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Demographic Changes, Household Savings and Economic Growth in All China: A Time-Series Approach

Presented by:

Ya Xu

E-mail: yaya_jessilin@hotmail.com

Thesis supervisor:

Tommy Bengtsson

Kerstin Enflo

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ABSTRACT

This paper investigates the effects of population age structure and economic growth on the household saving rate in China and examines whether life cycle hypothesis (LCH) holds in the country like China, where LCH may be less applicable. By applying two popular time series econometric techniques (cointegration technique and vector error correction model), the author examines the long-run convergence between household saving rate, age structure of population and GDP growth in all China from 1963 to 2006. The empirical findings can be summarized as follows. Firstly, there exists a long-run steady-state relationship between them. Secondly, both the youth dependency ratio and old dependency ratio have a negative and significant impact on the household saving rate, while the GDP growth rate have a positive effect on the household saving rate. Therefore, the results support the life cycle hypothesis (LCH). Thirdly, with regards to the vector error correction model (VECM), the estimation results show that all variables expect youth dependency ratio (YDR) will not have a significant adjustment to a new equilibrium if there is a disturbance occurred in the whole system.

Key Words: Life-Cycle Hypothesis, Household savings rate, Dependency ratios, Economic growth, Cointegration test, Vector Error Correction Model (VECM).

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1 Introduction

Along with the persistent economic growth, China has also experienced a long-run surge in household saving rate. The household saving rate (see figure 4), which is calculated by Chunrong and Wei (2008) is the ratio of household savings to disposable income of households. Since the past four decades, the household saving rate went up from below 10 percent to exceeding 35 percent. The high household saving rate in China has attracted more scholars' attentions. What are the causes of high household saving rate in China? A growing number of the literatures have focused on understanding this phenomenon. They analyzed different factors stimulating China's high household savings. For example, a widely adopted perspective is that China's high saving rate is attributed to the precaution motive due to the lack of sound social security and pension system, high housing price, unaffordable rise in educational expenditure and uncertainty about future incomes. Young households increase their savings to finance education expenditures of their children and increasingly high housing price, while old households save more for the uncertain health and retirement expenditures. Others believe that the financial market in China has not developed well, and thus a considerable degree of uncertainty is involved in financial markets. Chinese households are lack of diversified investment opportunities and at the same time they do not want to take a risk on investing in the financial market and hence save more money. Another motive is based on "distortions theory" which asserts that high interest rates, an undervalued currency, and other market distortions bring about the redistribution of income from consumption-oriented households to saving-fixated enterprises (Bonham and Wiemer, 2012).

This paper researches the behavior of Chinese household saving ratio from demographic aspect, and is mainly concerned with whether demographic shifts and economic development measured by GDP per capital income (at natural log scale) play the predominant role in driving long-run trend in household saving rate. The author examines this topic within the framework of the life cycle hypothesis. Based on the life cycle hypothesis proposed by Modigliani's (1970), the individuals smooth their consumption over time. They save when they are young and their incomes are high, and dissave when they are old and their incomes are low. In other words, household savings are highest during their working years, but when

their incomes fall during the retirement years, households draw from their previous savings to maintain retirement livings. This hypothesis can also be expanded to include the minors' burden on savings: at the early stage of the household formations, the children act as a drain on savings since the working age adults need to support the living of their young dependents by sacrificing their savings. Nevertheless, during the empty nest stage, the working age adults can accumulate more savings to maintain the normal living standards after retirement (Wilson, 2000). Accordingly, life cycle theory is considered to be a natural starting place, because it implies that change in demographic pattern can exert a potentially large effect on savings, or in other word, saving rate can be influenced by the shift of differences in the age structure of the population.

As China experiences high household saving ratio, the dependency rate of children has declined and the relative size of the pre-retirement working population has increased, and meanwhile achievements of Chinese economic growth are also very remarkable. How are these occurrences linked? In a recent paper, Horioka (1997) and Thornton (2001) examined the linkages about population structure and household saving rate in Japan and United States, respectively. Both of their findings support the life-cycle hypothesis. Inspired by their researches, it is worth to visiting this issue in China, which life-cycle hypothesis may be less applicable due to culture and social factors, ect. Besides, until now there is no robust consensus on the relationship between demographic structure, household saving rate and economic growth in China, which is evident in the literature rEViews part.

This essay adopts two popular time-series econometric techniques: cointegration test and vector error correction model (VECM) to Chinese annual data for the period 1963-2006. In the late of 1970s, China launched two crucial policies, that is, economic reform and opening-up policy and one-child policy. To capture these effects, a shift dummy variable is included in the cointegration estimations. And the following questions are studied:

- 1) Identify if the demographic structure, household saving rate and economic growth have any long-run relationships;
- 2) Investigate whether the drastic demographic change or the rapid economic growth that China has experienced during this period were responsible for the change in the household saving rate. Do demographic structure and economic growth have a positive or negative effect on the household saving rate?

- 3) Measure the dynamic adjustments between the first differences of the variables by using vector error correction model (VECM).

Unlike Horioka (1997) and Thornton (2001) which only examined the linkages about age structure and household saving rate, this paper also takes into account of the effect of economic growth on the household saving rate. The second contribution of this paper is that the shift dummy variable is included in the cointegration test and vector error correction model, which is able to capture the effects of policies which implemented in 1979.

The main findings of this paper are below: (1) there is a long-run dynamic relationship between age structure, household saving rate and economic growth. (2) The increase in China's household saving rate can be largely explained by the combination of a declining dependent share in the population and high rate of GDP growth. (3) Both the old dependency ratio and the youth dependency ratio have a negative effect on the household saving rate in China, which is in line with the simple life cycle hypothesis developed by Modigliani (1970). But the change of the old dependency ratio makes more influence on the household saving rate than the change of the youth dependency ratio. (4) The economic growth has a positive and significant effect on the household saving rate. (5) The estimation results of vector error correction model (VECM) indicate that all variables except youth dependency ratio (YDR) do not have significant conservative force tending to bring the model back into equilibrium whenever it moves too far.

The remainder paper is organized as follows. Section 2 provides an overview of Chinese birth control campaigns, and summarizes demographic changes, household savings and economic growth in China. Section 3 briefly reviews the Life Cycle Hypothesis model and related literatures. The data selection and methodology are described in section 4. Section 5 presents and interprets the estimation results. Concluding remarks and discussion follow in Section 6.

2 Demographic Changes, Household Saving and Economic Growth in China

2.1 An Overview of China's Birth Control Campaigns

Since the founding of the People's Republic of China in 1949, there have been four birth planning campaigns¹.

- The First Campaign, 1956-1958
- The Second Campaign, 1962-1966
- The Wan Xi Shao (Later, Longer, Fewer) Campaign, 1971-1979
- The One-Child Campaign, 1979-present.

Soon after the establishment of the communist regime in 1949, the society was very peaceful and stable, the economy was gradually recovering and the living standards, medical and health care were improving. The death rate was reduced markedly, while birth rate increased very quickly, thus the situation then was characterized by more births, fewer deaths and high growth. However, it should be noted that at that time the total population was only 547.1 million, which is much less than one-half of current population size. Government officials did not realize the importance to control population size. They viewed a large population as an asset. The government officials even thought if they told the people to reduce their fertility, a stable population size could quickly be attained (Banister, 1987). As the problem of a large, rapidly growing population becoming apparent, leaders realized that the population control should be a long-term campaign. Starting in August 1956, vigorous support was given to the Ministry of Public Health's mass birth control efforts (Banister, 1987). However, these efforts had little impact on reducing fertility rate. During the interval of the Great Leap Forward (1958-1961), the rapid population growth had attracted more attention again. But the Chinese Great Famine temporarily halted the national efforts of birth control. In 1964, the Family

¹ "Population and Birth Planning in the People's Republic of China." Population Report, Population Information Program, The Johns Hopkins University, Hampton House, 624 North Broadway, Baltimore, Maryland 21205, USA, 1982, J (25), January-February.

Planning Offices were set up in the central government and some provincial governments to take charge of matters relating to the family planning, which successfully controlled the birth rate of urban areas. But the national family planning programs were interrupted again during the Culture Revolution (1966-1976).

Unlike the first two campaigns which were less effective to control the birth rate, China launched a third family planning campaign in 1971 and the government officials issued the *Wan, Xi, Shao* policy to guide the new birth planning program. The Chinese government began to request unmarried people to marry and bear children later and called for married couples to prolong the spacing between births and to have fewer children (Zhang and Goza, 2006, Wang, 1996). The rules applied in the cities were much more rigorous than in the rural areas. Couples who were urban residents were encouraged to delay marriage until age 25 for women and 28 for men and to have no more than two children. The policy for those who lived in rural areas was more accommodating: The minimum age for marriage was set at 23 for women and 25 for men, and maximum family size was set at three children (Attane, 2002). After the economic stagnation of the Cultural Revolution, the Chinese government also embarked an economic reform and opening-up policy in the late 1970s. At that time, two thirds of the population were under the age of 30 years, and the baby boomers of the 1950s and 1960s were entering their reproductive years. The government thought the rapid population growth placed more stress on the economic well-being and improvement of living standards. So the one-child policy was introduced to both rural and urban areas. Although this policy is simply called one-child per couple, it is actually quite complicated and has some exemptions. The policy is very strictly enforced for the urban residents and those who work for the government, while for the rural residents, a second child is allowed if the first child is a girl due to the son preference culture. A third child is allowed among some ethnic minorities and in remote, underpopulated areas (Hesketh et al., 2005).

Nowadays, due to the profound influence of one-child policy, increasing numbers of couples will be solely responsible for the care of one child and four parents. This phenomenon is named by 4:2:1. To address this problem, though no fundamental policy has changed until now, some demographic scholars have already suggested government to consider a relaxation of the strict family planning policy in some provinces, that is, couples who are themselves both only children are allowed to have more than one child. However, the expenditures of

childbearing and childrearing are much more costly than before, and increasingly educational costs also contribute to a couple's decision to raise only one child. Probably even government will relax one child policy and encouraged couples who are only children can have two children, some of couples still choose to have only one child.

