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SHOULD CHINA CANCEL THE ONE CHILD POLICY? AN EMPIRICAL RESEARCH BASED ON POPULATION AND ECONOMY DATA

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Abstract

China implemented its controversial one child policy over thirty years ago. It was originally applied due to severe social, economic and environmental issues. However, China has become a major economy in the world and its less expensive labor force is frequently attributed as the main reason for China's miracle economic growth. Thus, whether this policy that was published thirty years ago is still necessary, and whether it will potentially hurt China's economy puzzles many researchers globally. This thesis mainly tries to answer these questions with empirical data support. I use changes in capital stock, dependency ratio, and dependency population to predict GDP growth rate until 2050. The results show that if China continues to implement this policy, it will face economy downturn no later than 2017, three years from now.

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Introduction

China has become popular in the world in the past decades. It has begun to exert its economic, political, and cultural influence to its neighboring countries as well as countries as far as Zambia and Brazil. Its over eight-percent annual economic growth rate has been recognized as unprecedented in modern human history. Mass production, industrial plants, and highways have spread to the furthest and the most unknown corners of China. Some provinces that are neither close to the sea border, nor have abundant natural resources have been occupied by plants and factories of famous Fortune 500 companies. According to ABC News reports, Apple has its biggest manufacturing and assembling line in Henan province, the geographic center of China. Henan province has scarce natural resources, but it is the most populated province in China, according to National Geographic Database. It has more than one billion aggregate population. Indeed, China's population is also another hot topic that makes China famous: It has become the most populated country in the world. According to the World Bank, in 2012, China's total population had reached 1.351 billion, 114 million more people than India, the second most populated country. China also has 1.037 billion more people than the United States.

China has been exerting its One Child Policy for more than thirty years. This policy has long been a source of controversy since its debut. With the initial intention of controlling the rapidly growing population, the policy decreases the population growth rate and has exerted profound influence to China's future. Fast pace of economic development also leads to huge demographic transition. Millions of residents from rural areas either relocate with their whole family to major cities or commute during an annual break known as the Chinese New Year. Now China has faced many consequential issues that have caused severe social and economic problems. One is

the growing proportion of the aging population. Another one is that China has higher death rate than birth rate. According to statistics by the World Bank in 2013, China's birth rate is 1.58 births per woman, and the death rate is 78.9 per one thousand people. This will lead to decreasing population in a near future, which will bring about more social crisis and possible economic downturn. Therefore, it is important to test and reconsider the One Child Policy and whether it is still necessary to implement under the current situation. The one child policy serves as a catalyst for China’s demographic transition and is causing the aged dependency ratio to increase, which in turn will lower the savings rate and force pension reformation.

The goal of this thesis is to examine the economic implications of the One Child Policy. This thesis will start with background information of the One Child Policy. Next, the thesis will present a list of objective facts about China's saving rate, dependency ratio, economic data (mainly GDP), and population data across time starting in 1979, the date that the policy was initiated. Then, according to these data, the thesis will present empirical analyses to make predictions on GDP, GDP growth rate, population, and proportion of senior population in the next thirty years. At the end, according to the analyses, I will draw conclusions on whether China should cancel its One Child Policy.

Background Information about One Child Policy

The One Child Policy, officially known as the Family Planning Policy, is the population control policy of China. This policy is also one of the seven fundamental national policies, together with environmental protection, preservation of natural resources, optimal usage of land resources, equality between males and females, preservation of land fertility, and globalization. This policy is applied to every family and citizen with certain exceptions. In 2007, approximately 95.9% of China's population was subject to this restriction. The policy is enforced at the provincial level through fines that are imposed based on family income and other factors. The Department of Population and Family Planning Commissions exists at every level of government to raise awareness and carry out registration and inspection work.

The One Child Policy is the main approach that the Chinese government in 1979 used to control its rapidly growing population due to a policy announced and implemented by its first leader Mao Zedong in 1950. Since the establishment of the Chinese government in October 1949, China has been through several destructive wars: the Xinhai Revolution and the establishment of the Republic of China, World War II and invasion of Japan, the Civil War between the Kuoming Tang and the Communist Party. The huge demand for labor for post-war reconstruction led to the early encouragement of birth between 1949 and 1979. During this period, women with more children could receive rewards such as beans and rice from government. According to the Ministry of Foreign Affairs of China, in 1949, China's grain output was 113.18 million tons, an insufficient amount of food for the nation. Relatively low agricultural production per capita caused widespread starvation. This policy states that one additional child in a single family can receive certain amount of money and food stipends from the government. Therefore, one of the feasible ways to obtain additional food is from this reward. In addition, a large domestic

population was seen as an indicator of national power and military strength. All of the first generation of political leaders had experiences in wars, either in the Sino-Japan War or the Civil War. A larger population meant a larger potential military force, which helped to strengthen political and military stability. Therefore, in the first three decades after 1949, rapid population growth was the main trend, as shown in the following figure.

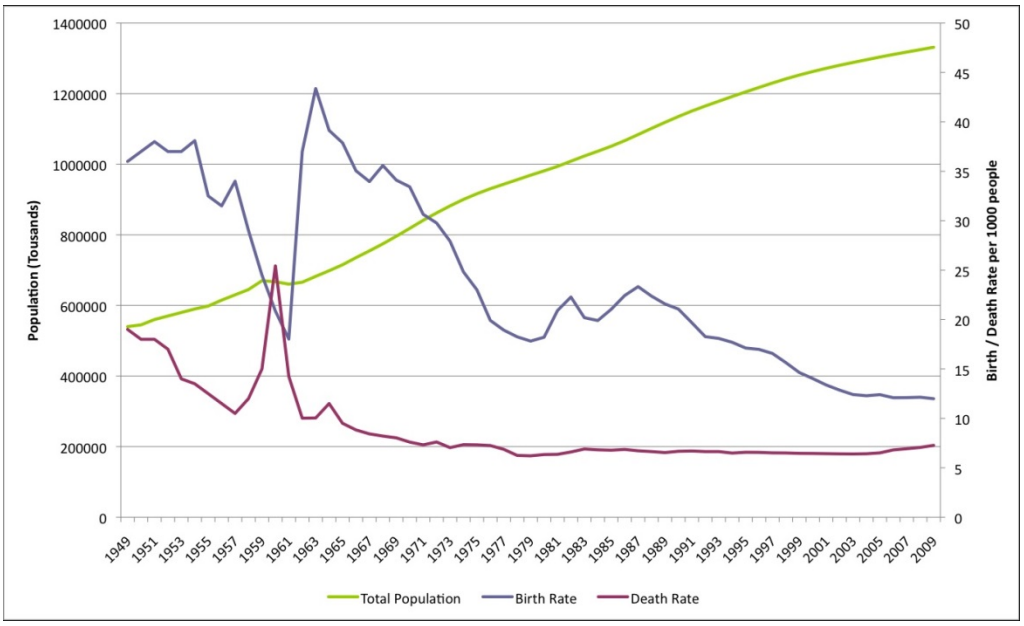

Figure 1: Population Growth, Birth Rates, and Death Rates. Source: China Statistical Yearbook 2009. National Statistical Bureau of China.

