model with accumulation of both human and physical capital offers an excellent justification for international income disparities, i.e. about 80 percent of the cross-country disparity in income per capita can be clarified using just three variables: population growth, and investment rates of physical and human capital. Furthermore, by investigating the dynamic forces of the economy out of steady state, MRW found confirmation that countries converge to their respective steady states at about the rate that the augmented Solow model expects, holding population growth and capital accumulation constant. Their results are founded on three samples with a maximum of 98 countries over the period 1960-1985, but then again none of them comprises China.

Islam (1995) criticized the procedural tactic of MRW in two key grounds. Primarily, the single cross-section estimation of growth equation cannot deal with the country specific shock from the aggregate production function and therefore rise the problem of omitted variable bias. Furthermore, the result reached by Ordinary Least Square disregards the significant shocks by production technology, resource endowments and institution to the aggregate production function. Such notion can violate the elementary orthogonality condition: shocks are expected to be correlated with the explanatory variable which suggest the OLS estimators are biased. Thus, along with the single cross-section, Islam (1995) applied a panel framework using the same sample as MRW. His research stressed that the lower the value of output elasticity with respect to capital, the higher the rates of conditional convergence.

The literature exposes that most of the studies analyzed cross-country growth regression and highlighted that the factor accumulation drives output per worker growth. However, a number of other researches underline the impact of total factor productivity (TFP) in clarifying international variances in levels and growth of output per worker. Specifically, Ding and Knight (2009) - by using system GMM for the cross-country panel analysis that encompasses 146 countries- realize that Chinese rapid economic growth is due to a large amount of investment in physical capital, change in employment structure and output, conditional convergence gain and low population growth strategy.

### *2.5.3 Literature Review on Capital Stock Estimations*

It is important to notice that when Solow model is applied to study the economic growth, compiling data series of physical capital stock is crucial. For example, in the case of China, studies of its economic growth in the former two decades have been controversial either because the methodologies used are diverse or because the data of capital stock series constructed are not consistent to each other. Since 1990s, economists have made several efforts to construct China's capital stock series to put into effect the empirical studies of China's productivity and economic growth.

Originally in 1990s, though, most of the studies have only assembled the national or aggregate series on capital stock using sectoral or industrial figures. Only a small number of studies have tried to get an estimation of China's provincial capital stock series and they constructed a data series that covers not only the post-reform period but also pre-reform era. But since later 1990s, with the focus of interest shifting to the studies on China's regional or provincial variations on sources of economic growth, productivity change and income disparity, the construction of provincial capital stock series became urgently required. Recently, studies on China's productivity and economic growth using provincial panel data have considerably increased (e.g., Ezaki and Sun, 1999; Young, 2000; Wu, 2004, 2007; Li, 2003). For example, Li (2003) is the first economist in the literature who constructs China's national and provincial capital stock series using national and provincial GDP and financial resources, rather than using standardized perpetual inventory method. Wu (2004) employs perpetual inventory method to make the capital stock series for 30 Chinese provinces. But his estimation spans the years between 1900 and 2000. In his work he assumes that the initial value of capital in 1900 was null and the rate of depreciation for all regions is 7%. In his later work he lengthens his estimation by adopting different rates of depreciation for different provinces (Wu, 2007).

### *2.5.4 Literature Review on China's Economic Growth*

When considering the correlation between population size and a country's output, China is an essential focus and an important case study in the previous researches that explore this association. In reality, Li and Zhang (2007) display in their paper that a drop of the birth rate by 1/1000 surges the economic growth rate by a proposed 0.9% a year. They reach the conclusion that the steady-state GDP per capita would be raised by 14.3%. Through an estimation employing the generalized method of moments (GMM), they discover that the economic growth rates of the Chinese provinces decrease with increasing birth rates and vice versa. These two authors, consequently, are in accordance with the Malthus model maintaining that too high birth rates can impede economic growth and probably have done so in China before instigating population control policies.

Wei and Hao (2010) argue in their empirical investigation that China had a considerably higher GDP per capita growth rate during the years 1978 to 2008 than the United States, Europe, Japan and India. Undeniably, it was not only the demographic progress that backed those high growth rates but likewise other reasons such as institutional reform, rapid accumulation of capital, general riddance of inefficiencies or the enhancement of total factor productivity (Wei and Hao 2010, Holz 2006). Other factors include the reallocation of resources (Song et al 2011), market liberalization and the embracing of an open-door policy (Yu 2011).

Academics have estimated the effect of the population age structure on previous growth rates. Cai and Wang (2005, 2006) expose that an increase of the total dependency ratio of 1% pulls down the GDP per capita growth rate by 0.115%. Moreover, Wei and Hao (2010) guess a 0.065% increase in economic growth per 1% decrease in total dependency ratio. The correlation is obviously negative, their results display this at the 5% significance level. In their paper, the two authors also show that the youth dependency ratio has a substantial negative influence on economic growth whereas the old dependency ratio is negatively related, but the approximations are insignificant and trivial.

Yu (2011) shows a very interesting approach .He adds the prevented and averted average 13 million births a year to the dependency ratio and estimates China's GDP per capita growth rate with the different numbers, paralleling it afterwards with real growth rates. He indicates that for instance in 1995, the real GDP per capita would have been 13.2% lower without the OCP. Coalescing diverse research concepts, he gives the following deduction: the high ratio of working to non-working population led to higher savings, higher savings led to a higher level of investment and the large capital stock led to threshold externalities as revealed as prevailing in developing countries. This all together completed in an economic take-off effect. The estimated threshold value of the ratio of working population and non-working population is 1.81. Given the fact that 1.81 workers support one dependent non-worker, saving rates and investments were high enough for the economic take-off to transpire. He calculated that the commencement of the economic take-off effect was around 1984 to 1985. Without the

OCP, the threshold value would have been reached in 1996, hence the OCP hastened economic growth for approximately twelve years.

### *2.5.5 Literature Review on the Effect of the Population's ageing on the Growth*

The structural ageing of the population has deep consequences on the economic growth of countries. The United Nation defines the ageing population as the proportion of population aged over 60, which is more than 10 percent of the total population. Most economists maintain that a country with a higher proportion of the older age group has a tendency to be linked with lower productivity levels and savings and higher government spending (Bloom et al., 2010; Mèrette and Georges 2009; Sharpe, 2011). This demographic trend also makes room for an increase in the age dependency ratio, signifying that the smaller working age group will have the compulsion to care for the elderly (Lindh, 2004). In previous studies, the direct or indirect impact of aging on economic growth has been recognized through three main channels: labor supply, consumption and savings rate in addition to public social expenditures. Regarding human capital or labor supply, a number of authors claims that countries can sustain economic growth in spite of the ageing population problem. For illustration, Elgin and Tumen (2010) assert that confronted with a decline in human capital, the economy will shift from traditional production that uses young workers to new human capital adapted production that employs old age workers. So, according to this reasoning, an ageing population will disturb neither the production nor the growth dynamics. Besides, Elgin and Tumen (2012) stress that modern economies depend more on machines than human capital. Consequently, a reduction in the labor force will have zero effect on productivity. According to these authors, labor can be substituted by machineries. They held the belief that a decrease in the young working group has no effect on economic growth.

In keeping with some authors, such as Bloom et al. (2010), increasing the retirement age and immigration will indeed help to overcome the decrease in the labor force. On the other hand, Lisenkova et al. (2012) have a conflicting understanding of this phenomenon. They discover that even though increasing the retirement age will aid in overcoming a decreasing labor market, workers of different ages are not perfect substitutes and so there will absolutely be a decline in productivity per worker. Additional authors also underline the negative effect of population ageing and the associated decrease in a country's size of human capital (Narciso, 2010), with an ensuing negative impact on economic growth. Consequently, an ageing population will decrease the labor force, which will consequently affect economic growth owing to lower productivity levels. Even though the higher participation of women in the labor force increases labor productivity, this participation will further lower the fertility rates, which will ultimately lead back to the original problem (Alders and Broer, 2004).