2.2 Demographic Changes in China

In terms of demographic transition, Ronald Lee (2003) has explained it in his own words: *“Before the start of the demographic transition, life was short, births were many, growth was slow and the population was young. During the transition, first mortality and then fertility declined, causing population growth rates, first to accelerate and then to slow again, moving toward low fertility, long life and an old population.”* Therefore, generally the stages of demographic can be classified as the different combinations of fertility and mortality and it can be divided into three stages: high fertility/high mortality; high fertility/low mortality; and low fertility/low mortality.

China has also experienced a dramatic demographic transition since the middle twentieth century. But the speed of demographic transition in China is the fastest in the world. Generally, it takes one century or one and half centuries to shift from a demographic transitional society into a post-transitional society. Nevertheless, China completed its demographic transition only within 40 years (Fang and Dewen, 2010). One element of demographic transition is the change of total fertility rate (TFR). To place Chinese total fertility rate under the international context, table 1 presents the international comparison of total fertility rate and shows that in 1950s and 1960s, the Chinese total fertility rate (TFR) is even higher than that of the whole world level. However, in 1970s, TFR went down dramatically from 5.5 in 1970 to 2.9 in 1978 by the reason that the Chinese government successfully called for “later marriage, longer birth intervals, and fewer births”, which is also known as *Wan, Xi, Shao* program. This program has effectively controlled for the overgrowth of Chinese population. Throughout the 1980s, the Chinese government put into operation of “One Child” policy, but TFR hover above the replacement level with ups and downs and it was around 2.6 per woman on average. In the year 1992, Chinese fertility level dropped to 2.1, which is also known as a replacement level. Since then, the total fertility rate declined further and it was 1.61 in the year 2009. Figure 1 (World Development Indicators, World Bank, 2012) depicts the trend of total fertility

rate in China between 1960 and 2009. It should be noted that the sharply declining of fertility rate actually occurred prior to one-child policy implemented in 1979. Thus we cannot attribute that one-child policy, is the key factor to drive the decline of Chinese fertility rate. Cai (2010) has demonstrated that social and economic development, such as economic development measured by GDP per capita, women educational level, changes in urbanization and migration, plays the decisive role in understanding the fertility variations in China. The other element of demographic transition is life expectancy. The life expectancy is only 43.46 in the year 1960. With the improvement of the living standards, health as well as medical conditions, the life expectancy is significantly prolonged in China. Figure 1 (World Development Indicators, World Bank, 2012) exhibits the trend of life expectancy in China from 1960 to 2009. Starting at 40 years soon after mid-century, life expectancy increased precipitously in the 1950s and 1960s, has now reached approximately 73 in the year 2009, and is expected to be nearly 80 by 2050.

Table 1: International Comparison of Total Fertility Rate (TFR)

Year	World	Developed Countries	Less Developed Countries	Underdeveloped Countries	Asia	China
1950-1955	5.02	2.84	6.17	6.64	5.89	6.22
1955-1960	4.96	2.82	6.02	6.67	5.64	5.59
1960-1965	4.97	2.69	6.03	6.72	5.64	5.72
1965-1970	4.91	2.37	6.02	6.71	5.69	6.06
1970-1975	4.49	2.12	5.44	6.61	5.08	4.86
1975-1980	3.92	1.91	4.65	6.44	4.18	3.32
1980-1985	3.58	1.85	4.15	6.33	3.67	2.55
1985-1990	3.38	1.83	3.84	6.05	3.40	2.46
1990-1995	3.04	1.68	3.41	5.75	2.96	1.92
1995-2000	2.79	1.55	3.10	5.35	2.67	1.78
2000-2005	2.65	1.56	2.90	5.02	2.47	1.70

Source: Fang, C. and Dewen, W. "Demographic Transition and Economic Growth in China", Institute of Population and Labor Economics, Chinese Academy of Social Sciences, Beijing, 2010.

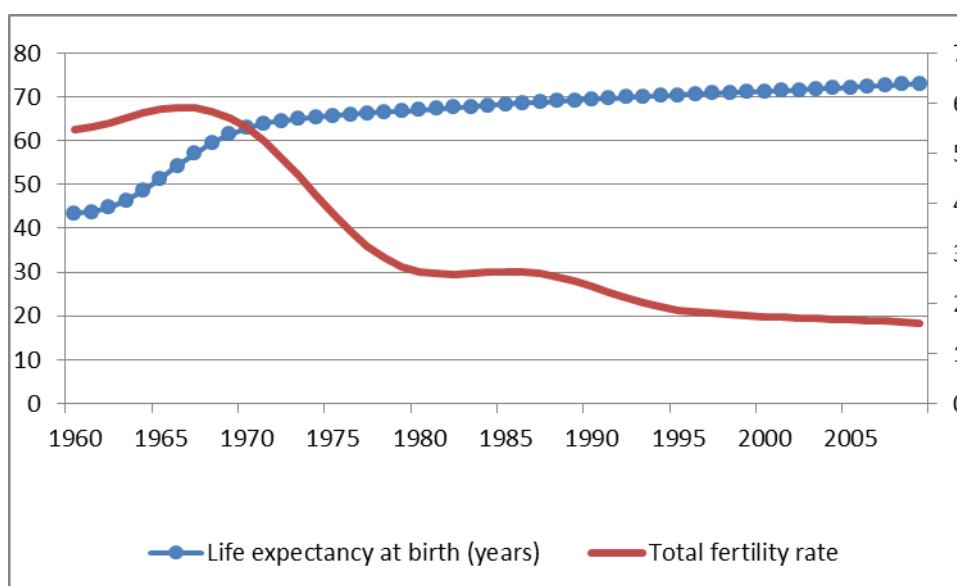


Figure 1: Life expectancy at birth and total fertility rate of China from 1960 to 2009.

Source: World Development Indicators (WDI), World Bank, 2012

More importantly, declined fertility rate and prolonged life expectancy induces the shift of demographic age structure. Figure 2 (World Development Indicators, World Bank, 2012) displays the share of the young (population ages 0-14), working age group (ages 15-64) and the old (ages 65 and above) in the total population from 1960 to 2009. The share of the young declined considerably from 39.61 percent in 1960 to 19.85 percent in 2009, which was mainly ascribed to the continuous decline in fertility rate. The share of the working age group has increased from 56.40 percent to 72.11 percent during 1960-2009. However, the most notable change is the old age group. The percentage of the population over the age of 65 increased from 4 percent in 1960 to 8.03 percent in 2009 but is expected to rise to more than 15 percent by 2025. It is anticipated that in the near future, the proportion of the old age group will continue to go up and China's society becomes aging due to the further declined fertility and prolonged life expectancy. Though these figures are lower than those in most developed countries, such as, Japan, where the proportion of people over the age of 65 is 20 percent, what makes the challenge even more daunting is that the age wave in China takes place before the economic develops well and the society can offer adequate pension system.

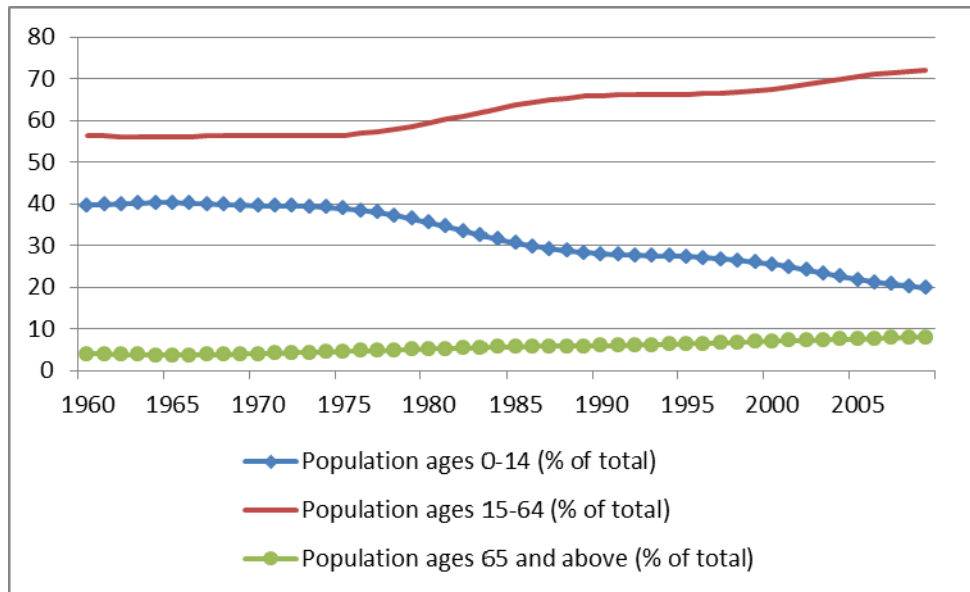


Figure 2: Changes of population age structure in China, 1960-2009.