However, the government soon realized that the country did not have the resources and foundations to meet the needs of its growing population. Although between 1950 and 1953, the Chinese government carried out a wide-ranging land reform in rural areas where peasants with little or no land were given land of their own and agricultural production increased by 4.5 percent on average, the following twenty years showed unpleasant results. China's population growth rate increased way more than the growth rate of agricultural productivity. So, in the

1970s the government announced the "later, longer, fewer" policy to control the increasing birth rate. Citizens were encouraged to marry at a later age than before, have a larger gap between kids and have only two children. Although this policy was neither enforced nor publicly recommended, it brought the idea of birth control to civilians and helped the implementation of the One Child Policy that would come at the end of the decade.

Under the One Child Policy, the Department of National Population Planning sets population targets and the local government comes up with initiatives to ensure its implementation. Contrary to its name, the policy only strictly applies to a certain percentage of the population and there are exceptions to the rule. For example, families that have lost or injured members due to natural disasters are allowed to have additional children, by birth or adoption. Residents of rural areas can petition to have more than one child and ethnic minorities are also exempt from the One Child Policy. There is also an exception where parents that are both without siblings can have more than one child. Though the One Child Policy is not as rigorous as its name suggests, it is obvious that it has had an impact on population control.

The impact of the One Child Policy in China so far

China’s population increased from 677.07 million in 1960 to over 1.35 billion in 2012. Meanwhile, China’s real GDP per capita increased from $124.69 in 1960 to $3,348.01 in 2012 (base year 2000), as shown in following figures.

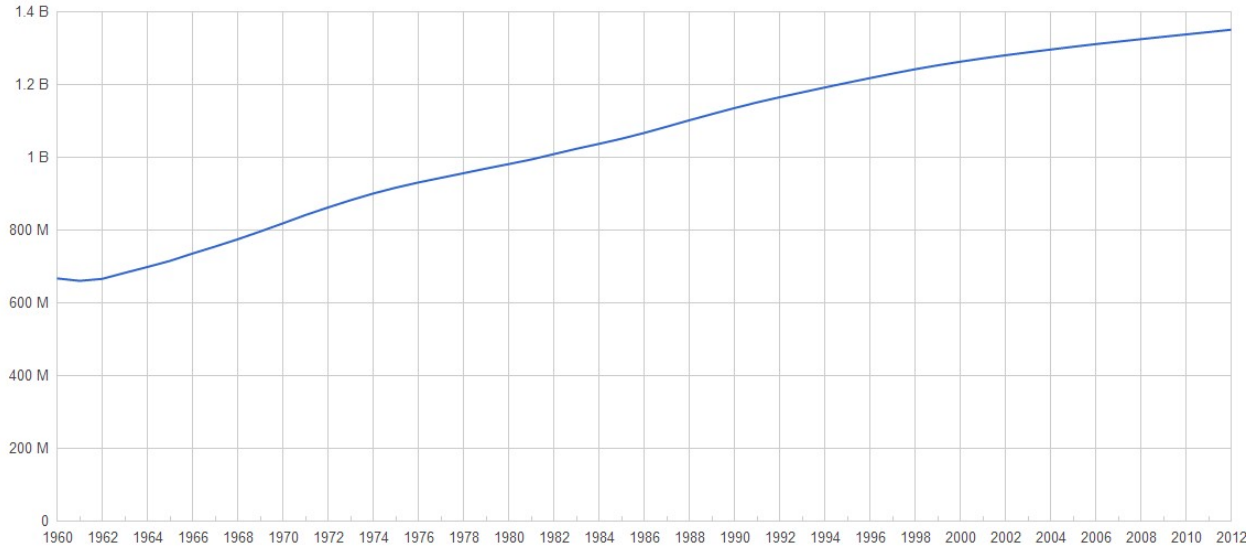

Figure 2: Population in China. World Bank Database 2012

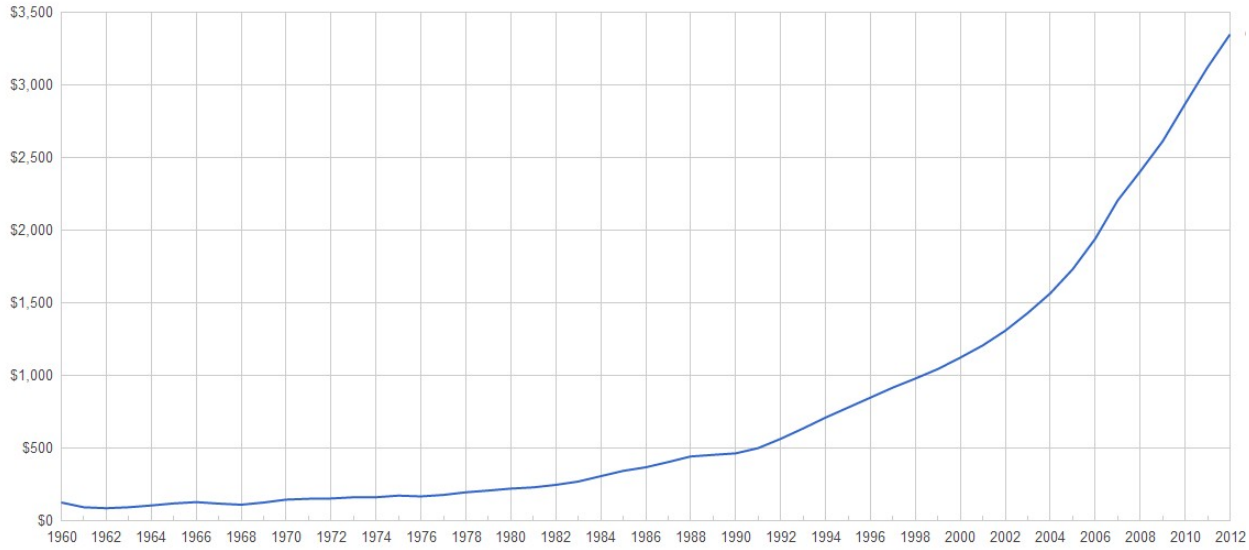

Figure 3: GDP per capita (Constant 2000 US dollar). World Bank Database 2012

According to standard development economics theories, population changes can impact demographic shifts which have influences on economic growth. I will discuss changes in dependency ratios and birth rates.