Other than the argument of age retirement, it is also believed that higher immigration is unable to help much with overcoming public expenditure because of this ageing problem, as immigrants will have rights under the pension and health care system (Elmeskov, 2004). Despite the negative effect on human capital accumulation identified by Lindh (2004), Ludwig et al. (2011), other authors argue that, for the US economy, increasing human capital investment will reduce the impact of an ageing population. The endogenous human capital through proper and formal schooling and on-the-job training programs will positively impact human capital technology (Ludwig et al. 2011). Henceforth in the example of the US, Ludwig et al. (2011) report that when we allow for endogenous human capital  accumulation, the welfare losses in terms of lifetime consumption increase only about 8.7%, but when human capital is presumed as exogenous, these losses increase to 12.5% taking into consideration the  assumption that replacement rates to the pension system are constant.

The second channel is the consumer and saver path. Some authors (e.g., Hock and Weil 2012; Walder and Döring, 2012) show that the increase in the ageing population will cause a decrease in consumption, which eventually deprives growth. The argument is established as follows: an increase in the elderly tends to decrease the per capitaincome of the three generations, youngster, working group and senior retired citizen, and this can be translated as a net drop in the total consumption of the family (Lee et al., 2007).

To Hock and Weil (2012), consumption patterns are influenced by ageing through disposable income. Undeniably, the increase in the old age dependency ratio will reduce the disposable income of the working group, bringing about a decrease in the fertility rate and further supporting population ageing.

As saving turns into the source of their spending, the saving rate drops for retirees (Davies and Robert III, 2006). Therefore, the ageing population will increase the dependency ratio in a family. An increase in the child dependency in a family will cause a momentous decline in the per capitaincome of the child cohort alone (Lee et al., 2007). Additionally, an increase in the old age dependency will lead to an important decline in both child and worker groups (Lee et al., 2007). This means that, as already explained, the increase in the ageing population will decrease the whole consumption of the household.

Concentrating more on the saving channel, Leff's dependency hypothesis (Leff, 1969) proposes an inverse relationship between dependency ratios and saving rates for the reason that their expense paid for consumption rather than production. Therefore, the demographic change has an impact on aggregate saving because the high ratio of dependents to the working age population leads to lower aggregate saving. The impact of a larger ageing population decreases the saving. For example, (IMF, 2005) asserts the increasing 1% of elderly dependency ratio leads to reduced saving by 1.50% of GDP. In Japan, Horioka (1991, 1992) prepared a single-equation analysis of Japan's savings rate in combination with the age structure of the population and used the estimated regression coefficients to forecast its future trends. Explanatory variables are the old-age dependency ratio and the young-age dependency ratio, which are the ratios of the population aged 65 years and over and the population aged 19 years and under to the population aged 20-64 years, respectively. Horioka concludes that Japan's private savings ratio (both household and corporate sector) will become negative after the year 2007 with rapid population aging.

The third channel is about social expenditure. As it is generally known, taxation is relied on as the chief source of income for a government agency. A rise in the ageing population will affect government revenues from taxes and increase government spending, particularly on health care, the pension system and other old age related reimbursements (Tosun, 2003; Elmeskov, 2004).

On the one hand, taxes directly incite an increasing deficit in the government budget. In fact, strategies whereby government agencies raise taxes to accommodate pension and medical expenses affect the disposable income of the working group, which tends to result in a decline in the fertility rate (Hock and Weil, 2012). Therefore, this type of response will further boost the ageing problem.

# CHAPTER 3

# THEORETICAL MODEL

## 3.1 The Solow model of growth

### *3.1.1 Background*

The Solow model is a theory established by Robert Solow in 1956 and for which he was granted the Nobel Prize in Economics in 1987. Professor R.M. Solow builds his model of economic growth as an alternative to the Harrod-Domar line of thought without its central assumption of fixed proportions in production. As a matter of fact, in the modification of the Harrod-Domar model where population growth was accounted endogenously, what is found is that even a short-term change in policy like a family planning program can have lasting long-run effects on the growth rate. This change could move the economy out from the development trap, and it could reach the area where sustained growth is possible. More generally, factors deemed exogenous (savings rates) may possibly be affected by the outcomes that they apparently cause such as the output or its rate of growth. The growth model developed by Solow had such a major impact on how the economists think about growth. He altered the Harrod-Domar story by making the capital-output ratio endogenous. Solow's model is based on the diminishing returns to individual factors of production. Capital and Labor (L) are both compulsory to produce output. Contrasting with Harrod-Domar-model, the K/Y ratio is no longer fixed but depends for instance on the economy's wide relative endowments of capital and labor. Hence, Solow proposes a continuous production function linking output to the inputs of capital and labor which are substitutable: so for the same output, we could have many different combinations between capital and labor. The model explains the economic growth by considering how capital, labor and population growth determine the short run level of GDP per capita in its simple form, and how technological advancement and human capital affect long run economic growth when the model is relaxed.

### 3.2 The simple Solow model

The simple version of the model describes how an economy's level of GDP per capita is established using only 2 factors: capital and labor.

Capital including physical capital, machineries, roads etc. is formed by savings and investments. The three agents:  households, firms and governments save some of their income, which is borrowed by others for investments. If, for example, a firm invests in new machines, GDP increases, which consecutively raises future savings and investments. Capital does not only grow with investments; it can also decrease due to depreciation like the case of equipment that run down and must be replaced. Following the reason that capital depreciates, it is important for savings and investments to be equivalent or larger than the depreciation rate to retain a steady level of GDP per capita. Labor is the other factor that creates output in an economy since it is required to work with the given capital. The original Solow model differs between labor and population but in this thesis labor and population are used synonymously. This substitution occurs because data for labor across Chinese regions from the 1950s are hard to find in addition to the main idea that a large population size implies a similarly  large labor force  Capital and labor will act together to create a level of GDP per capita, called the steady state. At the steady state, there is no economic growth; it is merely a stable standard of living for the country.

### *3.2.1 Assumptions of the simple Solow model*

The simple Solow model starts with a linearly homogeneous production function $Y = F(K, L)$. The output (Y) increases whenever capital (K) or labor (L) increases. This function is then putted in per-worker terms:

- $Y/L = F(K/L, L/L)$
- $y = f(k)$

Where k is the amount of capital per worker and y is the amount of output per worker. The slope of this function evaluates the change in output per worker due to a one unit increase in capital per worker which is equivalent to the MPK. Hence, the slope of $y = f(k)$ is $f'(k) = MPK$. It is assumed that adding capital and labor raises output:

- $\partial Y / \partial K > 0$
- $\partial Y / \partial L > 0$

However, the model also presumes that there are diminishing marginal returns to capital accumulation. In other words, adding additional amounts of capital gives progressively smaller and smaller increases in output. This is explained as the second derivative of output with respect to capital is negative: $\partial 2Y / \partial K < 0$

Due to the decreasing marginal productivity of capital, this is decreasing in y, making f(k) a concave function. In addition to that, as a crucial assumption, the model also assumes a closed economy where all savings are used for investments. Hence, these two factors are considered as one: Savings are equal to investments. Moreover, savings, investments and population growth are exogenous and there are constant returns to both capital and labor jointly. The output in the Solow model can be produced using any combination of labor and capital.

### *3.2.2 Derivations and Interpretations*

We assume a closed economy with no government sector or international trade. This means all output takes the form of either consumption or investment:

- $Y = C + I$

And that savings equals investment:

- $S = Y - C = I$

Hence, by definition, the net change of capital input ($\Delta K$) is equivalent to investment (I) minus capital depreciation $\delta K$. By consequence, we have $\Delta K = I - \delta K$ (1). The economy's stock of capital is assumed to change over time. This is translated as $\Delta Kt / \Delta t = It - \delta Kt$ .In other words, the addition to the capital stock each period depends positively on investment and negatively on depreciation, which is assumed to take place at rate $\delta$.