Source: World Development Indicators (WDI), World Bank, 2012

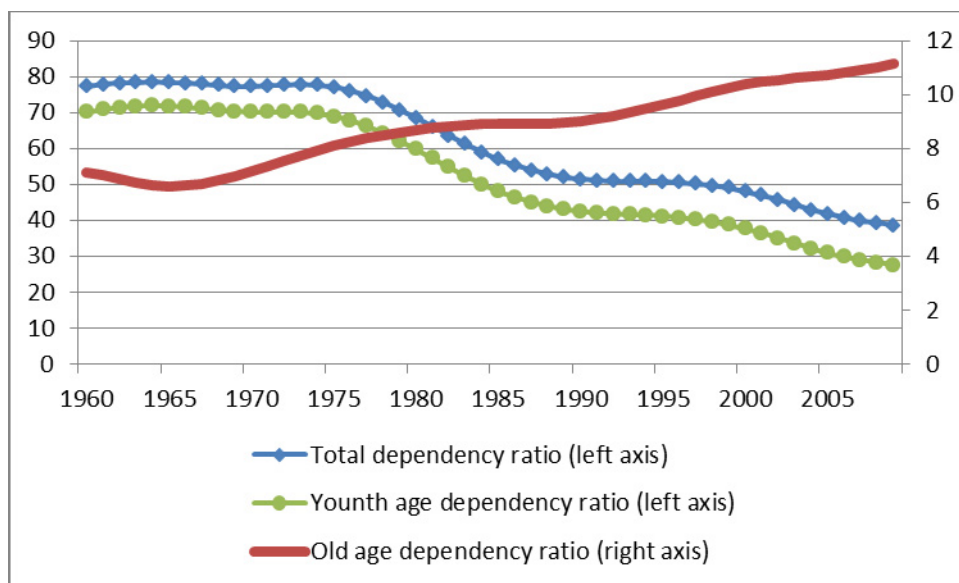


Figure 3: Dependency ratios of China, 1960-2009.

Source: World Development Indicators (WDI), World Bank, 2012.

All societies can be divided into dependents (people who are too young or too old to work, so they depend on their families or on pensions for support) and workers who generate economic activity and are generally defined as people ages 15 to 64. The ratio of dependents to the working-age population is called total dependency ratio. Generally speaking, the dependency ratios are of importance since they are taken as the indicators of population age structure. The

total dependency ratio is the sum of the youth and old dependency ratios. The key ratio for measuring the effect of aging is the older dependency ratio, which is the number of older age population (ages over 65) as a percentage of the number of working age population (age 15 to 64). The youth dependency ratio is the number of children (0-14 years old) relative to the number of working age population (15-64 years old). Now we turn to examine the changes of dependency ratios (figure 3) in China. As illustrated in Figure 3 (World Development Indicators, World Bank, 2012), the total dependency ratio fell from 73.33% to 38.67% during period 1960-2009. It is also evident that the declined total dependency ratio was mainly contributed by changes in the youth dependency ratio, which fell from 66.18 percent in 1960 to 27.53 percent in 2009. However, from the figure 3 (World Development Indicators, World Bank, 2012), we can also find that the elderly dependency ratio in China has gradually increased from 8.40 percent in 1960 to 11.13 in 2009. The reason is the share of old age population has risen more rapidly than the share of working age group.

The change of age distribution will have a profound influence on economic growth, savings, investment, consumption, labor markets, pension system and taxation. The reason is different age groups have different productive capabilities, consumption pattern, savings behavior and rate of labor force participation. The relatively low dependency ratios can contribute more of GDP growth. The low dependency ratio can make a country to devote more resources on education, technology development and physical capital. At the same time, the high proportion of working age population will increase the labor force supply of a society, and have high level of productivity and savings and consequently stimulating economic growth. In contrary, the increasing number and proportion of older persons and minors will result in shortage of labor forces, and as a consequence, diminish economic productivity. Besides, the high dependency ratio makes the society to spend more resource on taking care of the dependents, and place more financial burdens on the working-age group². For example, the elderly dependency ratio and youth dependency ratio in 1960 are 8.40 percent and 66.18 percent, respectively, it means that 100 working-age adults will support 8.40 people aged 65 and over and 66.18 people aged 0-14. As Cai and Wang (2010) pointing out, changes of population age structure have made China to gain the demographic dividend since the 1960s. They also indicated the empirical results that the Chinese demographic transition has

² The Habitable Planet Online Text Book, Chapter 5. From:
<http://www.learner.org/courses/envsci/unit/text.php?unit=5&secNum=7>

contributed to 15-25 percent of economic growth and 5-21 percent of saving rate since the Chinese government implemented the “reform and open-up” policy. At present, the burden of the working age population in China is relatively low, the labor supply and savings continuously increase. But, the artificially control of younger generation will eventually lead to fewer working age population to support more aging population in the near future. Horioka (2008) also holds the same conclusion that population momentum will produce a rapid aging of the Chinese population in the third and fourth decades of this century, which leads to the labor force participation and savings shrinkage, and thus depleted demographic dividend.

Although it widely accepted that the decline of fertility and population aging will slow the pace of economic well-being by its negative influence on the rate of labor force participation, a strong trade-off between fertility and human capital is highlighted by Mason and Lee (2011, P18), which implies that the declining fertility goes hand in hand with the increasing investment on human capita per worker with regards to education and health. Therefore it is not only the size of labor force participation that matters for the economic growth, but the quality of labor force is great of importance. The negative effect of the fertility decline and population aging will be mitigated in some extent by investing on children’s education and own health, which induces the enhancement of productivity and thus the aggregate effective labor supply. In another word, even though the quality of the workforces will be shrinkage as fertility declines, the technological process can still develop and economic growth is able to boost if the quantity of workers improve or if the human capital has a sufficiently strong effect on productivity. They also suggested that in the countries with very low fertility, such as Japan, Taiwan, Austria, South Korea, an increased human capital per child might mitigate or at least postpone the support problems for the elderly because of population aging (Mason and Lee, 2010).

2.3 Economic Growth and Household Savings in China

It is generally agreed that the Chinese economy growth since economic reform and opening up policy in 1979. Table 2 (World Development Indicators, World Bank, 2012) shows and compares annual GDP per capita growth in selected countries during 1960-2009. The Chinese annual GDP per capita growth rate increased from 0.25% in 1960-1964 to 10.64% in 2004-2009, one of the highest growth rates in the world. It should be noted that Chinese economy

still developed sound even during the Asian Financial Crisis during 1997-2000 and recent Subprime Financial Crisis.

Table 2: International Comparison of GDP per capita Growth (Annual %), 1960-2009

Year	China	Japan	United States	United Kingdom
1960-1964	0,25	7,93	3,49	2,39
1965-1969	4,58	9,10	2,31	2,08
1970-1974	3,57	3,14	1,77	1,94
1975-1979	5,18	3,51	2,66	1,74
1980-1984	9,27	2,42	2,33	2,11
1985-1989	6,27	4,33	2,24	3,08
1990-1994	10,95	1,10	1,22	1,39
1995-1999	7,61	0,75	3,16	3,90
2000-2004	9,06	1,16	1,47	2,42
2005-2009	10,64	0,24	-0,10	-0,12

Source: World Development Indicators (WDI), World Bank, 2012.

Along with the rapid economic growth in China, the household saving rate in China have also increased dramatically. Due to the unavailability of Chinese household saving rate, the author uses and reports the Chinese household saving rate calculated by Chun-rong and Wei (2008) without modification. Figure 4 (Chun-rong and Wei, 2008) displays the Chinese household saving rate from 1960-2006. The household saving rate was relatively low and trendless during the command economy era, averaging 3.6 percent. Since economic reforms in 1979, the household saving rate have been gradually increasing, which was 10% in 1979, and climbed to 30% in 1995. After then the household saving rate declined to 24.1% in 2000, and it rebounded to 36.1% in 2006. To some extent, the upward trend in the household saving rate is coinciding with both the decline in the dependency ratios that followed from a fall in the birth rate and the rapid increase in income growth that accompanied with reform and opening.

China's household saving rate have exhibited an upward trend until now is mainly by the reason that the decline in the youth dependency ratio has been more pronounced than the increase in the elderly dependency ratio (Horioka, 2008). Nevertheless, Horioka and Wang (2007) pointed out that since the increase in the proportion of older age population is more

pronounced than the decrease in the proportion of minors population after about 2010, Chinese household saving rate can be expected a downward trend after around 2010.

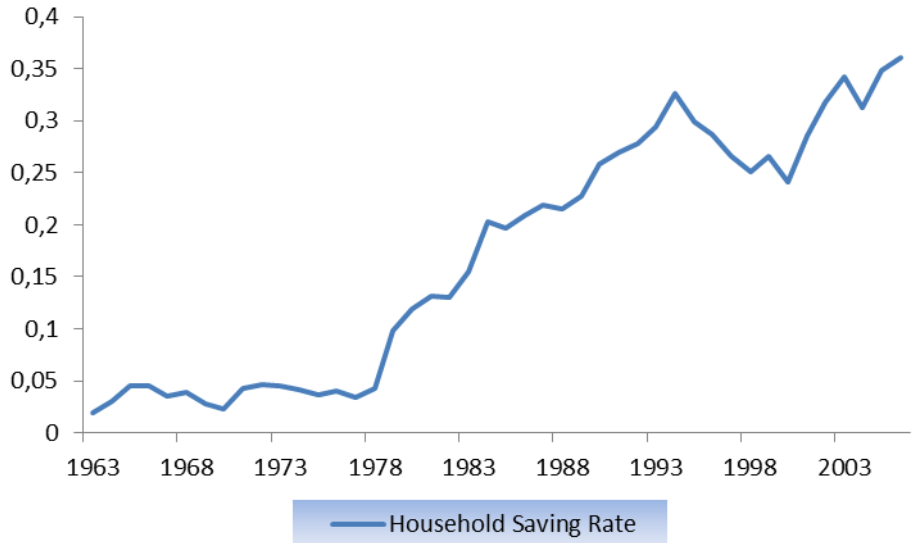


Figure 4: Household saving rate in China, 1963-2006.
Source: Chun-rong and Wei (2008).