Changes in Dependency Ratio

Birth and death rates determine demographic shifts. Not surprisingly, the One Child Policy has a huge impact on China's age distribution as following figure shown:

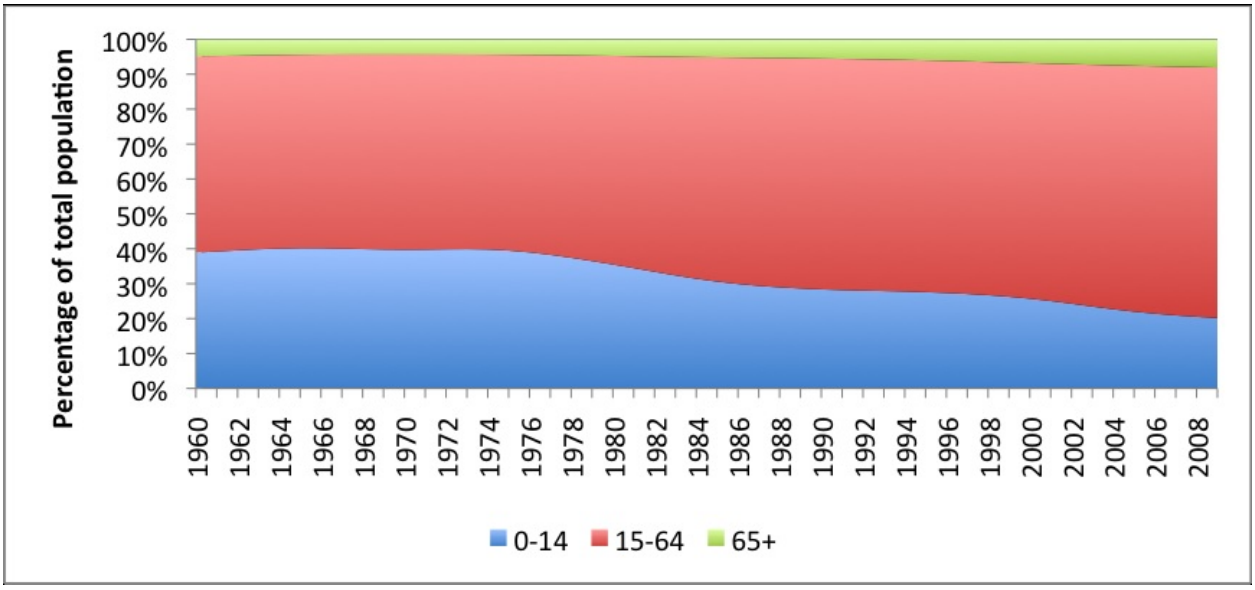

Figure 4: Population Age Structure 1960-2009. Source: United Nations Population Division 2009

According to Greenhalgh (2003), the One Child Policy has prevented a population increase of about 290 million since the policy's debut in 1978. We can see from the figure above that the population percentages in the 0-14 age range (classified as youth) show clear decreases since 1978 because of the decrease in birth rate, and has influenced the dependency ratio (Wei and Hao 2010). The youth dependency ratio decreased from 72% in 1960 to 32% in 2008, leading to a drop of 38% in the overall dependency ratio. The elderly dependency ratio increased from 9% in 1960 to 9.5% in 2008. The working force percentage increased to 71% in 2008.

According to Salditt's research (2008), if a country enters a period where the relative amount of workers is high, the country has an opportunity for economic growth, known as the period of

demographic window. He predicts that China will be in economic growth until 2015. If national policy helps to maintain a dependency ratio of 40-60%, the demographic window can lead to *demographic dividend* (Bloom and Williamson 1998). Since China implemented economic reform, known as Revolution of Opening in 1978, China's economy has achieved the greatest speed of growth from the demographic dividend. We can see from China's GDP growth rate trend in the past 30 years.

Many research papers cited above hold the assumption that youth and elderly do not work at all. Therefore they are not in the labor force, and it is necessary to maintain these assumptions for validity of this research.

Change in Saving Rate

Hammer (1986) shows in his research that age structure, population growth rate and saving rate have functional relationship. It proves that at certain age, the proportion of the population of age a (noted as c(a)) is determined by the following equation:

$$c(a) = \frac{p(a)e^{-na}}{\int_0^w p(a)e^{-na}da}$$

Where p(a) is the survival probability at age a, n is the population growth rate, a is the specific age, and w is the maximum possible age in the population.

From this equation, we can obtain c(a) for each age in the population, and use this to get the overall saving rate in the country, as the following equation indicates:

$$S = \int_0^w s(a)y(a)c(a)da$$

Where s(a) is the age-specified saving rate, y(a) is the fraction of national income gained by people with age a.

This equation tells us that aggregate savings is determined by these factors mentioned above. Therefore, age structure in the population can affect indicators of economy such as savings. It makes sense since that more population in the lower age range can increase family financial pressure and take out savings. On the other hand, more population in the working age can lead to higher savings (because of higher amount of money with less expense). Changes in savings can potentially affect national GDP as shown in many standard growth economics textbooks.

From the previous section, we can see that age structure has changed dramatically since 1978. Lower youth dependency ratio and slightly higher older dependency ratio lead to more savings, which is also discussed in detail and supported by our data and empirical analyses in later chapter. Thus, age structure also has dramatic effects on national savings.

Change in Birth Rates

According to data from National Bureau of Statistics of China, the birth rate in 2014 is 1.4, but United Nations Population Division predicts it will reach 1.8. The difference can be the fact that families with extra children are in fear of fines and refuse to report correct information. The World Bank also shows that the birth rate is under the replacement level of 2.1 and that of other “upper middle income countries”. The decrease in birth rate is usually because of the decrease in infant mortality. According to Wei and Hao (2010), as a result of better public health system, it decreased from two percent in 1960 to 0.66 percent in 1990, a level that is close to other developed countries. According to Weil (2009)’s textbook “Economic Growth”, birth rate decreased from about 6 in 1965 to 1.76 in 1995. Some other researchers have provided us an

explanation. For example, Li and Zhang (2007) show that the policy influences birth rate and creates so called “feedback effect” via better standard of living that affects birth rate. According to the trend from figure above, we can see a reverse causality through lower birth rates, longer life expectancy, and older marriage. Also, the feedback effect of income change on birth rates is obvious. Higher wages earned by female labor can also be a reason (Galor and Weil 2009).

Impacts on Economic Growth

Mankiw (1992) shows the significant negative correlation between population growth rate and output per working age adult of a country. Li and Zhang (2007) show that a 0.1% decrease in birth rate can increase the annual growth rate by 0.9%. They also show that steady-state GDP per capita will increase by 14.3%. As conclusion, they argue that, along with Malthusian model, high birth rates can hurt economic growth and probably already did before the debut of the One Child Policy. Wei and Hao (2010) argue that China had a high GDP per capita growth in the first thirty years of the One Child Policy. It also has higher rate than other middle income countries. Indeed many factors contribute to this miracle of development, such as institutional reform and capital accumulation (Holz 2006), and the Revolution of Opening (Yu 2011).