Since all savings eventually find their way to investment, we have S=I, and taking into consideration that the Solow model does not attempt to model the consumption-savings decision. However, it assumes that consumers save a constant fraction s of their income $S = sY$. In other words, savings constitute a fixed proportion of income where s is saving propensity.

Plugging the two equations into equation (1), we can re-state the equation for changes in the stock of capital:

$\Delta K = I - \delta K = s.Y - \delta K$ (2)

In per capita terms, k=K/L, after total differentiation, we get:

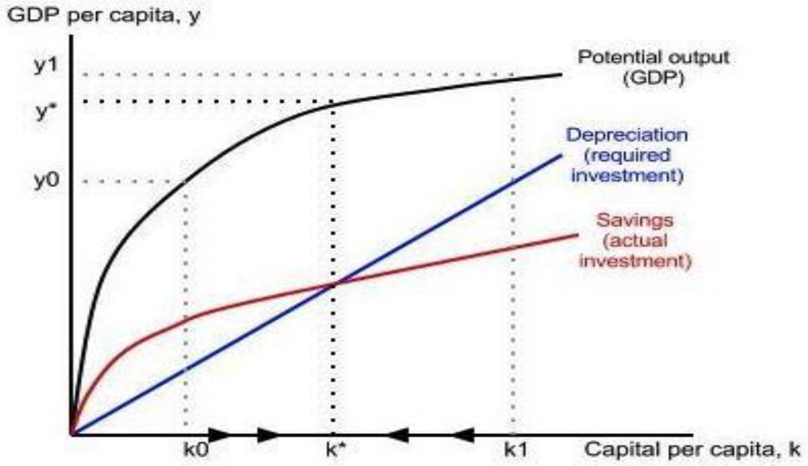
$\Delta k = \Delta K/L - \Delta L.L/L2 = \frac{\Delta K}{\Delta L} - \frac{K}{L}.\frac{\Delta L}{L} = \frac{\Delta K}{L} - k.n(3)$

Where n is the population growth rate and it is assumed to be equal to the labor growth rate

Plugging (2) into (3), we have:

$$\Delta \mathrm{k} = \frac{sY - \delta K}{L} - k.n = s.y - \delta k - n.k = sy - (n + d)k$$

**Figure 6: The Simple Solow Model**



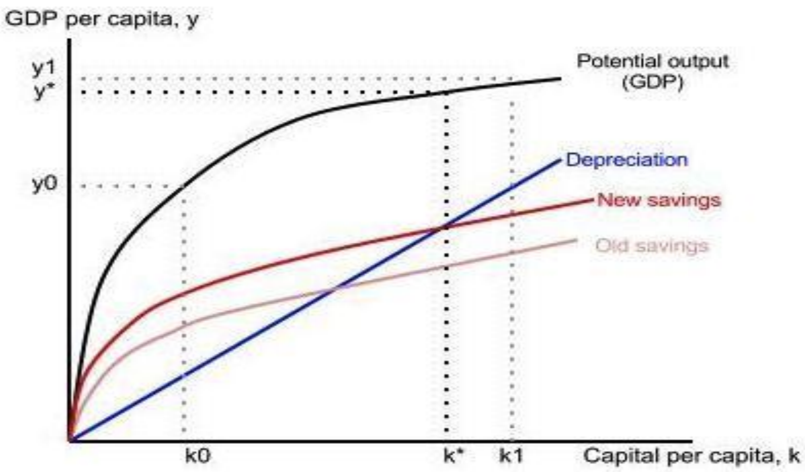

Source: sh.diva-portal.org.

Figure 6 depicts how savings and depreciation create GDP per capita. Depreciation is a simple straight line function of the stock of capital while output is a curved function of capital, featuring diminishing marginal returns. When the blue line representing depreciation and the red one connoting savings intersect, the savings are equal to the depreciation rate and the economy is at a steady state where GDP per capita, y*, and capital per capita, k*, is neither rising nor falling. There is no economic growth. If the capital stock is at k0, there are more investments than what is being depreciated and the economy will grow towards k*. At k1, investments fail to replace all capital that is being depreciated, and GDP per capita will be lower next year. This way the capital per capita always moves towards k*, the steady state. So, as a general explanation, whether the capital stock increases, diminishes or stays the same depends on whether investment is greater than, equal to or less than depreciation.

- $dKt/dt > 0$ if $\delta Kt < sYt$
- $dKt/dt = 0$ if $\delta Kt = sYt$
- $dKt/dt < 0$ if $\delta Kt > sYt$

In other words, if the ratio of capital to output is such that $Kt/Yt = s/\delta$, then the stock of capital will stay constant. If the capital-output ratio is lower than this level, then the capital stock will be increasing and if it is higher than this level, it will be decreasing. So, when the level of capital is low sYt is greater than δK. As the capital stock increases, the extra investment due to the extra output tails off but the additional depreciation does not, so at some point sYt equals δK and the stock of capital halts increasing. The particular point at which the capital stock remains unchanged is where $Kt/Yt = s/\delta$.

**Figure 7: The Simple Solow Model with Increased Savings**

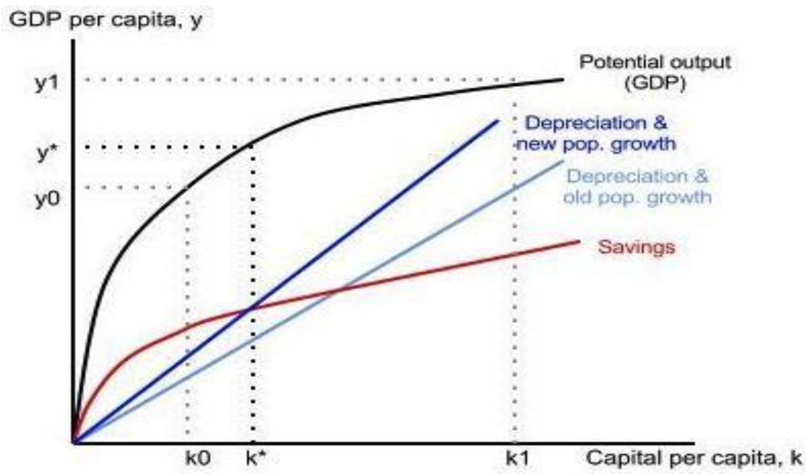



Source: sh.diva-portal.org

In the case where savings increase, the latter will now be equivalent to depreciation at a higher steady state, where there is a larger GDP per capita, y*, at more capital per capita, k*. The standards of living are greater than in the preceding example, and the country is better-off meaning that it will have a higher steady state.

As shown, a country's standard of living is measure in GDP per capita and capital per capita. If GDP per capita is to remain unchanged in an economy, output must increase at the same rate as population. The sole difference from the earlier model is that savings not only need to make up for depreciation of capital, but also for increased population that demands a part of GDP.

**Figure 8: The Simple Solow Model with Population Growth**




Source: sh.diva-portal.org

In case there is an increase in population, the depreciation line now also comprises population growth, which signifies than savings ought to be even larger to sustain both the new population and depreciation. If savings are fixed and do not change, the steady state shifts to a lower point, where both capital and output per labor drop, at y* and k*. This clarifies why nations with a rapid population growth and low savings are likely to be poorer than countries with little population growth.

The question that arises is that: are labor and capital sufficient to cause economic growth? The answer is a no since there is positive but diminishing marginal productivity. This means that if a firm has capital and labor, increasing the number of workers will increase the output. If the process of increasing the number of workers carry on over and over, output will increase, but at a decreasing rate. The last worker added will not supplement as much to output as the first one. Hence, the shape of the output line starts off steep and grows flatter.