3 Literature Review

Life cycle hypothesis proposed by Modigliani (1970) provides us a good theoretical framework to examine the interactions between population structure, savings and growth. According to this hypothesis, the individuals work and save when they are young and they retire and dissave when they are old. Therefore, it implies that the savings rises with a higher percentage of the working population, and falls with a higher percentage of the minor and aging population (hereafter referred to as the youth dependency ratio and elderly dependency ratio). Assume that individuals begin working at D years old, working for W years and retired for R number of years, and die at age L . And we also assume that consumption and growth are independent of age and there is no productivity growth, that there are no bequests or other intergeneration transfers, and that the interest rate is zero. Using a simplified version of Modigliani's (1970) model, the aggregate saving rate SR can be shown as follows (Thornton, 2001):

$$SR = \frac{(D + R)}{L} - \left(\frac{W}{L}\right) * DEP - \left(\frac{W}{L}\right) * AGE$$

where DEP is the ratio of minors to working population and AGE is the ratio of retired population to working population.

The above equation indicates that the saving ratio is a decreasing function of DEP and AGE , and the coefficients of DEP and AGE are the negative of the ratio of the working life to life span. In a word, according to Modigliani's (1970) life cycle theory, demographic structure can be regarded as an underlying factor in determining saving rate. Besides, there is a negative relationship between aging and savings in the economy.

A related implication of life cycle hypothesis is about the interactions between age structure, economic growth and saving, and argues that there is a positive relation between savings and growth, and furthermore savings is caused by growth. Higher rate of economic growth is likely to increase the saving rate by increasing the lifetime wealth of the younger savers relative to older dissavers. As is also emphasized in the variable-rate-of-growth models of Fry

and Mason (1982) and Mason and Andrew (1987, 1988), the influence of changes in age structure on the saving rate will rely on the lifetime wealth of individuals in different age groups, something that is determined by economic growth. Habit persistence theory proposed by Carroll et al (2002) provides an alternative basis for the same causal channel: growth-to-savings, that is, higher income growth causes higher saving rate since consumption reacts slowly to the income growth. By contrast, the neoclassical growth model states opposite direction running from saving to growth: higher saving results in higher growth by inducing faster capital accumulation.

Until now, there is quite a large empirical literature that examines the relationships between demographic structure, savings, and economic growth. These studies differ from each other in terms of both the estimation approaches and the set of the data utilized. Generally, there are at least classified into three types of studies (i) cross-country evidence; (ii) time-series evidence for individual countries; and (iii) micro evidence from household surveys. Leff (1969) finds that the dependency ratio of the young (those under 15 years of age) and of the old (those aged 65 and above) are statistically significant and quantitatively important to the aggregate saving ratios on the basis of a cross-section of 74 countries. He is also the first to have obtained that the inverse relationship between dependency ratio and saving rate. Subsequent analysis such as Adams (1971), Rams (1981, 1982) indicates that the dependency variables are insignificant effect on the saving rate, but the rate of growth per capital income is significant. More recently, Kelley and Schmidt (1996) examine the impact of dependency share on savings by the modification of Leff's model. The data set for their research is comprised of panels of six growth periods (1960-65 1985-90) and 88 countries (65 Less Developed Countries and 23 Developed Countries). They find the coefficients of dependency ratio on the saving are small and not statistically significant in the 1960s and 1970s; in contrast, the coefficients of old and young dependency ratios on the savings are statistically negative in the 1980s, which is in line with the prediction of life cycle hypothesis. Higgins and Williamson (1997), using pooled cross-sectional and time-series data from a number of Asian countries, have found that much of the impressive rise in Asian saving rates since the 1960s can be explained by the equally impressive decline in youth dependency burdens. Loayze, et al. (2000) study the factors driving the savings across the world and find that the growth rate per capital income is the most robust determinant for the increase in savings. They also assert that young and old dependency ratios have a significantly negative impact on

the private saving rate, and the coefficient on the old dependency ratio is significantly larger than that on the young dependency ratio. From above literatures, it is not hard to find that the correlation between growth and savings is quite stable, although the causal channel is not definite. But the effect of demographic structure on savings is not robust consensus.

With regards to the case of China, Kraay (2000) utilizes China's provincial panel data of household savings from 1978 to 1989 and points that the dependency ratio does not have a statistically significant influence on the saving rates of either rural or urban households in China. He also asserts that the long-term income growth has negative and significant effect on the household saving rate. However, Modigliani and Cao(2004) conduct the regression analysis of the determinants of household saving rate in China based on the time series data from 1953-2000. They show that a significant cointegration relationship is founded between saving rate and dependency ratio in China, and the rise in the saving rate is in line with the life cycle hypothesis. They also claim that high saving rate in China is mainly caused by high economic growth and transition of demographic structure. Besides, they contend that China's high growth in recent decades has meant that the savings of the young has more than offset the dissaving of the elderly, leading to a net increase in the saving rate. Horioka and Wan (2007) obtain the mixed results for China. They conduct a dynamic panel analysis of the factors contributing the growth of the household saving rate in China. The authors utilize the panel data on Chinese provinces for the period 1995-2004 from China's household survey. They find that the old age dependency ratio never has a statistically significant effect on the household savings, while the statistically significant relationship with the correct sign is gotten in the pooled sample of urban and rural households but not for urban and rural households separately. Banerjee et al. (2010) utilize a sample of urban household savings covering nineteen cities from nine provinces and find evidence in favor of the life cycle model. They also indicate that the family planning program, especially one-child policy in China contributes more of the high household saving rate. C.Zhu(2011) employs the cointegration test and granger causality to explore the interactions between the demographic dependency ratio and saving rates and finds that there is a negative relationship between the total dependency ratio and saving rates. Besides, a positive connection between youth dependency ratio and saving rate and a negative connection between old dependency ratio and saving rate are also obtained.

4 Data Selection and Methodology

4.1 Data Selection

Different types of savings are discussed in the academic papers, including national savings, household savings, corporate savings and public savings ect. The national savings can generally be decomposed into public savings, corporate savings and household savings (Kraay, 2000). And the household savings contributes a major part of the national savings since choices by individuals and families about their savings are one set of fundamental determinants of national savings. It has also been identified that the household savings is a major impetus for long-term economic growth. Therefore, this paper focuses on researching the linkages between the demographic structure, household saving rate and economic growth in China from 1963 to 2006. Basically, Chinese birth control campaign can be divided into four stages, as motioned previously. Since the real start of the birth control campaign was in 1964, when the Family Planning Offices were set up in the central government and some provincial governments to take charge of matters relating to the family planning, this paper chooses 1963 as the starting point of data sample.

Many approaches can be used to measure the household saving rate. The household saving ratio has traditionally been defined as household savings (household disposable income minuses household disposable expenditure) divided by household disposable income. Due to the unavailability of the household saving ratio from the official statistical database, this paper directly uses the calculated data from Chun-rong and Wei (2008) without modifications (figure 4). The household saving ratio calculated by Chun-rong and Wei (2008) is based on the traditional measurement, which is measured by household savings divide by household disposable income. But the household savings is the sum of two components: financial savings and physical savings. Before Chinese market-oriented economic reforms in 1978, the estimation by Chun and Wei are quite similar to Modigliani and Cao (2004), which measures the household savings as the change of personal wealth. After 1978, the estimation of household saving rate is very similar to the estimation calculated by the People's Bank of

China. However, Chun and Wei (2008) also consider the financial holdings by households in details, such as, stocks, securities, cashes, banking deposits, personal insurance and foreign currencies, ect. The data for household disposable expenditure is from the Yearly Book of China Statistic Bureau.

To explore the impact of demographic change on the household saving ratio, it is very necessary to select the well-defined indicators, which can reflect the overall shape of population composition. Recently, some researchers select the crude birth rate, crude death rate, total fertility rate or life expectancy as indicators to represent the demographic structure. But these factors cannot capture the overall profile of age structure of population, since the shift of demographic structure is the combined outcomes from changes of fertility rate and life expectancy. Accordingly, in this paper, I use both the youth dependency ratio (YDR) and the old dependency ratio (ODR) to represent the characteristic of demographic structure in China. The reason to use both ratios in my paper is that even though the old age dependency ratio increases, the economic burden of working age population may not be increased due to the decline of child support ratios (An and Jeon, 2006).

The youth dependency ratio (YDR) is defined as the ratio of the number of minors (the population aged 0-14) to the working-age population (the population aged 15-64); the old dependency ratio (ODR) is defined as the aged population (the population aged 65 and over) to the working aged population. Both old dependency ratio and youth dependency ratio come from *WDI (World Development Indicators), World Bank*. The plot of youth and old dependency ratios is shown in figure 3 (World Development Indicators, World Bank, 2012).

Besides, the indicator to represent the performance of economic growth is GDP per capita in current US\$, which is also from *WDI (World Development Indicators), World Bank*. But the author transforms the data by taking the logarithm (figure 5).

Finally, in the year 1979, China launched two crucial policies, that is, economic reform and opening-up policy and one-child policy. To capture these effects, a shift dummy variable is included in the cointegration estimations. The shift dummy variable is defined as below:

$$Dummy_{-1979} = \begin{cases} 1, & \text{in the year 1979 and after} \\ 0, & \text{before 1979} \end{cases}$$

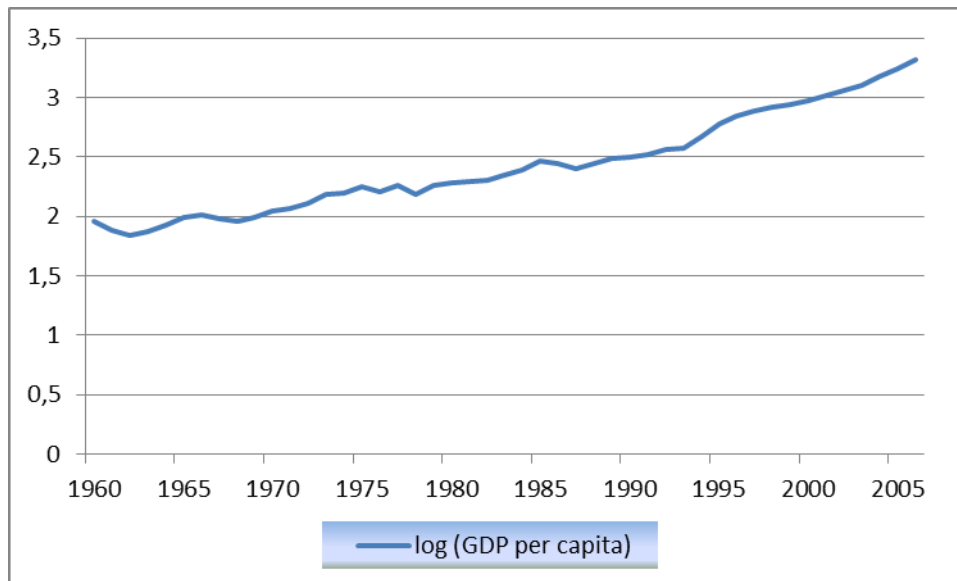


Figure 5: Log (GDP per capita) in China, 1960-2009.