Many researchers predict population age structure on previous growth rates. Cai and Wang (2005) show that an increase on dependency ratio by one percent can hurt GDP per capita growth rate by 0.115%. Wei and Hao (2010) predict a 0.065 percent increase in economic growth per one percent decrease in total dependency ratio (with $\alpha=0.05$ significant level). They also show that youth dependency ratio has negative impact on economic growth when old dependency ratio is negatively correlated (did not achieve $\alpha=0.05$ significant level, however).

Some other researchers have implemented unique approaches. For example, in his research, Yu (2011) adds an averted average of 13 million births per year to the dependency ratio and calculates GDP per capita growth rate with different numbers, and see the differences between this and the actual growth rates. The outcome is that, for example, the 1995 real GDP per capita would be 13.2% less without the One Child Policy. Thus he concludes that high ratio of working population to non-working population generates higher saving rates and more investment with larger capital stock, and threshold externalities as existing in developing countries. These effects create so called “economic take-off effect”. The estimated threshold value of working/nonworking population ratio is 1.81, which means that the threshold is 1.81 workers supporting one non-worker (in a family, for instance), which leads to higher saving rates and investment level that are sufficient for economic fast growth. In this paper, he shows that starting time for economic growth is 1984. If the One Child Policy was not published, this threshold would be postponed to 1996, and therefore the policy actually pushed forward the China’s economic growth by 20 years.

Some other researchers believe that participation of female workers in the labor force also help China’s economic growth, shown in figure:

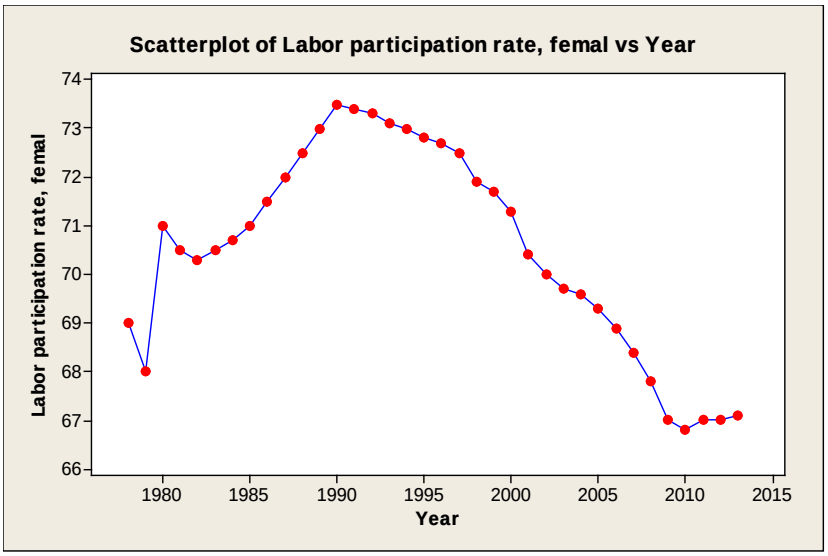

Figure 5: Female Labor Participation Rate 1978-2013. Source: World Development Indicators 2013, World Bank

Some researchers have shown scientific works that support this argument. For example, Ding and Kinght (2008) show in their research that low population growth rate is the main reason that China's economic growth is so fast. They take Solow model and add new variable "Human Capital" and "Structural Change" to the classical model and conduct empirical research. Chen (2009) concludes that more women are in the labor pool that added to working age population due to the One Child Policy. Bloom (2009) also conducted similar research that supports this claim. He concludes that lesser birth rates enhance female labor participation. However, according to our data, female participation rates decreased since 1990, the highest point. This contradiction with Chen (2009)'s research may be caused by the recurrence of communist policy of equal working opportunity and equal living environment, but there is no research that proves this causation relationship.

In summary, many researchers have shown demographic shifts since the debut of the One Child Policy are the main reason for China's economic miracle, and contribute at least $1/5^{th}$ of the GDP per capita growth.

Analyses of the One Child Policy via Solow Model

This thesis will not use Overlapping-generations growth models (known as OLG models) since calculations and other works are too difficult to make with a two-period OLG model. Since this policy has been enacted for only thirty years, and usual assumption of one generation is 25 years, one period of analyses is enough. Therefore I implement neoclassical growth model by Solow (1956) with modification as adding dynamic population. Data is similar to that used by Chen and Liu in their empirical research in 2009. In their research, they predict population growth rates of China from 2005 to 2050 with three different situations: low projected growth rates, middle projected growth rates, and high projected rates.

Theories and Backgrounds of Solow Model

I have borrowed Solow model and its corresponding assumptions. I also have added dependency ratio to the model and have seen what outcome will be with income per capita if dependency ratio or the number of dependents is different. These factors can be useful for predicting changes in economic growth in the future. For simplicity, I assume that there is no international migration. This assumption is warranted because data shows that relative migration is almost zero in China, and many other researchers use the same assumption.

I also have used traditional symbols for various variables:

Y: GDP, overall income	L: total population
y: GDP per capita = Y/L, also income per capita	K: capital stock
s: saving rate	A: technology
α: percentage of capital $\alpha \epsilon (0,1)$	W: people aged 15-64 classified as working population
D: dependents population, below age 15 or above 65	d: dependency ratio =D/W

I also have used the following symbols to indicate growth rate for the following factors:

g_Y: total income = $(Y_{t+1}-Y_t)/Y_t$	$g_{k:}$ capital stock = $(K_{t+1}-K_t)/K_t$
$g_{A:}$ technology = $(A_{t+1}-A_t)/A_t$	g_w: working population = $(W_{t+1}-W_t)/W_t$

Since Solow model assumes that entire population is working population, I have changed it to use only working population. In this way I can bring population age distribution into my model.

Model 1: Assume K is constant

I used GDP per capita and added the ratio of workers among population and changed to GDP per worker (symbol j) as

$$y = j * \frac{W}{L} = j * \frac{W}{W+D} = j * \frac{1}{1+d} = j * \frac{1}{1+\frac{D}{W}}$$

Thus the GDP per capita equals the GDP per worker times $\frac{1}{1+\frac{D}{W}}$

We can conclude that if d changes, y will behave in the opposite direction. GDP per capita increases if d decreases (either D decreases or W increases or both), and vice versa.

We now consider the situation that only some of the populations are working instead of everyone. Bringing into Cobb-Douglas function, we have:

$$Y = A * K^{\alpha} * W^{1-\alpha}$$

Then we divide both sides by L to get GDP per capita:

$$y = A * K^{\alpha} * W^{1-\alpha} * \frac{1}{L} = A * K^{\alpha} * W^{-\alpha} * \frac{1}{1+d}$$

Now we take derivatives with respect to d to know the change of dependency ratio in the Solow model:

$$\frac{\partial y}{\partial d} = A * (\frac{K}{W})^{\alpha} * (-\frac{1}{(1+d)^2}) < 0$$

This is negative since only the last fraction is negative. Thus we can conclude that dependency ratio, population age distribution and GDP per capita behave in opposite directions. One increase leads to another's decreases. We can also deduce that GDP is also in the same relationship with dependency ratio.