### 3.3 The Solow model Augmented with Technological Progress and Human Capital

Thus far, capital, labor and population growth have caused a change in the steady state level of GDP per capita. Different countries end up at different steady states. Because of diminishing marginal productivity, adding capital and labor to increase economic growth is not useful since, in the end, it will make no difference. The model requires additional explanation for the long-term growth. In fact, it needs to answer the following questions: why various countries grow faster than others? And what can be done to increase growth in developing countries? Two factors can increase the growth rate: technological progress and human capital.

Technological progress: As a definition, technological progress includes all "intangible aspects of human progress that allow both population and capital to increase their productivity", which can change from country to country.[1] Solow added technological progress A to the model in order to explain why labor and capital is more efficient in some countries. This variable enters the production function as follows:

$$Y = f(K, AL) = K^{\alpha} (AL)^{1-\alpha}$$

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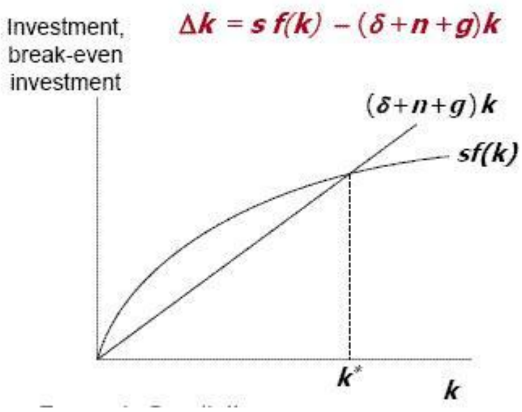
[1] Carlin and Soskice, Macroeconomics: imperfections, institutions, and policies, 2006, p. 481.

Where AL means “effective labor” and the latter is more productive when the level of technology is higher.

**Figure 9: The Solow Model with Technological Progress and Human Capital**




Source: Mankiw, N. Gregory. Macroeconomics. 6th ed. New York: Worth, 2007.

One point that Solow does not explain is how the technology is improved. He just points out the fact that technology increases the output by π, without explaining the origin of this number. But, he assumes that technological progress is exogenous which means that no matter what the agents do in this economy, technology variable A always grows with the rate g. Hence, by supposition:

$$\frac{\dot{A}}{A} = g \Leftrightarrow A = A_0 e^{gt}$$

The capital formation function we get is:Δk=sy-(δ+n+g)k .

In graph 9, kand yare in “per effective worker” units instead of “per worker” units. Additionally, the break-even investment line is a little bit steeper: it means that at any given value of k, more investment is required to keep k from falling - particularly, gk is needed. Or else, technological progress will cause k = K/LE to drop at rate g (because Ein the denominator is growing at rate g).

In the steady state, income per worker/capita is growing at rate g instead of being constant.

To recapitulate, technological progress causes economic growth without an increase in capital or labor because it makes the prevailing capital and labor more productive. In other words, better machines and improved knowledge among workers increase output.

Human capital was introduced to the model, not by Solow himself but by Mankiw, Romer and Weil. They believed that human capital could make clear the origin of technological progress because an educated and healthy labor force will be more productive. As a result, human capital such as education and healthcare will positively influence the economic growth. The model assumes that population growth is constant, so all change in productivity of labor is caused by human capital. It also takes into consideration the endogeneity of both the technological progress and human capital.

The production function including human capital is linearly homogenous with constant returns to scale and positive but diminishing marginal productivity.

$$y = k^{\alpha} \cdot h^{1-\alpha}$$

Where h signifies human capital, $\alpha$ is the share of output from physical capital and 1-$\alpha$ is the part of output from human capital.

Part of output that is saved is: $k(t+1) - k(t) = s \cdot y(t)$

Part of output that is consumed is: $h(t+1) - h(t) = q \cdot y(t)$

Where t represents this time period, t+1 is the next time period, s is the propensity to save in physical capital, q is the propensity to invest in human capital. All variables, y, k and h, grow at an equal rate. The growth rates are computed in this manner:

$$\frac{k(t+1)-k(t)}{k(t)} = s \cdot r^{1-\alpha}$$ for physical capital, and

$$\frac{h(t+1)-h(t)}{h(t)} = q \cdot r^{1-\alpha}$$ for human capital

The two growth rates are similar in the long run, therefore: s.r1-α = q.r1-α or r=q/s

# CHAPTER 4

# EMPIRICAL MODELS AND DATA

## 4.1 Panel Data Model

According to Hsiao (2003), panel data set is one that follows a given sample of individuals over time, and hence offers multiple observations on each individual in the sample. A panel is assumed to be balanced if we ensure the same time periods, t = 1…T, for each cross section observation. For an unbalanced panel, the time dimension, represented by Ti, is particular to each individual.

Compared to conventional linear regression models, the panel data model generally give the researcher a large number of data points (N T), increasing the degrees of freedom and decreasing the collinearity among explanatory variables , hence enhancing the efficiency of econometric estimates . By merging time series of cross-section observations, panel data gives more informative data that is more variable and more efficient. Panel data are better appropriate to examine the dynamics of change, which is mainly suitable for evaluating the impact of a certain event or policy. Using the panel data can avoid the difficulty of international comparability of data as the provincial data are collected in one country that surmounts the unobservable individual “country effect” (Islam, 1995). Other than that, panel data permit the researcher to analyze many significant economic questions that cannot be dealt with using cross-sectional or time-series data sets. In addition to that, panel data provides a way of solving the extent of econometric complications that frequently arises in empirical papers, specifically the often heard statement that the real reason one finds or does not find particular effects is the existence of omitted variables that are correlated with explanatory independent variables. So, Panel data allows to control for omitted such as undetected or mis-measured variables. Panel model is employed not only for mezzo-business applications, but also in areas such as microeconomics and macroeconomics and it is appropriate for the analysis of competitiveness. However, there are several issues associated with using this approach. One of the complications that the researcher can face when adopting panel data is the heterogeneity bias. In fact, ignoring the individual or time-specific effects that occur among cross-sectional or time-series units but are not captured by the included independent variables can make the parameter heterogeneous in the model specification.

**4.2 Unit Root Testing**

Panel unit root testing arose from time series unit root testing. The main distinction to time series testing of unit roots is that it is necessary to examine asymptotic behavior of the time-series dimension T and the cross-sectional dimension N. The manner in which N and T converge to infinity is crucial if we want to decide upon the asymptotic behavior of estimators and tests used for nonstationary panels. There are numerous options to control the asymptotics:

- Sequential limit theory which means that there is one dimension that is fixed and the other dimension is permitted to go to infinity and provides an intermediate limit.
- Diagonal path limits: N and T converge to infinity along a diagonal path.
- Joint limits meaning that N and T are permitted to move to infinity at the same time.

#### *4.2.1 Levin-Lin-Chu Test*

It is known that individual unit root tests have limited power. As a definition, the power of a test is the probability of rejecting the null when it is false and the null hypothesis is unit root. It happens that there are many unit roots. Levin-Lin-Chu Test (LLC) suggest the following hypotheses:

- H0: each time series comprises a unit root.
- H1: each time series is stationary where the lag order p is permitted to change across individuals.

These authors start by running run augmented Dickey-Fuller (ADF) for each cross-section on the equation:

$\Delta yit = \rho iyi,t-1 + \sum \theta i\ L\ \Delta yit-L + \alpha midmt + \varepsilon it$

And then they run two auxiliary regressions:

1. Δyit on Δyi,t−L and dmt to gain the residuals eˆit

2. yi,t−1 on Δyi,t−L and dmt to get residuals νˆi,t−1.

After that, they standardize the residuals and they run the pooled OLS regression.