Source: World Development Indicators (WDI), World Bank, 2012.

4.2 Methodology

This paper investigates the long-run linkages between demographic structure, household saving rate as well as economic growth, and the dynamic adjustment of the first difference of variables, and specifically analyzes the impact of demographic structure and economic growth on the household saving rate from 1963 to 2006 in China. The following time series econometric techniques are applied, Augmented Dickey-Fuller (ADF) unit root test and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) stationary test, two-step Engle-Granger residual-based cointegration test and Johansen cointegration technique based VAR model and vector error correction model (VCEM). To capture the effect of the economic reform policy and one-child policy launched in 1979, the shift dummy variable in 1979 is included in the cointegration test and vector error correction model (VECM). ADF test and KPSS test are conducted first since the stationary property of the data is the premise for the other techniques. After testing for the stationarity of each variable, I use the two-step Engle-Granger residual-based cointegration test and the Johansen trace and maximum eigenvalue approaches based on VAR model to measure whether the variables in the system are cointegrated. If so, how many cointegrating vectors can be identified in the system. A finding of the cointegration

means that even though the variables are non-stationary, they have a long-run equilibrium, or in another word, a set of variables never drift apart in the long term. Besides, the impact of age structure and economic growth on the household saving rate is given by Johansen maximum likelihood estimates of cointegrating vectors. While cointegration test measures the dynamic linkages among different variables in the long-run, the vector error correction model (VECM) is also utilized to measure the dynamic adjustments of the first difference of variables. It should be noted that the VECM can only be used if the variables in the system are cointegrated.

4.2.1 Augmented Dickey-Fuller Unit Root Test and KPSS Stationary Test

Since majority of time series econometric techniques are built upon that the time series variables are stationary, when we apply standard estimations and test procedures in the dynamic time series model, as the first step, it is necessary to examine the stationary property of a series. A stationary series can be defined as one with a constant mean, constant variance and constant autocovariance for each given lag. Many approaches can be performed to detect the stationarity of a time series. But the most popular methods are Augmented Dickey-Fuller (ADF) test, Phillips-Perron (PP) test and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS, 1992) test. However, in this paper, Augmented Dickey Fuller (ADF) test and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test are applied to verify the property of the data.

4.2.1.1 Augmented Dickey-Fuller (ADF) Unit Root Test

The early and pioneering work for detecting the presence of a unit root in a time series data was developed by Dickey and Fuller (1976, 1979). There are mainly three versions of ADF test.

- (i) Test for a unit root

$$\Delta y_t = \varphi^* y_{t-1} + \sum_{i=1}^{p-1} \varphi_i y_{t-i} + u_t$$

- (ii) Test for a unit root with a constant

$$\Delta y_t = \beta_0 + \varphi^* y_{t-1} + \sum_{i=1}^{p-1} \varphi_i y_{t-i} + u_t$$

(iii) Test for a unit root with a constant and deterministic time trend

$$\Delta y_t = \beta_0 + \beta_1 t + \varphi^* y_{t-1} + \sum_{i=1}^{p-1} \varphi_i y_{t-i} + u_t$$

where y_t denotes the value of a variable at time period t ; $\Delta y_t = y_t - y_{t-1}$; β_0 is a constant term; t is a linear time trend and u_t is an error term. The basic objective of this test is to examine null hypothesis and alternative hypothesis below in above equations (i)-(iii).

$$H_0 : \varphi^* = 0 \rightarrow \text{Series contains a unit root};$$

$$H_1 : \varphi^* < 0 \rightarrow \text{Series is stationary}$$

To test for the presence of a unit root, we need to calculate the T statistic $\tau = \frac{\varphi^*}{\sqrt{\text{var}(\varphi^*)}}$ and then compare it to the corresponding critical value at different significant levels. If the null hypothesis is rejected, it is concluded that a series y_t which includes drift, trend or none doesn't contain a unit root. It is widely used that the unit root process is called an integrated to the order one, or for short, I (1) process, and on the other hand, a stationary process called an I (0) process.

When utilizing Augmented Dickey-Fuller (ADF) test, we usually meet two problems. The first one is which version of ADF test we should use? Another question is how to decide the optimal lag length of the dependent variable. One solution of the first problem is to choose the third version of the ADF test which includes a constant and deterministic time trend. The reason is that the first two versions are the special cases of the third one. But if we include some irrelevant variables in the regression equation, the power of the test to reject the null hypothesis of a unit root will be reduced. Verbeek (2004) proposed that the test form can be based on the graphical inspection. If the plot of a series indicates clear upward or downward trend, it is most appropriate to run the test with time trend term. In terms of selecting the optimal lag length of the dependent variable, one approach is based on the lowest value of Information criteria, such as, Akaike Information Criterion (AIC), the Schwartz Bayesian

Criterion (SBIC). However, sometimes, we even face the problem that AIC and SBIC provide us contradictive results. In such situation, SBIC criterion is preferred by the reason that SBIC usually will select the correct model with few lag lengths than that of AIC.

4.2.1.2 Stationary Test - Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) Test

To avoid the limitation that ADF test always has a low power, Kwiatkowski, Phillips, Schmidt, and Shin (1992) (Kwiatkowski et al., 1992) proposed an alternative test- the stationary test. The null hypothesis of KPSS test is the time series is stationary against the alternative hypothesis of a unit root.

The KPSS test is a Lagrange multiplier test and the test statistic can be computed by firstly regressing the dependent variable y_t on a constant or a constant and a time trend t . And then save the OLS residuals ε_t and compute the partial sums $S_t = \sum_{s=1}^t \varepsilon_s$ for all t . Further the test statistic is given by (Verbeek, 2004):

$$KPSS \text{ LM} = \sum_{t=1}^T \frac{S_t^2}{\hat{\sigma}_\varepsilon^2}$$

where $S_t = \sum_{s=1}^t \varepsilon_s$ and $\hat{\sigma}_\varepsilon^2$ is the estimated error variance from the regression

$$y_t = \alpha + \varepsilon_t \text{ Or } y_t = \alpha + \beta t + \varepsilon_t$$

In my paper, both the ADF test and KPSS test are conducted to see whether the same conclusions can be achieved. If the results are conflicted, KPSS test is preferred due to the limitation of ADF test.

4.2.2 The Vector Autoregressive (VAR) Model (Brooks, 2002)

The vector autoregressive (VAR) model is proposed by Sims (1980) and is regarded as the extension of the univariate autoregressive model to multivariate time series. Moreover, the VAR model is useful to capture the dynamic behavior of economic and financial time series.

The simplest case is the bivariate VAR (1) model which contains two variables $[y_{1t}, y_{2t}]$. The current values depend on the previous values of y_{1t} and y_{2t} and error terms. This can be written as:

$$\begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix} = \begin{pmatrix} \beta_{10} \\ \beta_{20} \end{pmatrix} + \begin{pmatrix} \beta_{11} & \alpha_{11} \\ \alpha_{21} & \beta_{21} \end{pmatrix} \begin{pmatrix} y_{1t-1} \\ y_{2t-1} \end{pmatrix} + \begin{pmatrix} u_{1t} \\ u_{2t} \end{pmatrix}$$

Where u_{1t} is a white noise term with $E(u_{1t}) = 0$ and $E(u_{1t}, u_{2t}) = 0$. The system above can also be extended to contain g variables $y_{1t}, y_{2t}, \dots, y_{gt}$, and each current value depends on the different combinations of the previous k values of g variables and error terms.

Since the researchers need not to specify which variables are endogenous or exogenous, the VAR model is proved to be one of the most successful, flexible, and easy to use models for the analysis of multivariate time series. One problem need to notice is how to determine the optimal lag length of VAR model. Generally, two approached are used more often. One way is the likelihood ratio test, and the other is the information criteria, such Akaike's (AIC) and Schwarz's Bayesian Information Criteria (SBIC). The optimal lag length is selected by maximizing LR, or minimizing the information criteria. However, the information criteria method is more powerful than LR. If AIC and SBIC provide the contradictive lag length, SBIC criterion is preferred in this paper. The reason is that SBIC will deliver the correct model with few lags, while on average AIC will choose a model with too many lag orders.

4.2.3 Cointegration Test

If we regress the non-stationary variable X on the non-stationary variable Y , the "spurious regression" may arise, which leads to incorrect estimation results. However, there exists one exception, that is, if two or more time series variables are themselves nonstationary, but a

linear combination of them are stationary, then the series are said to be cointegrated. Cointegration is an econometric technique and is used to examine the correlation between non-stationary time series variables. In practice, many economic series which contain unit roots (non-stationary) move together over time, that is to say, although the variables under consideration may drift away from equilibrium for a while, there exist some forces on the series that make them converge upon some long-run value. Test of cointegration can be done by two-step Engle-Granger residual-based test and Johansen approach.