We can also take the derivatives on

$$Y = A * K^{\alpha} * W^{1-\alpha}$$

We get: $\frac{\partial Y}{\partial D} = A * (\alpha - 1) * (\frac{K}{L-D})^{\alpha} < 0$, and GDP and number of dependents behaves in the opposite direction as well.

We can also analyze GDP per capita with respect to D:

$$\frac{\partial y}{\partial D} = A * K^{\alpha} * (1-\alpha) * (L-D)^{-\alpha} * (W+D)^{-1} - A * K^{\alpha} * (L-D)^{1-\alpha} * (W+D)^{-2}$$

We do not know the sign of this differentiation since it is a subtraction of two polynomials. Let's do some manipulation on the formula:

$$A * K^{\alpha} * W^{-\alpha} * (W+D)^{-1} * [(1-\alpha) - \frac{W}{W+D}]$$

We only need to consider the sign of $[(1-\alpha) - \frac{W}{W+D}]$ to determine the sign of the entire equation. There are three situations:

1. If $(1-\alpha) > \frac{W}{W+D}$, then $\frac{\partial y}{\partial D} > 0$
2. If $(1-\alpha) < \frac{W}{W+D}$, then $\frac{\partial y}{\partial D} < 0$
3. If $(1-\alpha) = \frac{W}{W+D}$, then $\frac{\partial y}{\partial D} = 0$

According to researches (Liang 2006, Minghai 2010, Song 2011), α is believed to be between 0.35 and 0.5. Thus if $\frac{W}{W+D}$ >0.5 to 0.65, the entire equation is still negative.

Now we substitute W/L by $\frac{1}{1+d}$ and assume α=0.5, we have following three situations:

1. If $d > 1$, then $\frac{\partial y}{\partial D} > 0$
2. If $d < 1$, then $\frac{\partial y}{\partial D} < 0$

3. If $d = 1$, then $\frac{\partial y}{\partial D} = 0$

Therefore, we can argue that if d<1, then we have dependents and GDP per capita behave in the opposite direction.

According to our data (see figure below), dependency ratio is always less than 1 (means more workers than dependents), and we can conclude that increasing dependents will bring about less GDP per capita. Similarly, we can also know that increasing dependency ratio leads to lower overall GDP. We made the same assumption that total GDP is decreased due to increasing dependency ratio.

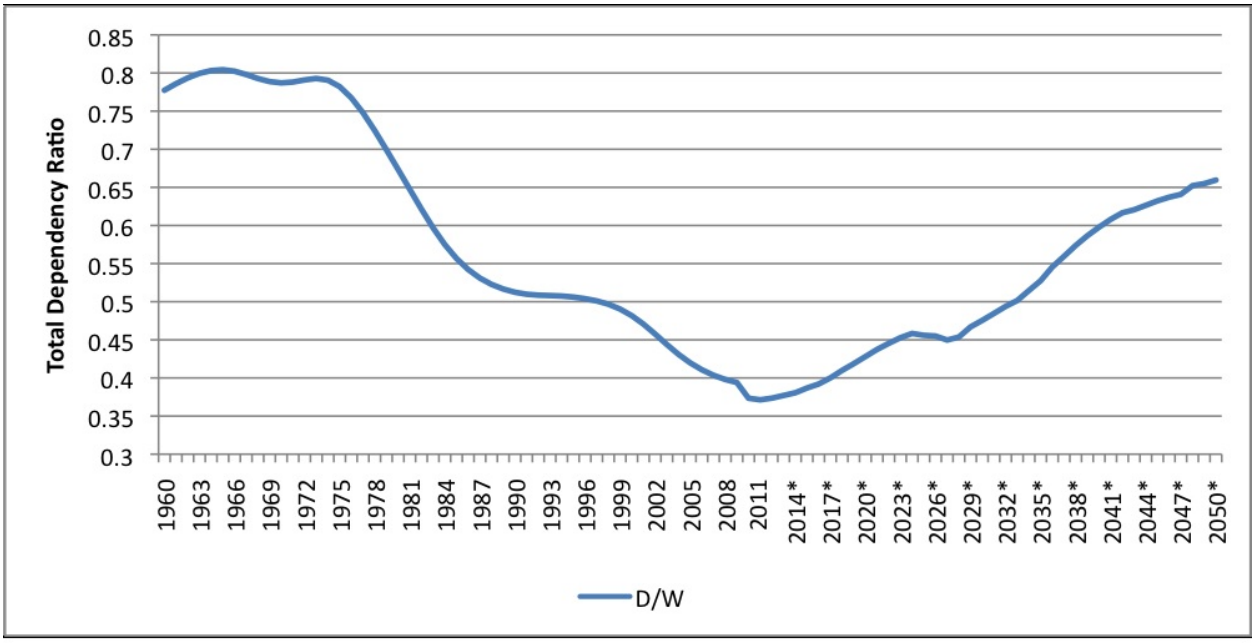

Figure 6: Total Dependency Ratio 1960 – 2013, and Forecast Until 2050. Source: World Bank, 2013

We try to know how population structure affects GDP growth, and therefore know the trend of the total GDP. Now we can analyze growth rates as the indicator for the economy. We can take the logarithm of the following equation and take derivatives with respect to t:

$$Y = A * K^{\alpha} * W^{1-\alpha}$$

Bring into the symbols for growth rates of various factors to get the following equation:

$$g_Y = g_A + \alpha g_K + (1-\alpha) * g_W$$

We have that GDP growth rates is determined by that of working population which is determined by overall population growth and dependency ratio. Now we can analyze how demographic shifts affect GDP growth rates in each year, holding capital stock and technology constant.

Model 2: Assume K is changed over time

Now assume K depends on t, and $s_t = s(\frac{W_t}{L_t})$. We have:

$$K_{t+1} = s_t Y_t = s_t A K_t^{\alpha} W_t^{1-\alpha}$$

It is reasonable to say that if $\frac{W_t}{L_t}$ increases, then s will also increases. Next we calculate growth rate of capital g_K:

$$g_K = \frac{K_{t+1} - K_t}{K_t} = \frac{sAK_t^{\alpha} W_t^{1-\alpha} - K_t}{K_t} = sA(\frac{K_t}{W_t})^{\alpha-1} - 1$$

Plug this into

$$g_Y = g_A + \alpha g_K + (1-\alpha) * g_W$$

We have:

$$g_Y = g_A + \alpha[sA\left(\frac{K_t}{W_t}\right)^{\alpha-1} - 1] + (1-\alpha) * g_W$$

This is the model to predict GDP growth rates and overall GDP until 2050 in later chapter of this thesis.