The essential condition for the LLC test is $\sqrt{}$ NT /T → 0, while sufficient settings would be NT/T → 0 and NT /T → κ. (NT denotes that the cross-sectional dimension N is a monotonic function of time dimension T.) As stated by the authors, the statistic operates well when N is between 10 and 250 and when T is among 5 and 250 .Hence, the test is appropriate for most macro panels. If T is very small, the test is undersized and has low power. One drawback of the test statistic is that it depends chiefly on the notion of cross-sectional independence. Furthermore, the null hypothesis that all cross sections have a unit root is very restrictive. To be precise, it does not permit the 2 intermediate case, where some individuals are subject to a unit root and some are not. If T is very large, then Levin et al. (2002) propose individual unit root time-series tests. On the other hand, If N is very large or T very small, typical panel data procedures can be employed.

### *4.2.2 Im, Pesaran and Shin Test*

The Im-Pesaran-Shin (IPS) test is not as restricting as the Levin-Lin-Chu test, as it permits for heterogeneous coefficients. The null hypothesis is that all individuals follow a unit root procedure whereas the alternative hypothesis is about allowing some (but not all) of the individuals to have unit roots. Monto Carlo simulations expose that the small sample performance of the Im-Pesaran-Shin test is much suitable than Levin-Lin-Chu test. In fact, IPS requires $N/T \rightarrow 0$ for $N \rightarrow \infty$. If N is small or large relative to T, then both IPS and LLC display size distortions. Furthermore, the tests have little power in case deterministic terms are encompassed in the analysis.

### *4.2.3 Breitung's Test*

Breitung's test involves several steps. The first step is similar to the one in the Levin-Lin-Chu test, except that we do not comprise deterministic terms. Subsequently, forward orthogonalization transformation is applied to the residuals. As a final point, pooled regression is operated.

### *4.2.4 Fisher-type Test*

The Fisher-type test employs p-values from unit root tests for each cross-section i. It adopts the following equation: $P = -2 \sum \ln pi$. The test is asymptotically chi-square distributed with 2N degrees of freedom (Ti → ∞ for finite N). A major advantage is that the test can work with unbalanced panels. Besides, the lag lengths of the individual augmented Dickey-Fuller tests are permitted to differ. Nevertheless, a shortcoming of the test is that the p-values have to be gained through Monte Carlo simulations.

## 4.3 Fixed and Random Effects Models

In general, two techniques are adopted to analyze panel data: the fixed and random effects.

### *4.3.1 Fixed Effect Model*

The Fixed Effect model investigates the association between predictor and outcome variables within an entity. Each entity possesses its own individual characteristics that may or may not have an impact on the predictor variables. When adopting FE, we presume that something within the individual may influence or bias the outcome variables and we ought to control for this. This is the justification behind the assumption of the correlation between entity's error term and predictor variables. FE eliminate the effect of those time-invariant characteristics so we can evaluate the net effect of the predictors on the outcome variable. An additional significant assumption of the FE model is that those time-invariant characteristics are unique to the individual and ought not to be correlated withother individual characteristics. Each entity is not the same so the entity's error term and the constant which depicts individual characteristics should not be correlated with the others. Fixed-effects will not work well with data for which within-cluster variation is marginal or for slow changing variables over time.

The equation for the fixed effects model is:

$Yit= \beta 1Xit+ \alpha i+ uit$ [equation.4]

Where: $\alpha i$ ($i=1….n$) denotes the unknown intercept for each entity, Yitis the dependent variable where i= entity and t= time, Xit exemplifies the independent or explanatory variable, $\beta 1$ is the coefficient for that independent variable and uit is the error term.

### *4.3.2 Random Effect Model*

The underlying principle behind random effects model is that, unlike the fixed effects model, the discrepancy across entities is presumed to be random and uncorrelated with the predictor or independent variables incorporated in the model. In other words, and according to Green (2008), the central difference between fixed and random effects is whether the unobserved individual effect represents elements that are associated with the regressors in the model, not whether these effects are stochastic or not. A benefit of random effects is that we could comprise time invariant variables. However, in the fixed effects model, these variables are absorbed by the intercept Random effects takes as an assumption that the entity's error term is not correlated with the predictors which permits time-invariant variables to play the part of explanatory variables. Moreover, RE permits to generalize the inferences beyond the sample employed in the model. The random effects model is:

$Yit= \beta Xit+ \alpha+ uit+ \varepsilon it$[equation.5]

whereuit is the between-entity error and $\varepsilon$itis the within-entity error.

## 4.4 Hausman Test

The fixed effects and random effects models both have possible benefits as well as drawbacks to contemplate when choosing an approach. The fixed effects model will give unbiased estimates of β, nonetheless, those estimates can be open to high sample-to-sample variability. On the other hand, the random effects model will, except in exceptional situations, present bias in estimates of β, but can significantly restrict the variance of those estimates—leading to approximations that are nearer, on average, to the accurate value in any specific sample. In this thesis, choosing between these two approaches is going to depend on the results of the Hausman Specification Test (1978). The Hausman test is intended to identify violation of the random effects modeling assumption that the explanatory variables are orthogonal to the unit effects. If there is no correlation between the explanatory variable(s) and the unit effects, then estimates of β in the fixed effects model (βˆFE) ought to be like to estimates of β in the random effects model (βˆ RE). The Hausman test statistic H is a measure of the dissimilarity between the two estimates:

$$H = (\hat{\beta} RE - \hat{\beta} FE)' [Var(\hat{\beta} FE) - Var(\hat{\beta} RE]-1 (\hat{\beta} RE - \hat{\beta} FE).$$

Under the null hypothesis of orthogonality, H is a distributed chi-square with degrees of freedom equivalent to the number of regressors in the model. A result that $p<0.05$ is taken as indication that, at conventional levels of significance, the two models are different enough to reject the null hypothesis, and hence to reject the random effects model in favor of the fixed effects model. Nonetheless, if $p>0.05$, then the random effect is accepted and the fixed effect is rejected.

## 4.5 Regression of the OCP on the Regional Economic Growth

### *4.5.1 Methodology*

The Solow Growth Model would be implemented to take the population as one variable in the case of China on its provincial level. The model is expressed according to the following equation:

$Yt$ = $AtKt\alpha Lt$[equation. 6]

Where $Yt$, $At$, $Kt$, and $Lt$ represent variables of output, technological progress, capital and labor in this equation. The model has been extensively acknowledged to divide L on both sides in order to use GDP per capita in the analysis. In this circumstance, population is taken as one variable, so the fundamental form of this equation is kept. The overall population growth would be used rather than the working labor force. Technological progress also signifies the total factor productivity (TFP) which is an endogenous factor of this model. Meanwhile, α and β denote the share of capital and labor in the total output correspondingly. In the conventional Solow Model, it is understood that the output is computed with constant returns to scale. In other words, α+β=1. In this thesis, though, it may not be suitable to utilize the constant return to scale. Adjusting equation (6) in the log form, we would get equation (7):

logYt = logAt+αlogKt +βlogLt[equation.7]

Subsequently, differentiating both sides with respect to time, we find the equation (8):

$dYt$/ $Y$ = $dAt$/ $A$ +$\alpha dKt$/ $K$ +$\beta dLt$/ [equation.8]

Where$dYt$ /$Y$,$t$/ $A$ ,$dKt$ /$K$ and $dLt$ /$L$ illustrate the growth of output, technology, capital and labor. To simplify the terms indicated above, $yt$, $at$, $kt$ and $lt$

are proposed to represent the growth of output, technology, capital and labor, so [equation.8] may well be manipulated as:

$yt = at + \alpha kt + \beta lt$ [equation. 9]

The TFP could be expressed as: $at = yt - \alpha kt - \beta lt$

In Solow Model, labor represents the number of labor force age. Contrariwise, in terms of growth rate, we just employ the total population growth to substitute the working labor in the regression. Concerning TFP, it will not be covered in this thesis due to the lack of time and the shortage of data that depicts technological progress and that goes back to 1954 on the provincial level.