4.2.3.1 Residual-based Test for Cointegration

One of most popular tests for (a single) cointegration has been suggested by Engle and Granger (1987). Consider the simple model:

$$y_t = \beta_0 X_t + u_t \quad (*)$$

Assume that all individual variables X and Y are $I(1)$, i.e. non-stationary. Firstly, we estimate the regression equation $y_t = \beta_0 X_t + u_t$ using OLS method, and then we save the residuals of the regression \hat{u}_t and perform ADF unit root test on \hat{u}_t

$$\Delta u_t = \varphi^* u_{t-1} + \sum_{i=1}^{p-1} \varphi_i u_{t-i} + v_t \quad (**)$$

It should be noted that if the deterministic components like a constant or a time trend are to be included, they can be only added in one of the equation (*) and (**), never in both two equations. The null and alternative hypothesis for above unit root equation is below.

$$H_0 : \hat{u}_t \sim I(1)$$

$$H_1 : \hat{u}_t \sim I(0)$$

Under the null hypothesis there exists a unit root in the potentially cointegrating regression residual, while under the alternative hypothesis, the residuals are stationary. Thus if we reject the null hypothesis, it indicates that a stationary linear combination of the non-stationary variables has been founded, i.e. the non-stationary variables are cointegrated.

However, for the multivariate time series model, more than two variables are included. There probably exist more than one cointegrating relationships. For such situation, EG approach is not enough and an alternative multivariate cointegration technique was proposed by Johansen (1988).

4.2.3.2 The Johansen Technique Based on VARs (Brooks)

The Johansen approach is more generally applicable than two-step Engle-Granger since it is a procedure for testing for cointegration of two or more time series, each of which is integrated to order one I(1). In other words, the Johansen approach allows more than one cointegrating relationships exist.

The Johansen cointegration tests and estimations are carried out by restricting a vector autoregressive (VAR) model. Suppose that a set of n variables ($n \geq 2$) are non-stationary and integrated to order one-I(1) and they are thought to be cointegrated. A vector autoregressive (VAR) model with k lags containing these variables could be set up:

$$Y_t = \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \dots + \beta_k Y_{t-k} + u_t$$

where Y_t is an $N \times 1$ column vector of dependent variables which are integrated of order one. u_t denotes an $N \times 1$ column vector of innovations.

The premise to utilize the vector autoregressive model (VAR) is that all variables including in the system should be stationary. Thus in order to use the Johansen test, the VAR above needs to be transformed into a vector error correction model (VECM) by the reason that VECM releases the stationarity requirement of data. The VECM contains first difference terms and cointegration relationships and can be written as below:

$$\Delta Y_t = \Pi Y_{t-k} + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \dots + \Gamma_{k-1} \Delta Y_{t-k-1} + u_t$$

where $\Pi = (\sum_{i=1}^k \beta_i) - I_n$ and $\Gamma_i = (\sum_{j=1}^i \beta_j) - I_n$

The long-run cointegrating matrix of Π determines the number of cointegrating vectors, say, r . Therefore, the Johansen test focuses on the examination of coefficient matrix Π . We define two matrices α ($N \times R$) and β ($N \times R$) and the coefficient matrix Π is a product of α and β , i.e. $\Pi = \alpha * \beta'$. If there exists a long-run equilibrium, all the $\Delta Y_{t-i} = 0$, and setting the error term, u_t , to their expected value of zero will leave $\Pi Y_{t-k} = 0$. So the test of cointegration between different variables is by looking at the rank of Π via its eigenvalues. The rank of a matrix is equal to the number of its eigenvalues which are different from zero. The eigenvalues are denoted by λ_i . If the variables are not cointegrated, the rank of Π will not be significantly different from zero, i.e. $\lambda_i = 0$.

Johansen and Juselius (1990) suggest the trace test and the maximum eigenvalue t-statistics in making the inference of the number of cointegrating vectors, which are formulated as:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i)$$

and $\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1})$.

where r is the number of cointegrating vectors under the null hypothesis T is the sample size and λ is the eigenvalues. The null hypothesis of at most r cointegrating vectors against the alternative hypothesis of more than r cointegrating vectors is tested by trace statistics. The null hypothesis of r cointegrating vector against the alternative of $r+1$ is tested by maximizing eigenvalues statistic.

When we apply Johansen approach, we usually face a problem that how to select the deterministic elements of the model, such as whether deterministic components, i.e. a constant or a time trend, are contained in levels of data or cointegration equation. This is important because cointegration tests can be sensitive to the empirical specification of the deterministic component and the distribution of the test statistics is different for each possible combination. One way is to plot the data, which gives us some intuitive ideas. However, sometimes the graph of the data supplies little information about the selection of deterministic component. In such situation, we apply Pantula principle (see Johansen 1992) to find the appropriate deterministic factors for each model, which is summarized as below.

There are five different assumptions in accordance with EViews 7.0 options

Model 1: There is no deterministic trend in data and no intercept or trend in cointegration equation (CE);

Model 2: There is no linear trend in data but an intercept (no trend) in CE;

Model 3: There is a linear trend in data and intercept (no trend) in CE;

Model 4: There is a linear trend in data, while intercept and trend exist in CE;

Model 5: There is a quadratic deterministic trend in data, intercept and trend in CE.

In practice, model 1 and model 5 are rarely used. We only consider the model 2-4. It is easy to find that the model 2 is most restrictive and model 4 is least restrictive.

The Pantula principle involves the estimation of all three models and the presentation of the results from the most restrictive hypothesis (i.e. $r = \text{number of cointegrating relations} = 0$ and Model 2) through the least restrictive hypothesis, i.e. $r = \text{number of variables entering the VAR} - 1 = n - 1$ and Model 4). The process of Pantula principle starts from the most restrictive model, i.e. no deterministic components, the rank statistic is compared with its corresponding critical value. If the model is rejected, one continues to the model with a restricted intercept in the cointegration equation. If this model is still rejected, we keep going to the model with an unrestricted constant and linear trend. If the model is also rejected, the procedure is repeated to the next rank. The test is stopped when the null hypothesis is not rejected at the first time (Iranoust and Ericsson, 2004).

4.2.3.3 The Johansen Cointegration Technique with Dummy Variables (Giles and Godwin 2011)

When applying Johansen cointegration test, it is frequently to encounter the time series containing structure breaks. In this paper, the shift dummy variable is included as an exogenous variable in the Johansen Cointegration test. The method is the same as the Johansen technique based on the VAR model. But the standard tests must be modified in this situation, and the asymptotic distributions of the test statistics change accordingly. So the only difference is the critical values are changed when dummy variable is included. The practical details are presented in the empirical results part.

4.2.4 Vector Error Correction Model

The cointegration regression only considers the long-run linkages between the level series of variables, while the Error Correction Model (ECM) is developed to measure any dynamic adjustments between the first differences of the variables. A simple error correction term is defined by:

$$\varepsilon_t = y_t - \beta x_t$$

where β is the cointegrating coefficient, and ε_t is the error term from the regression of y_t on x_t . Then the Error Correction Model (ECM) is simply defined as:

$$\Delta y_t = \alpha \varepsilon_{t-1} + \gamma \Delta x_t + u_t$$

where u_t is *i.i.d.* and the first difference of y_t can be explained the lagged ε_{t-1} and Δx_t . ε_{t-1} is the one period lagged value of the residuals from estimation of equilibrium error term, or in another word, an disequilibrium error term occurred in the previous period. For cointegrated series, the error correction term ε_{t-1} , which represents the speed of adjustment toward the long-run values, offers an added explanatory variable to explain the first difference of y_t .

The equation above is a single equation of ECM which can be also used in multivariate system. In this paper, there are four variables: household saving rate (SR), old dependency ratio (ODR), youth dependency ratio (YDR) and log (GDP per capita) as endogenous variables and the constant term and shift dummy variable in 1979 (Dummy_1979) as exogenous variable. The error correction model (ECM) can be extended to the following equations:

$$\Delta SR_t = \alpha_0 + \alpha_1 \Delta SR_{t-1} + \alpha_2 \Delta YDR_{t-1} + \alpha_3 \Delta ODR_{t-1} + \alpha_4 \Delta GDP_{t-1} + \alpha_5 ECT_{t-1} + \alpha_6 Dummy_{1979} + u_{1t}$$

$$\Delta YDR_t = \beta_0 + \beta_1 \Delta SR_{t-1} + \beta_2 \Delta YDR_{t-1} + \beta_3 \Delta ODR_{t-1} + \beta_4 \Delta GDP_{t-1} + \beta_5 ECT_{t-1} + \beta_6 Dummy_{1979} + u_{2t}$$

$$\Delta ODR_t = \gamma_0 + \gamma_1 \Delta SR_{t-1} + \gamma_2 \Delta YDR_{t-1} + \gamma_3 \Delta ODR_{t-1} + \gamma_4 \Delta GDP_{t-1} + \gamma_5 ECT_{t-1} + \gamma_6 Dummy_{1979} + u_{3t}$$

$$\Delta GDP_t = \delta_0 + \delta_1 \Delta SR_{t-1} + \delta_2 \Delta YDR_{t-1} + \delta_3 \Delta ODR_{t-1} + \delta_4 \Delta GDP_{t-1} + \delta_5 ECT_{t-1} + \delta_6 Dummy_{1979} + u_{4t}$$

where ECT_{t-1} is the lagged error correction term departed from the long-run cointegrating relations between these four variables. The above equations constitute a vector autoregression model (VAR) in first difference, which is a VAR type of ECM. Therefore, a VECM is basically a VAR in its first difference form with the addition of a vector of cointegrating residuals.