Empirical Studies with the Model

In this part of the thesis, I will focus on population dynamics and its impacts on GDP growth rate. As the previous chapter discussed, the GDP growth rate is determined by capital growth rate and working population growth rate. In addition, datasets analyzed are similar to the datasets that Chen and Liu used in their research for consistency (Source: Statistical Bureau of China Yearbook 2009 and 2013). The two authors introduced a clear way to predict population until 2050. For simplicity and accuracy, I used the middle scenario Chen and Liu analyzed (moderate growth rates).

I have following assumptions for the calculations:

1. There are no social transitions and political turmoil. (both can hugely affect population)
2. There is an overall economic production function (Cobb-Douglas) with constant returns of scale and constant output elasticity with Inada conditions hold. Inada conditions are as following:
    a. Function is continuous and differentiable a.e
    b. Function is increasing in x with decreasing derivative (U-shape)
    c. Value of 0 is 0
    d. $\lim_{x\to\infty} f(x) = 0, \lim_{x\to 0} f(x) = \infty$
3. Education factors are negligible due to China's Obligatory Education policy. Every child has the equal opportunity to receive same education.

4. Holding other parameters as constant (technology, for example)
5. Assume α = 0.5 as our previous discussions. Some researchers use 0.4 instead (Liang 2006). According to Liang (2006), since 1990, capital's share of national income has increased but labor's share of income has decreased, α = 0.5 is more likely.

First I borrow the forecasting data, working population portion, from 2014 to 2050 conducted by Chen and Liu (2009) to calculate $g_w = (W_{t+1}-W_t)/W_t$, the working force growth rate. Its forecast on working population from 2009 to 2013 are extremely close to the real values (maximum error is 10k in 2010), and I use data from 2014 to 2050. Then we use equation $g_Y = g_A + \alpha g_K + (1-\alpha) * g_W$ to calculate growth rate of GDP, holding constant on capital stocks. In this way we have demographic factors and its impact on the economy until 2050, as the result of the following table and line plot:

Year	Working population growth rate (%)
2015	0.2
2020	-0.3
2025	-0.2
2030	-0.61
2035	-1.17
2040	-0.78
2045	-0.57
2050	-0.59

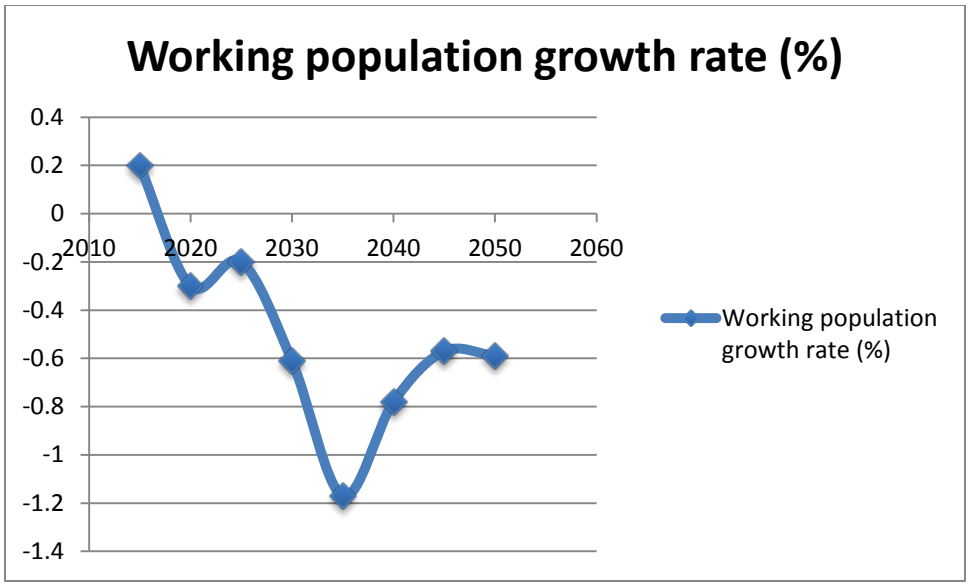

Figure 7: Working Population Growth Rates vs Year. Source: my calculation based on data used by Chen and Liu (2009), Statistical Bureau of China Yearbook 2013

We can see from these numbers that at first we have positive increments of working labor population (g_w in our equation), and then very soon we have negative working labor population growth rates. Then since we already know from previous part that g_w and g_Y behave in the same direction, we can know that same trend applies to GDP growth rate, and therefore know the trend of GDP. By forecast, since 2025, population dynamics and aging society will hurt economic growth. Detailed results are attached as a table at the end.

Now we consider the situation with dynamic capital (g_K). Since I need saving rates (s) corresponding to the future time period, I apply the OLS method. Same method also applies to percentage of working force in the population. The linearity of the regression is warranted based on normality error test and a reasonable correlation coefficient (0.53). Other non-linear regression models do not show significant improvements on the correlation coefficient. We

predict saving rate until 2050 by data for W and L. Detailed table is attached at the end as well.

The summarized linear regression for s vs W/L is as follows:

	Coefficient	t-value	Significant?
β_1	1.18703	13.4	Yes
β_0	-0.38029	-6.65	Yes
r^2	0.825		
F-value	178.3		Yes

$$S_t = -0.38029 + 1.18703(\frac{W_t}{L_t})$$

I use the following steps for my calculations:

1. Calculate K_t by equation $K_{t+1} = s_t Y_t = s_t A K_t^{\alpha} W_t^{1-\alpha}$
2. Calculate g_Y by equation $g_Y = g_A + \alpha[sA\left(\frac{K_t}{W_t}\right)^{\alpha-1} - 1] + (1-\alpha) * g_W$
3. Calculate Y_{t+1} for each forecast year
4. Calculate next year capital K_{t+1}, same method

This leads to forecasts of economic growth until 2050. In the situation with dynamic saving rates, I calculate negative GDP growth rates due to lesser working population (as figures in the last part of this chapter). Detailed tables are attached at the end. I also conduct alternative forecast with constant saving rate 0.5.