#### *4.5.2 Data and Regression*

A panel data is going to be adopted on E-views 8 software in order to investigate the effect of one child policy on the Chinese regional economic growth. The dependent variable is the growth rate of regional gross domestic product and the independent explanatory variables include the population growth and the capital stock growth rate. The provincial data of GDP and population is collected from China Compendium of Statistics 1949-2008 compiled by the National Economy General Statistics Division of National Bureau of Statistics (2010). Regional GDP values are in current prices and in 100 million Yuan and are deflated using GDP deflators calculated by Professor Yanrui Wu where the base year is 1953. These data span the period 1954 until 2004 and cover 28 provinces: Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang . Three provinces Chongqing, Hainan and Tibet are excluded from the analysis due to lack of data regarding the regional gross domestic product prior to the year 1979 for Chongqing and Hainan and the incompleteness of population records for the Tibet province. Hence, 28 cross sections are included in the empirical analysis.

Regarding capital stock, it is important to highlight the fact that amassing statistic series of physical capital stock is a crucial part for an estimation of aggregate production function and for exercising growth accounting. Prevailing literature, nevertheless, displays a pronounced variation on the approximation of capital stocks in China in terms of methods and data sources. It is not until later 1990s that estimations of China's provincial capital stock series and data that covers not only the post-reform era but also the pre-reform period start to emerge. In this thesis, data of capital stock are gathered from Professor Yanrui Wu's own estimates. He evaluates capital stock values using the conventional perpetual inventory method. In point of fact, the value of capital stock is appraised using gross investment or capital formation data in each year. The estimation technique can be given as $K_{i,t}=(1-\delta)K_{i,t-1}+\Delta K_{i,t}$ where $K_{i,t}$ denotes the real value of capital stock for the $i$th region in the $t$th year, $\Delta K_i$ is the real value of incremental capital stock or gross capital formation and $\delta$ is the rate of depreciation. The key difference in my thesis from previous papers that investigate the effect of capital stock on the economic growth is regarding the notation of depreciation. Some research papers did not include depreciation rate at all when computing the impact of capital stock on the GDP as the case of Qilei Fang and Chee Kian Leong and others have resorted to numerous sources such as national accounts, accounting interpretations at the firm level, findings in the prevailing literature and ad hoc assumptions. Accordingly, different rates of depreciation have been used, stretching from 3.6 to 17.0%. In this thesis, Wu's depreciation rates of capital stock are taken into consideration as he removes the assumption of an identical depreciation rate across regions and sectors. These rates are computed by adopting a simulation process to generate different rates of depreciation across the provinces and this is deemed to be the first of such exercise in the literature. The final capital stock data are expressed in Billion Yuan and in 1953 constant prices. The regression function carried out here is as follows:

$$GDP_{it} = \beta 1 POP_{it} + \beta 2 K_{it} + \beta 3 D1 + \alpha i + \mu it$$

Where $GDP_{it}$ stands for the annual growth of GDP of province i in the time series t, $POP_{it}$ represents the annual growth of population of province i in the time series t and Kitthe annual growth of capital stock. D1 is the dummy variable representing the one child policy and it is equivalent to 0 prior to the year 1979 when the OCP was implemented and 1 in 1979 and afterwards. The variable $\alpha i$ establishes the individual effect in different provinces i in which the fixed effect and random effect differs. In fixed effect the $\alpha i$ is assumed to be fixed for each province i no matter what the independent variables are, whereas in random effect it is assumed to be random signifying that the correlation between $\alpha i$ and the variables of $POP_{it}$ and $K_{it}$ is zero. Table4.1 that defines the variables and presents their statistics is shown in the Appendix.

Table 4.2: Variables' average regional growth rates (1954-2004)

| All Years(1954-2004) | | OCP | |
|---|---|---|---|
| | | Pre (1954-1978) | Post (1979-2004) |
| GDP | 7.75 | 5.55 | 9.78 |
| POP | 1.723 | 2.26 | 1.22 |
| K | 9.498 | 8.7 | 10.22 |

Table 4.2 recapitulates the growth rates of China from 1954 to 2004 when the regional GDP growth was 7.75%, population growth was 1.723% and capital stock growth rate was 9.498%. Independently, calculations of the data of both pre and post one child policy were advanced. GDP grew at a faster level at 9.78% after the OCP compared with 5.55 % in the previous period. The population, though, slowed down to 1.22% after the one child policy which was 2.26% before. On the other hand, the capital stock increased to 10.22 % in the post-period while it was 8.7% during 1954-1978.

### *4.5.3 Empirical Results*

Before putting into application the above-mentioned regression, it is important to ensure that all the variables are stationary or, in other words, integrated of order 0: I(0). Table 4.3 in Appendix represents the unit root testing for the dependent and independent variable. As observed in the table, all the variables are stationary as the probability values are equal to zero at the intercept level for all the tests. After completing this step, we can regress the growth rate of the regional GDP on both the population and the capital stock growth rate.

Table 4.4: Regression Results of the Effect of OCP on the Provincial Chinese Growth

Dependent Variable: dlgrp

| Regressor | Full Period: 1955-2004 | | Before Period: 1955-1978 | | Post Period: 1979-2004 | |
|---|---|---|---|---|---|---|
| | Fixed Effect | Random Effect | Fixed Effect | Random Effect | Fixed Effect | Random Effect |
| dlppln | 0.059107** (0.028249) [0.0366] | 0.06194** (0.028218) [0.0331] | 0.968316*** (0.162219) [0.0000] | 0.962354*** (0.158335) [0.0000] | 0.002889 (0.012268) [0.8139] | 0.003458 (0.012260) [0.7780] |
| dlk | 0.714776*** (0.048572) [0.0000] | 0.677955*** (0.046226) [0.0000] | 0.679251*** (0.072365) [0.0000] | 0.649246*** (0.069867) [0.0000] | 0.485350*** (0.055615) [0.0000] | 0.514671*** (0.045553) [0.0000] |
| D1 | 0.032065*** (0.005142) [0.0000] | 0.032636*** (0.005137) [0.0000] | | | | |
| Constant α | -0.008065 (0.005616) [0.1512] | -0.004883 (0.005465) [0.3718] | -0.025550*** (0.008319) [0.0022] | 0.022802*** (0.008196) [0.0056] | 0.048155*** (0.005883) [0.0000] | 0.045149*** (0.004894) [0.0000] |
| Observations nbr | 1400 | 1400 | 672 | 672 | 728 | 728 |
| Overall R2 | 0.1797 | 0.174456 | 0.193893 | 0.182672 | 0.178008 | 0.150350 |
| Hausman Test probability | 0.1061 | | 0.1516 | | 0.3690 | |

Note: The values in parentheses are the standard errors of the corresponding t-statistics and those in brackets are the p-values. Individual coefficients are statistically significant at the *10%level, **5%level or ***1%level.

From the results of provincial panel data regression, some findings from regional data sets are determined. Firstly, the coefficient of population growth is positive in the first period (1955-1978) and it is significant at the 5% level as the p-value approaches 0.03 for both the fixed and random approaches. It shows that the impact of population growth on GDP growth is positive. Though, this coefficient turned out to be insignificant in the second period but retains its positive effect on regional GDP growth. In other words, higher population growth actually contributes more to the GDP growth , but, by looking at this number, it is clear that it decreases from about 6% in the period that precedes the OCP to about 0.3% (closer to zero) in the period post-OCP. So, this reflects the significance of one child policy, which shifts the population growth from high rate to a relative small rate that approaches zero. Furthermore, in the full time period, the one child policy given as the dummy variable $D1$ is also positive, valid and significant at the 1%level: for instance, using the random approach, the adoption of the OCP has increased the regional GDP by about 3.3%. Hereafter, from the provincial level, the correlation between one child policy and GDP growth is positive. Moreover, Hausman test in the last part of the table adapted by Hausman (1978) is utilized for choosing between the fixed effect and random effect approach. In these provincial data sets, the result of this test is to reject the null hypothesis that the fixed effect method is consistent with random effect: in all the three periods, the p-value of the Hausman test was larger than 0.05. This means that the random effect method is more appropriate for this case.