5 Estimation Results and Discussion

5.1 Unit root test and Stationary Test

The first step in this analysis is to examine the time series properties of the data by using Augmented Dickey Fuller (ADF) test. As mentioned in the methodology part, which version of ADF test should we apply or do we need to include a constant or deterministic time trend in the estimation equation? To resolve it, the data are plotted. It is easy to find that the household saving ratio (SR) does not start from the original point and they do not show an upward or downward trend, thus I only include a constant in the estimation equation. For the series youth dependency ratio (YDR), old dependency ratio (ODR) and log (GDP per capita), all do not start from the original point and present the upward or downward trend. So both constant and time trend are included in the estimation equation. Table 3 displays the results of ADF test. Comparing the ADF test statistics with their corresponding critical values, I conclude that all the level series have unit roots, however the first difference of all series are stationary at least at 10% significant level. Therefore, we can conclude that all series under consideration appear to be integrated to order one i.e. I (1). To confirm the ADF test, the KPSS stationary test is also applied, which also shows that all the level series have unit roots, however the first difference of all series are stationary at least at 5% significant level.

Table 3: Results of Augmented Dickey-Fuller Test and Kwiatkowski-Phillips-Schmidt-Shin Test

Variables	<i>Level Series</i>		<i>First Difference Series</i>		Results
	Test Form (C,T,L)	ADF-Statistic	Test Form (C,T,L)	ADF-Statistic	
SR	(C,0,0)	-0.081621	(C,0,0)	-5.999844*	I(1)*
GDP	(C,T,0)	-0.391077	(C,T,0)	-6.015674*	I(1)*
YDR	(C,T,9)	-1.669584	(C,0,5)	-2.825535***	I(1)***
ODR	(C,T,5)	-3.459797	(C,T,3)	-4.147595**	I(1)**

Variables	Test Form (C,T,L)	KPSS-Statistic	Test Form (C,T,L)	KPSS-Statistic	Results
SR	(C,0,5)	0.800592*	(C,0,0)	0.106485	I(1)*
GDP	(C,T,5)	0.196303**	(C,T,6)	0.112305	I(1)**
YDR	(C,0,5)	0.810023*	(C,0,5)	0.164899	I(1)*
ODR	(C,0,5)	0.806848*	(C,0,5)	0.085826	I(1)*

Sources: The results are calculated by author using EViews 7.0 software. And Note:

- 1) *, ** and *** denotes the rejection of the null hypothesis of unit root at 1%, 5% and 10% significance levels. The corresponding critical values for ADF test and KPSS test are from Mackinnon (1996) and Kwiatkowski-Phillips-Schmidt-Shin (1992), respectively.
- 2) (C, T, L) represents the constant term, trend term and the lag length, respectively.
- 3) The optimal lag lengths for ADF test are selected by SIC criteria.

5.2 Cointegration Test

Having verified that all variables are integrated to order one $I(1)$ cannot be rejected, the next step is to perform cointegration test. Due to there are multivariate time series, the multivariate cointegration technique proposed by Johansen (1988) and Johansen and Juselius (1990) is applied to determine whether there are stable long-run relations between dependency ratios, household saving rate and economic growth. It should be noted that the cointegration test is performed before the Vector Error Correction Model (VECM) by the reason that the cointegration vectors will be utilized for the following vector error correction model (VECM).

5.2.1 Johansen Cointegration Test with a Shift Dummy Variable

The first step of Johansen test is to detect the order of the integration of the variables, which has done in the unit root test part. And it is indicated that all variables are integrated to order one, that is, all variables are $I(1)$. The second step is to determine the appropriate lag length. If the lag length is not optimum, the error term may not be Gaussian and the inference of the estimation may be invalid. Because the data sample is small, the author only estimates the

unrestricted VAR model with all variables from the lag 0 to lag 4. After estimated unrestricted VAR with different lag length, the corresponding Akaike information criterion (AIC) and Schwarz criterion (SC) are recorded and compared. The optimal length is determined by the minimized value of both information criteria. If we get contradictive results of AIC and SC, we prefer SC to select the optimum lag length. Table 4 shows that the optimal lag length for unrestricted VAR model is one recommended by both AIC and SC. Therefore, lag zero is used in the Johansen cointegration analysis and Vector Error Correction Model (VECM), which is the optimal lag length minus one.

Table 4: AIC and SC for Optimum Lag Length in Unrestricted VAR

Lag Length	1	2	3	4
Akaike AIC	-5.252435	-5.132716	-5.154335	-5.072287
Schwarz SC	-5.047644	-4.760359	-4.611007	-4.354514

Sources: The results are calculated by author using EViews 7.0 software.

Note: In the estimation of unrestricted VAR model, the dependent Variable is SR and the independent Variables: YDR, ODR, and GDP.

The third step in Johansen cointegration analysis is to select the deterministic component. As mentioned in the methodology part, this study applies Pantula (1989) Principle to determine the trend specification in the data and cointegration equation. As mentioned in the methodology part, there are five different models in accordance with EViews 7.0 options, but only model 2-4 are of interest. It should be noted that when the dummy variable is included as exogenous variable in the Johansen cointegration test, the corresponding critical values supplied by EViews 7.0 will be incorrect. David Gelies (2011) generates the asymptotic critical values for the Johansen cointegration test with structure breaks. The following paragraph is from Giles paper and explains how to read the critical values table calculated by him.

“Two variants of the usual trace test for cointegration among p time-series are considered by Johansen et al. (2000). These are the $Hl(r)$ and $Hc(r)$ tests for when there are $(q - 1)$ breaks (i.e., q sub-samples) in a linear trend or in a constant level of the data, respectively. Here, r denotes the cointegrating rank. The asymptotic distributions of the test statistics depend on

the values of $(p - r)$ and the locations of the break-points in the sample. These break-points are denoted $v_j = (T_j / T)$, where T is the full sample size and T_j is the last observation of the j th sub-sample; $j = 1, 2, \dots, q$.”

Since Giles only generate the asymptotic critical values for breaks in a linear trend and in a constant level of the data, which is model 3 and model 4 in EViews 7.0 option, respectively, table 5 only summarizes the trace statistic under model 3 and model 4. The pantula principle involves performing the Johansen test from the most restrictive model (model 3) to the least restrictive model (model 4), and then compares the trace statistics to their corresponding critical values at each stage. The test is completed when the null hypothesis is not rejected at the first time. As shown in first part of table 6, 87.84 is greater than 84.07, the 95 percent critical value of the $\lambda_{trace}(0)$ statistic. Therefore, we reject the null hypothesis of no cointegrating vector, and instead we accept that the alternative hypothesis that one or more cointegrating vectors have founded. Next, the λ_{trace} statistic is performed to test the null hypothesis of $r \leq 1$ against that the alternative hypothesis of two or three cointegrating vectors ($r > 1$). The $\lambda_{trace}(1)$ statistic is 34.19, which is less than 95 percent critical value of 58.77. Hence, there is one cointegrating relation in model 3. In the second part of table 6, 175.80 is greater than 64.13, the 95 percent critical value of the $\lambda_{trace}(0)$ statistic. Therefore, we reject the null hypothesis of no cointegrating vector, and instead we accept that the alternative hypothesis that one or more cointegrating vectors have founded. Next the λ_{trace} statistic is performed to test the null hypothesis of $r \leq 1$ against that the alternative hypothesis of two or three cointegrating vectors ($r > 1$). The $\lambda_{trace}(1)$ statistic is 74.41, which is still greater than the 95 percent critical value of 43.38. Hence we still reject the null hypothesis and continue to examine the $\lambda_{trace}(2) = 23.17$, which is less than the 95% critical value of 26.34. Therefore, the null hypothesis that there are two cointegrating vectors is accepted in model 4. Because the null hypothesis that the cointegrating vector is “ at most 1” is not rejected at the first time in model 3, the cointegration test should be performed with the model 3 specification, which is time trend included in the data, and there is an intercept but no trend in cointegrating equation. And now I can make a conclusion that there is indeed a long-run dynamic relationship among saving rate, log (GDP per capita), youth dependency ratio (YDR) and old dependency ratio (ODR).

Table 5: Summary on Number of Cointegration Relations in Different Models with a Dummy Variable

	Model 3	Model 4
Data trend	Linear trend	Linear trend
Test type	Intercept, No trend	Intercept and trend
Trace	1	2

Sources: The results are calculated by author using EViews 7.0 software.

Table 6: Johansen Cointegration λ_{trace} Test with a Dummy Variable

Null Hypothesis	Alternative Hypothesis	Eigenvalue	Trace Statistic	Critical Value (5%)
<i>Model 3:</i>				
$r = 0^*$	$r > 0$	0.712813	87.83584	84.07
$r \leq 1$	$r > 1$	0.367997	34.18809	58.77
$r \leq 2$	$r > 2$	0.218953	14.45705	37.14
$r \leq 3$	$r > 3$	0.085238	3.830922	18.81
<i>Model 4:</i>				
$r = 0^*$	$r > 0$	0.905247	175.7392	64.13
$r \leq 1$	$r > 1$	0.696294	74.41068	43.38
$r \leq 2$	$r > 2$	0.348330	23.16780	26.34
$r \leq 3$	$r > 3$	0.104675	4.754458	12.08

Sources: The results are calculated by author using EViews 7.0 software.

Note: The critical values are from Giles. The asymptotic critical values depend on the locations of the break-points in the sample ($\lambda = 0.40$ in our case); and on $(p - r)$, where p is the number of variables under test, $p = 4$ in our case, and r is the cointegrating rank being tested. So, for us, $r = 0, 1, 2, 3$. Giles supplies critical values under different significant levels, 1%, 5% and 10%. Here only critical values at 5% are presented.

5.2.2 Residual-based Cointegration Test with a Shift Dummy Variable

As the check for the Johansen tests, table 7 presents results from the Engle-Granger (1987) residual-based test for cointegration. The household saving rate is regressed on the youth dependency ratio, old dependency ratio, log (GDP per capita), dummy variable 1979 and a constant by Ordinary Least Squared (OLS). Since the constant is included in the OLS regression equation, the ADF test should be taken without including a constant. The ADF statistic in table 7 is -3.78 that is less than -3.39 of 99% significant level. We reject the null hypothesis that the least squares residuals are non stationary and conclude that they are stationary. This indicates that there is indeed a cointegration relationship between the variables.