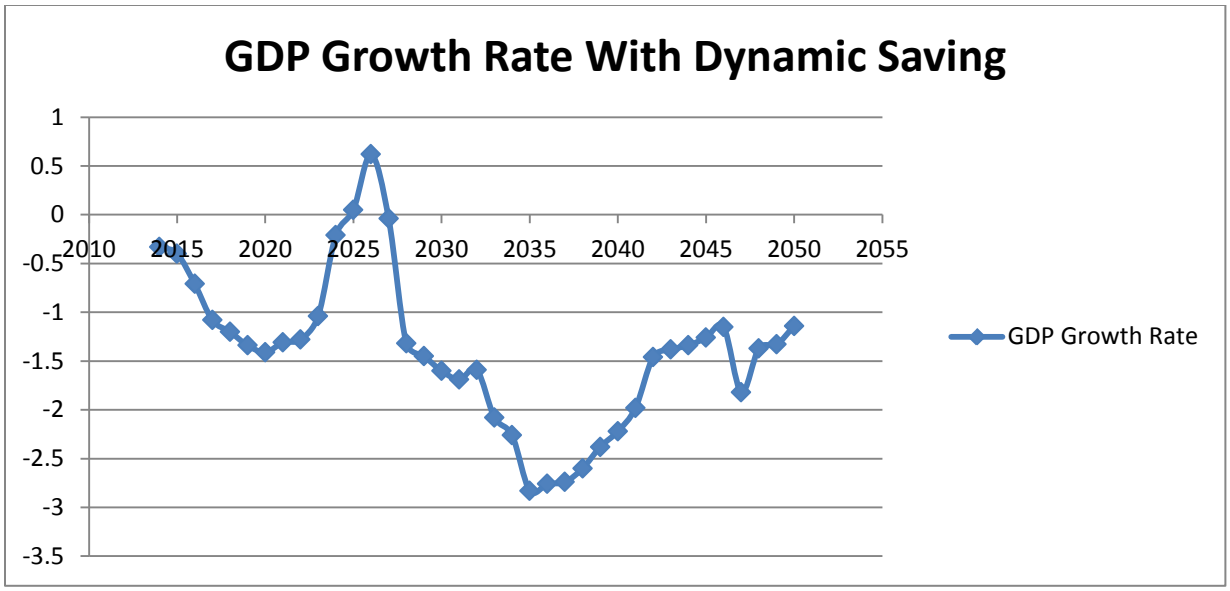

Figure 8: GDP Growth Rate with Dynamic Savings 2014-2050. Source: table 1, appendix section. Variables are "year" and "GDP Growth Rates"

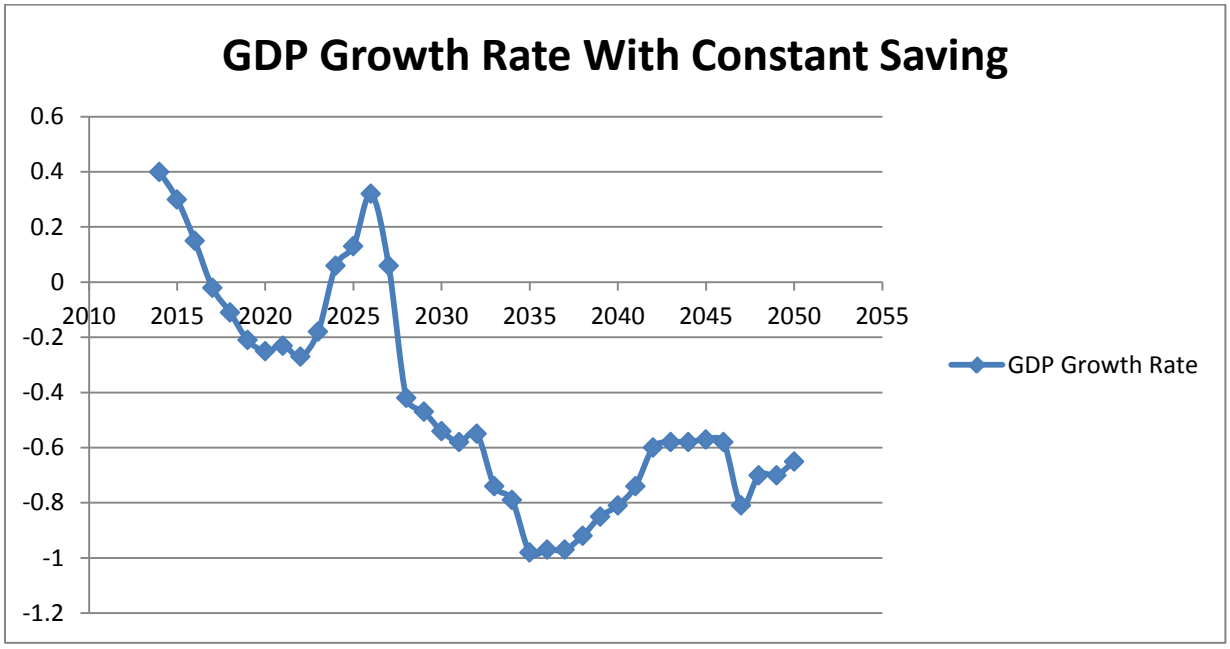

Figure 9: GDP Growth Rate with Constant Saving 2014-2050. Source: Table 2, Appendix Section. Variables are "year" and "GDP Growth Rates"

From these two graphs above, it is obvious that GDP growth rates fluctuate more dramatically with dynamic savings. In situations with dynamic savings, GDP growth rates only reach above

the horizontal axis twice in 2025 and 2026 where the GDP growth rates reach the peak at 0.62. GDP growth rates drop since the starting year 2014 until 2020, and then climb up. Soon after the GDP growth rates reach the peak at 2026, they start plummeting and reach the lowest point of negative 2.83 growth rate in 2035, and remain negative until 2050.

Unlike the dramatic fluctuation of GDP growth rates under dynamic savings, GDP growth rates under constant savings show much more positive results. GDP growth rates keep positive from 2014 to 2016 and from 2024 to 2027. They drop from the highest value of 0.4 in 2014 to negative zone, and climb up until 2026. Afterwards, GDP growth rates start to decline again and reach the bottom at -0.98 in 2035, and remain negative growth rates until 2050. The graph below clearly shows the huge difference of fluctuation between two situations.