To the extent that there is a classical measurement error2 as the population growth is used as a proxy for the labor force growth, this will attenuate the effects. In other words, since the OCP has proven to be significant on the regional level, its effect on the regional GDP could be larger.

## 4.6 Regression of the Impact of Old Age Dependency Ratio on the Per-Capita Regional Household Saving Rate

### *4.6.1 Methodology*

According to Yanjin, Hao and Shujin who build their model on Loayza et al (2000), linked with model selection of Horioka and Wan (2007) and Levin Star (2008),

[2]The standard classical measurement error (CME) model assumes that the measurement error is independent of the true value.Assuming that the measurement error has mean 0, this implies E [ε/X*] =0. Since by definition $\varepsilon_{CME}$= ε- E [ε/X*], it follows that, for this model to be correct, it must be that ε =$\varepsilon_{CME}$.

a simple econometric model, which does not depend on a specific theory, while not reliant on a specific environment is chosen.

Considering the development of China's financial market is not perfect, a measure of the degree of development of the financial market indicators fails to agree, and we cannot get the provincial urban data considered in the regression. The impact of the inflation rate is reflected by the introduction of the effective interest rate. Selected explanatory variables are as follows:

LNGRP = Regional GDP per capita logarithmic in Yuan.

YOUNG = Youths' population dependency ratio, that is the ratio of population under 14 years old to the total number of people aged 15-64.

OLD = elderly population dependency ratio, that is the ratio of population over 65 years old to the total number of people aged 15-64.

LEXP= life expectancy age.

Int = the real interest rate, that is the difference between the nominal interest rate and the inflation rate; determining the impact of the financial variables is an imperative feature to affect consumers' intertemporal choice.

LNSAV: The per capita household saving rate in logarithmic terms which is the difference between the per capita disposable income in urban regions or the net income in rural areas and the per capita household expenditure. Then, the resulted value is divided by the mentioned per capita income to get the saving rate in percentage unit.

### *4.6.2 Data and Regression*

The looked-for estimating model is the following:

$$lnSAV_{it}=\beta_0 +\beta_1 \, lnGDP_{it}+\beta_2 \, young_{it}+\beta_3 old_{it} +\beta_4 \, lexp_t+\beta_5 int_{it} +u_t$$

In order to acquire data of different type in the country's 31 provinces, the sample period 1997-2013 is selected. A panel data approach that includes 31 cross-sections is adopted. The pertinent data in figuring the per capita household savings rate, and figures in computing youths' population dependency ratio, and the elderly dependency ratio are all gathered from the 1998-2014China Statistical Yearbook. The absence of urban residents' disposable income data and urban residents consumption expenditure data of the Tibet's Region in 1997- 1998 are accomplished by the growth rate process. Owing to the fact that we can only acquire the life expectancy of the provincial data in 2000 and 2010 in the China Statistical Yearbook, I take use of the national average life expectancy statistics in the World Bank WDI database for all the other years. Regional GDP per capita data are collected from "China Statistical Yearbook" in its different editions and are deflated using the GDP deflator acquired from the same source. The real interest rate is calculated by getting the difference between the one-year deposit interest rate of each year, and the rate of inflation that are both taken from the World Bank WDI database. Tables 4.5 and 4.6 in the Appendix describe the variable definitions and statistics and the unit root testing respectively.

### *4.6.3 Empirical Results*

The per capita saving rate of the households in the Chinese Regions exhibit stationarity in three out of the five tests, but when this value is taken in log value, it is found that LSAV variable that stands for log of saving rate is stationary for all the tests. The OLD and YOUNG variables are stationary as the p-value is much less than 0.05. Moreover, LEXP and Int variables are stationary in the PP- Fisher Chi-square test whereas GRP is not stationary except when taking as logGRP as the p-value is largely less than 0.05 except for the Breitung t-stat test. Hence, the logarithm of GRP is considered in the regression.

Table 4.7: Regression Results of the Effect of the Old Age Dependency Ratio on the Per-Capita Regional Household Saving Rate.

Dependent Variable: lsav

| Variable | Fixed Effect | Random Effect |
|---|---|---|
| lgrp | 0.242671***<br>[7.628208]<br>(0.0000) | 0.226125****<br>[7.586711]<br>(0.0000) |
| young | 0.001850**<br>[1.734921]<br>(0.00834) | 0.002009**<br>[1.994055]<br>(0.0467) |
| old | -0.005723<br>[-1.437979]<br>(0.1511) | -0.005998<br>[-1.599774]<br>(0.1103) |
| int | 0.003626<br>[0.702736]<br>(0.4826) | 0.003208<br>([0.624526]<br>0.5326) |
| lexp | 0.008198<br>[0.633386]<br>(0.5268) | 0.003659<br>[0.292536]<br>(0.77) |
| c | 1.476677*<br>[1.876626]<br>(0.0612) | 1.297332*<br>[1.676034]<br>(0.0943) |
| Overall R2 | 0.378272 | 0.178817 |
| No. of observations | 527 | 527 |
| Hausman Test Probability | 0.2421 | |

Note: The values in parentheses are the p-values. Those in the brackets are the t-statistics. Individual coefficients are statistically significant at the *10%level, **5%level or ***1%level.

The results in Table 4.7 are estimated by using regression of fixed and random effects model. Since the Hausman test probability is tantamount to 0.24 which is larger than 0.05, random effects model is favored to investigate the results.

The results display that the elderly dependency ratio coefficient is negatively correlated with the saving rate which is expected: a 1 unit increase in the old age dependency ratio will decrease the per capita household saving rate by about 0.6%, and this is in accordance with expectations judgment, but it is not significant. Life expectancy coefficient is positively correlated with the dependent variable but it is insignificant. It can be seen from the coefficients, both are not influential in clarifying the household savings rate. In other words, ageing doesn't have a noteworthy impact on the Chinese household's per capita savings rate. The logarithm of the per capita income coefficient is significantly positive, which is in accordance with expectations, and the elasticity coefficient is the biggest, so it is a chief determinant of China's household savings rate changes. Simultaneously, it is clearly observable that the child dependency ratio coefficient is significantly positive. Taking into account the Chinese current situation that minor are given less social welfare, and education and health care costs are mostly borne by the family, besides the minor population burden rate will significantly lessen the consumption needs of the residents (Fang Fuqian, 2009), this result is satisfactory. These results regarding old and young dependency ratio reflect what has been mentioned in the literature by Li et al who found that the youth dependency ratio has a small positive impact on the Chinese provincial savings whereas old age dependency seems to have nonsignificant impact on the both consumption and savings. The results contradict those given by C.D Zheng in his paper entitled "An Empirical Study of the Relationship between Population Structure and Savings Ratio in Different Regions" who finds just the opposite. The coefficient of the real interest rate is not significant, on the one hand, it's because that the rise in interest rates itself has influence on savings in two aspects, substitution effect makes savings increase and the income effect makes the savings decline (Elmendorf, 1996; Wang Wei, 2008); alternatively, China has been in a condition where interest rates were under control in the past, then non-equilibrium interest rates generated by the non-equilibrium market failed to give full play to its function in the management of the supply and demand of funds, so that the relationship between the interest rate and the savings rate is not significant. But it can be anticipated that with the hastening process of China's marketization of interest rates, the influence of interest rates on savings rate will progressively appear.