Table 7: Residual-based Test for Cointegration

Dependent Variable	Independent Variable	Test Form (C,T,L)	ADF Statistic	Residuals
SR	GDP, YDR, ODR, Dummy_1979, Constant	(0,0,0)	-3.775219	I(0)*

Sources: the results are calculated by author using EViews 7.0 software. And note:

- 1) *denotes the rejection of the null hypothesis of unit root at 1% significance level. It should be noted that the corresponding critical values for ADF test given by EViews are invalid. The critical values for the E-G residuals cointegration test for series without trend and constant are -3.39, -2.76 and -2.45 at 1%, 5% and 10% significant level, respectively. These critical values are taken from J. Hamilton (1994). *Time Series Analysis*, Princeton University Press, pp266.
- 2) (C, T, L) represents the constant term, trend term and the lag respectively
- 3) The optimal lag lengths are selected by SC criteria.

5.3 Estimates of the Cointegrating Vector

The estimates of the cointegrating coefficients (normalized on the coefficient of SR) in table 8 can be re-written as:

$$SR = -0.027 * YDR - 0.604 * ODR + 1.013 * \log(GDP \text{ per capita}) + 4.388$$

And three findings are discussed below. Firstly, the youth dependency ratio (YDR) and old dependency ratio (ODR) have a significant negative effect on household saving rate (SR). In other words, it suggests that, in the long run, a reduction in the household saving is associated with the increase in the ratio of minors (aged below 14) to the working-age population (aged 15-64), YDR, and the increase in the ratio of old age population (aged 65 and over) to the working-age population (aged 15-64), ODR.

Secondly, the simplified version of Modigliani's (1970) model presented in the section 2 indicates that the coefficients of YDR and ODR will be equal and less than one in absolute value. In fact, both the coefficient of ODR and YDR are less than one, which is consistent with life cycle hypothesis. But the effect of ODR is much greater than that of YDR by the reason that the per-capita consumption of minors will be probably less than that of the aged (Modigliani (1970)). This result has also been founded by Horioka (1997) in the case of Japan and Thornton (2001) in the case of the United States. Juann and Rong (2010) also indicate that China's lower dependency is the most important factors contributing to China's higher saving rate. Horioka (2010) argues that an upward trend of China's household saving rate until now is by the reason that the decline in the youth dependency ratio has been more pronounced than the increase in the elderly dependency ratio. However, now population aging is a global trend. With the population aging taking place in most countries, there has been prevalent concern about the possible effects on savings and economic growth. These concerns have also found in China. And it is projected that the cohort with age 65 and over accounts for more than 30 percent of total population in the year 2050. China's economic boom from the 1970s to the present has been partially due to a very high share of working-age individuals in its population. China's savings rate which has been boosting is also by the reason that the working-age people save more than the other age groups. But the benefits of age structure will disappear in the near future because of the decrease of working-age cohorts and the increase number of old age cohorts. Thus, population aging will have a negative effect on the household saving rate in China, which is in line with the estimation results of this paper. Horioka (2010) states that, after about 2010, the increase in youth dependency ratio in China is expected to become more noticeable than the decline in the youth dependency ratio. Consequently, China's household saving rate can be expected to display a downward movement from then. The same finding is also contended by Carl and Calla (2010), who make

out of sample forecast that the saving rate drops in the 2010s as the dependency share falls and GDP growth moderates.

Thirdly, the GDP per capital have a significant positive influence on household saving rate (SR), which is also in favor of the implication of life cycle hypothesis. Individuals save more when they are wage earners in order to finance their negative saving after their retirement. When the economy experiences high rate of growth, workers saving will increase relative to retirees' dissaving, thereby raising aggregate savings. Juann and Rong (2010) also state that the effect of the economic growth on the savings is even stronger for China, where the social safety net is weak for retirees. Additionally, a high real GDP growth rate can create virtuous cycle in which the rapid income growth makes it easier for people to save. And the high saving in feeds back through capital accumulation to promote economic growth further (Horioka and Terada-Hagiwara, 2011).

Table 8: Johansen Maximum-likelihood Estimates (Normalized) of the Cointegrating Vector with a Dummy Variable

Dependent Variable		Independent Variables		
SR	YDR	ODR	log (GDP per capita)	Constant
	0.027496*	0.603741*	-1.012696*	-4.388193
	(0.00407)	(0.06196)	(0.19764)	

Sources: The results are calculated by author using EViews 7.0 software.

Note: The asymptotic standard errors are shown in brackets and * denotes 1% significance level.

5.4 Vector Error Correction Models for Dynamic Adjustments

Given that the finding that SR, YDR, ODR and GDP per capita are cointegrated in the long-run, I utilize the cointegration vector to construct the error correction model (ECM). It should be noted that the cointegrating vector is obtained from the Johansen Maximum-likelihood Estimates (Normalized).

Since only the household saving rate is of interest to us, Table 9 shows the Vector Error Correction Estimates of household saving rate as an endogenous variable. The coefficients of the error correction term of SR, ODR and GDP growth are all insignificant, but the coefficient of YDR is significant. These results show that if there is a disturbance occurred in the whole system, the change of youth dependency ratio (YDR) will have significant conservative force tending to bring the model back into equilibrium whenever it moves too far.

Table 9: Vector Error Correction Estimates

Cointegrating Equation				
SR(-1)	1.000000			
YDR(-1)	0.028641 (0.00430) [6.66680]			
ODR(-1)	0.623562 (0.06803) [9.16654]			
Log(GDP per capita)(-1)	-1.047844 (0.21051) [-4.97772]			
C	-4.535280			
Error Correction:	D(SR)	D(YDR)	D(ODR)	D(log(GDP per capita))
CointEq	0.018656 (0.01408) [1.32460]	-3.203300 (0.38563) [-8.30672]	0.035659 (0.06120) [0.58264]	0.004043 (0.02950) [0.13704]
C	0.006980 (0.00282) [2.47701]	-0.942596 (0.07715) [-12.2180]	0.089717 (0.01224) [7.32734]	0.032841 (0.00590) [5.56415]
DUMMY_1979	0.041780 (0.01912) [2.18507]	0.156313 (0.52352) [0.29858]	0.009025 (0.08309) [0.10862]	0.036260 (0.04005) [0.90532]

Sources: the results are calculated by author using EViews 7.0 software.

Note: The upper, middle, and lower figures estimated coefficient, standard error, and t-statistic, respectively.

6 Conclusion

This paper explores the dynamic evolution of household saving ratio in China during 1963-2006 from the effect of dependency shares and economic growth, and tests whether the standard life-cycle hypothesis (LCH) holds even in a country like China, where the LCH may be less likely to apply because of the cultural factor. The data from 1963 to 2006 is able to account for more comprehensive overview of Chinese household saving rate, which includes its relatively low level prior to the economic reforms, its upward trend from 1978 to 2006, the cyclical drop and recovery of the saving rate in the late 1980s and its current high level. It noted that the behavior of Chinese household saving ratio is result of two nearly coincidental sharp turns in two key policies. The first is the economic reform and opening-up policy initiated in the late 1970s. The second turn regards the most powerful birth control- one child policy implicated in the year 1979. The economic reform policy has made it possible for China to achieve remarkable economic growth, which was never seen before. It is evident that annual GDP growth rate increased from 0.25% in 1960-1964 to 10.64% in 2004-2009, one of the highest growth rate in the world. The one-child policy had a double profound effect on the saving ratio. On the one hand, one-child policy dramatically decline the share of youth dependency ratio, but in the future increase the share of old age dependency ratio. On the other hand, one-child policy weakened the traditional role of the family, which the children provide support to their parent, thus encouraging provisions through individual accumulation (Modigliani and Cao, 2004).

Two popular time series econometric approaches are adopted: cointegration test (Johansen cointegration test based on VAR model and Engel-Granger residual based cointegration test) and Vector Error Correction Model (VECM). Besides, in order to capture the effect of economic reform policy and one-child policy, a shift dummy variable is included in the cointegration test and vector error correction model (VECM). The author finds that there is a long-run dynamic equilibrium relationship between Chinese household saving rate, dependency shares and GDP growth rate. In particular, both the youth dependency ratio and old dependency ratio have a negative and significant impact on the household saving rate, while the GDP growth rate have a positive effect on the household saving rate. These findings confirm the standard life-cycle hypothesis. With regards to the vector error correction model (VECM), the estimation results show that all variables expect youth dependency ratio

(YDR) will not have a significant dynamic adjustment to a new equilibrium if a disturbance occurs in the whole system.

Projecting forward, the benefits of the age structure will disappear in the near future as working-age cohorts in China shrink and population becomes aging. Therefore, the high household saving may be a temporary phenomenon, and the rising household saving rate maybe arrested. Moreover, since aging will take place at the early stage of the social and economic development, the aging problem will act as a multiplier of the social and economic stress in China, Besides, Chinese age waves will arrive before welfare system is mature. At present, public pension coverage is still far from universal, even in cities. And less than one-third of China's labor force is gaining the benefit from the public pension and only a small minority of workers can accumulate sufficient financial assets to support their livings after retirement. We must realize that household savings could be significantly impacted by a future public retirement system. Therefore, it is very urgent for the policy makers to reform China's current retirement system to the right direction (Jackson et al., 2009).

Further studies can be taken as follows. Firstly, if the data are available, it is better to use provincial data or to investigate the household saving behavior in rural areas and urban areas separately, which may supply us more estimation results. Secondly, further research can be taken more factors into account to determine the household saving rates in China, for example, the interest rate, the urbanization rate, ect.

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