# CHAPTER 5

# CONCLUSION

The importance of population growth to the economic growth in the case of China on its provincial level is investigated. Furthermore, a pertinent policy, the one child policy implemented in 1979, which had influenced China's demographic growth pattern, was treated as a dummy variable in the panel regression analysis that is based on the simple Solow model. The provincial data from 1954 till 2004 was analyzed with separate periods before the OCP policy and after the policy in order to compare the impact of population growth on the regional GDP. The results shows the insignificant impact of population growth to the GDP growth since the policy was implemented while the correlation is positive and significant in the before period. Over the whole period, the dummy variable is viewed as positive and significant which means that the OCP affects positively the regional economic growth. The One Child Policy plays a major role in increasing the regional GDP of China. From the Hausman test, the random effect is more suitable for the panel data meaning the individual effect of different provinces is not fixed. This means that the situation of each province including the endowments, industrial structure and so on is randomly distributed.

Moreover, another regression is employed to study the effect of old age dependency ratio on the per capita regional household saving rate. This is taken into consideration because the Chinese government decided on November 15, 2013 to relax its OCP following implicit fears of increasing in the old age dependency ratio and concerns that by 2050, more than a quarter of the population is expected to be over 65 in addition to other factors like imbalance sex ratio, a shrinking labor force that materialized for the first time on the national level in 2012 where the working force aged from 15 to 59, decreased by 3.45 million from the previous year to 937.27 million and the 4-2-1 problem which means that every one child will have to care for his parents and his four grandparents as well and this could put an enormous financial pressure on the primary breadwinners and could lead to a further slowdown in an already sluggish economy. Then, in late October 2015, the government takes a historical decision by allowing all couples to have two children. So, in this paper, the elderly dependency ratio is going to be examined as an implied reason behind the loosening of the policy. This additional regression tends to explain whether the elderly dependency ratio plays a chief role in affecting one of the channels that affects the economic growth which is the saving rate of the households.

The conclusion derived from the empirical results suggests that old age dependency ratio has a negative effect on the saving rate but is not a significant factor. Hence, on the regional level, it was not the factor that pushes down significantly the saving rate of the household, and by consequence, lowering the investments and the regional GDP. Other factors – not investigated in this paper- must play an important role in influencing the channels that affect GDP and consequently changing the government's decision about the OCP. Furthermore, what the results denote is that GDP per capita plays a major role in affecting positively the dependent variable and the young dependency ratio presents a positive coefficient that is significant at the 5% level. Relaxing the OCP is a foreseeable step as mentioned by Professor Hyun Bang Shin from the London School of Economics who said that the end of the policy was expected and is "simply an endorsement of many changes and relaxation of policies in recent years." He adds that China is an ageing country with a long life expectancy. So, the younger generation will be burdened with the care of the elderly.

The problem of ageing in China is a crucial one even if the results on the regional level reflect the insignificant impact of the old age dependency ratio on the per capita household saving rate. China is closer to Japan in the model of aging compared to the European countries such as Britain and France that represent the Western European model. This is based on the fact that China shares with Japan the following features: a fast aging speed and an apparent trend of aging population and imbalance in regions, between rural and urban (Wang Wei, 2007). Since China has similar characteristics and processes of population's ageing to Japan and has also gone through a phase of rapid growth and a structural adjustment period, the Chinese government ought to learn from Japan's experience in economic growth to deal with the aging population. However, China should be aware of the costs that could fall on it if the government decides to increase the spending on the elderly as the case of Japan especially regarding the increase in debt in order to finance the retirees.

# APPENDIX

| Variable | definition | unit | average | Standard deviation | minimum | maximum |
|---|---|---|---|---|---|---|
| GDP | Regional GDP growth rate | % | 7.75 | 10.37 | -84.55 | 57.57 |
| PPLN | Population growth rate | % | 1.723 | 9.01 | -229 | 231 |
| K | Capital stock growth rate | % | 9.498 | 5.546 | -8.5 | 40.1 |

Table 4.1: Variables definitions and Statistics of the regression of the OCP on the regional economic growth

| variable | Levin, Lin & Chu t* | Breitung t-stat | Im, Pesaran and Shin W-stat | ADF - Fisher Chi-square | PP - Fisher Chi-square |
|---|---|---|---|---|---|
| Intercept | | | | | |
| Growth rate of regional GDP: dlgrp | -23.7630*** (0.0000) | -19.4551*** (0.0000) | -20.6408*** (0.0000) | 454.176*** (0.0000) | 979.048*** (0.0000) |
| Growth rate of capital stock: dlk | -14.6869*** (0.0000) | -9.57222*** (0.0000) | -12.1472*** (0.0000) | 247.780*** (0.0000) | 130.250*** (0.0000) |
| Growth rate of population: dlppln | -15.5585*** (0.0000) | -15.4307*** (0.0000) | -15.8329*** (0.0000) | 341.082*** (0.0000) | 817.662*** (0.0000) |

Table 4.3: Unit root testing of the variables in the regression of the OCP on the regional economic growth

Note: The null for both the Levin, Lin & Chu t* and Breitung t-stat tests is the presence of a unit root where we assume a common unit root process whereas for the Im, Pesaran and Shin W-stat , ADF and PP Fisher Chi-square the assumption is for individual unit root process. The values in the parentheses are for the p-value.

| Variable | definition | unit | average | Standard deviation | minimum | maximum |
|---|---|---|---|---|---|---|
| grp | The per capita gross regional product | yuan | 18277.15 | 16253.68 | 2017.484 | 88539.56 |
| sav | The per capita household saving rate | % | 24.63 | 6.017 | 0.16 | 40.58 |
| old | Old age dependency rate | % | 13.08 | 7.96 | 2.33 | 104.07 |
| young | Young age dependency rate | % | 34.81 | 27.46 | 9.64 | 204.07 |
| lexp | Life expectancy | years | 73.56 | 1.78 | 64.37 | 80.25 |
| int | Real interest rate | % | -0.501 | 3.12 | -5.55 | 4.695 |

Table 4.5: Variables definitions and Statistics of the regression of the old age dependency ratio on the regional per-capita household saving rate

| | Levin, Lin & Chu t* | Breitung t-stat | Im, Pesaran and Shin W-stat | ADF - Fisher Chi-square | PP - Fisher Chi-square |
|---|---|---|---|---|---|
| Constant & Linear Trend | | | | | |
| Sav | -4.26385*** (0.0000) | - 3.08596*** (0.0010) | -1.24582 (0.1064) | 67.5697 (0.2927) | 162.329*** (0.0000) |
| GRP | 1.14855 (0.8746) | 11.5194 (1.0000) | 10.1856 (1.0000) | 9.83637 (1.0000) | 29.8502 (0.9998) |
| Old | -10.3239*** (0.0000) | - 7.34130*** (0.0000) | -4.79540*** (0.0000) | 114.195*** (0.0001) | 293.750*** (0.0000) |
| young | -10.8528*** (0.0000) | - 6.37154*** (0.0000) | -4.81515*** (0.0000) | 114.277*** (0.0001) | 278.185*** (0.0000) |
| lexp | -4.20242*** (0.0000) | - 2.54132*** (0.0055) | 0.81539 (0.7926) | 53.1673 (0.7804) | 150.119*** (0.0000) |
| int | -5.56347*** (0.0000) | -0.14393 (0.4428) | -1.05881 (0.1448) | 59.4638 (0.5678) | 83.8911** (0.0335) |
| Constant & Linear Trend | | | | | |
| lgrp | -7.1688*** (0.0000) | 3.81663 (0.9999) | -2.22519** (0.0130) | 79.5374* (0.0661) | 129.852*** (0.0000) |
| lsav | -5.19974*** (0.0000) | - 5,17053*** (0.0000) | -2.38153*** (0.0086) | 81.6452** (0.0480) | 199.842*** (0.0000) |

Table 4.6: Unit root testing of the variables in the regression of the old age dependency ratio on the regional per-capita household saving rate

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