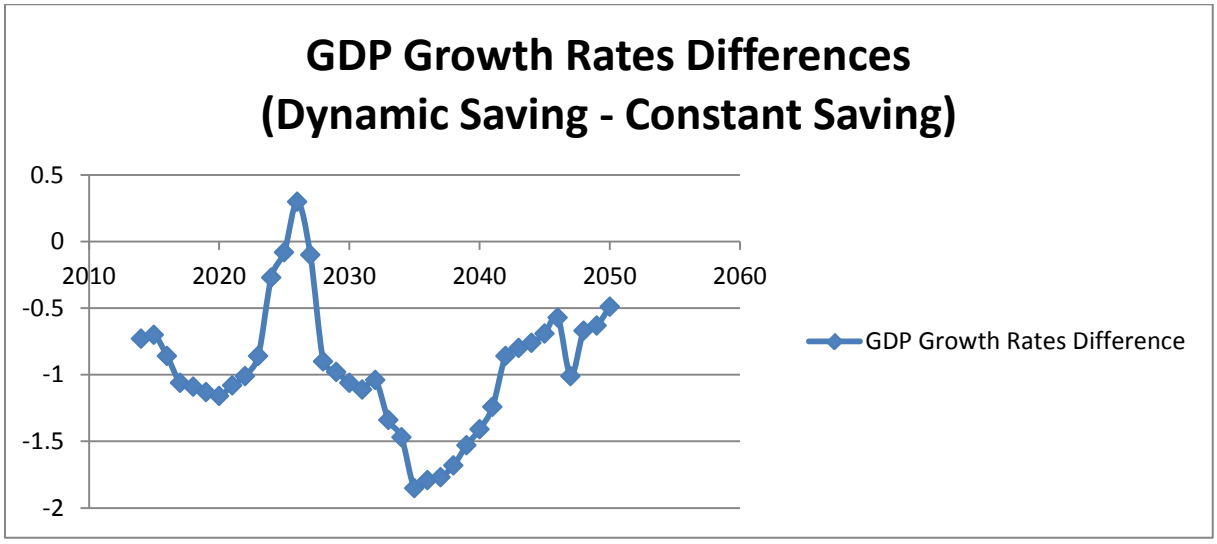

Figure 10: GDP Growth Rates Differences (Dynamic Saving – Constant Saving). Source: Appendix Table 1 and 2, my calculation.

The lower growth rates in the dynamic savings model reflect the effect of dependency rates on savings. According to the life-cycle model, if there are more young people than old people because the population is growing, there will be more workers saving for their retirement than there will be retirees who are spending their savings. But when low birth rates reduce the working age population, savings rates and GDP growth are reduced.

To sum up previous analyses, with the current policies held, China can still have economic growth until 2017, three years from now. However, population aging crisis is around the corner, and the One Child Policy can truly hurt China's economy within less than five years. China has about 9 percent of the population over 65 years old, and now this group of population raises to more than twenty percent of the entire population. Higher burden of living on working classes in a household will push people to save more money and properties before their retirements. Nowadays, standard family has two working class members who support one child and four parents. In the short term future, we can expect less dependency ratio that is more likely to increase living burden of the two working class family members.

The One Child Policy and its Consequential Social Problems

As discussed at the beginning of this thesis, the One Child Policy can hugely affect sex ratio at birth. The ratio is about 117 men to 100 women, according to D.L.Poston Jr's research (2011) (shown in figure below). It makes sense in terms of economic and social perspectives. For example, in the economic perspective, boys are usually labeled with "easy to feed and raise", "can do agricultural and labor work", "independence". If there is only one child, Chinese households are more leaning to having a boy instead of a girl. After the boys enter adolescence, they can either help out family business, farms, or go to other areas looking for jobs. This idea indicates that in the short term of future, given amount of females, more males will compete with each other for a successful marriage. The "deficient girls" problem will come soon and may cause social unrest among unmarried young men.

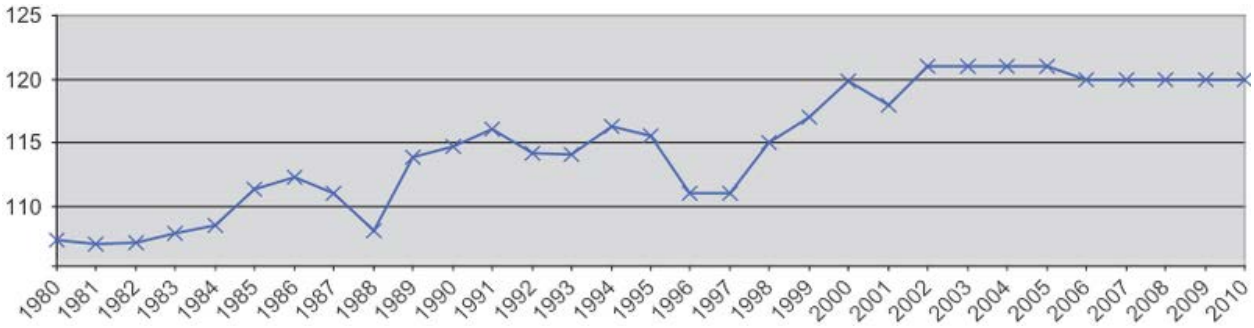

Figure 11: Sex ratio at birth 1980-2010. Source: "China's unbalanced sex ratio at birth, millions of excess bachelors and societal implications" *Vulnerable Children and Youth Studies* 6(4):314-20 doi:10.1080/17450128.2011.630428

In addition, in this thesis, I assume no population migration, but in recent years this is not the case. For example, many students go overseas to seek advanced education, including undergraduate and postgraduate. Meanwhile, more international students come to China. There were about 265,000 international students in 2010, according to China's Ministry of Education. These amounts of population are not counted in the data. Since universities in China usually

require one to two years of internship experiences as a part of graduation requirements (Ministry of Education of China, Department of Higher Education Webpage, 2014), these international students can affect working salary, technology, saving rates and other factors. It is also worthy to mention that there are more and more workers choosing to work outside of their home area, where they are born. The usual situation is that workers leave their parents and kids at home and go to other provinces or areas for jobs. This can affect dependency ratio at both the home province and the province that they work at. According to Clifford (2006), there were two billion workers leaving their hometown for jobs. It is highly likely that this number will be increasing in the future. This, combined with higher pressure to find a successful marriage, can worsen social and economic situations and affect economic growth.

Conclusion

Although the One Child Policy is one of the most controversial policies in modern society, it indeed shows some positive effects in social, economic and environmental areas. Its economic implications are salient and positive as so far. It indeed helps this country to achieve the highest speed of growth in the human history. At least 8 percent annual GDP growth rate has made China the center of the world economy.

China's economy has gained numerous benefits from the One Child Policy. With decreasing dependency ratio, it pushes economic growth on the fast track and brings about huge amount of fortune. However, incoming aging population leads to a higher dependency ratio. I predict that it will have negative impacts on the economy no later than 2017. I have to admit that demographic shifts count as a relatively minor factor, but it still shows significant impacts on the economy. The simulations in this thesis concentrate on the population factors and thus explain only impacts caused by them. There are many factors that can swing the trend of the economy, such as political turmoil, breakout of deadly disease, etc. However, this thesis is still valid because it clearly shows that based on the One Child Policy, China's economy will suffer within a few years, and it is the time to make significant changes on this policy so that China's economy can avoid this downturn.

Recently, there has been unofficial news introducing an alternative one child policy to the following scenario: If both parents are the only child in their original family, they are allowed to have a second child if they want without penalty. The authenticity of this news is unknown so far, but it has clearly shown a tip of iceberg that Chinese political leaders already foresee the dark side of this policy in the future. It is a good sign for China's economy in the future. Since China

has its long history of radical changes (Revolution of Culture, Revolution of Opening, etc), it is reasonable to suggest Chinese authority to avoid any radical change in the future. This is beneficial for the stability of society as well as politics.

Appendix. Tables and Data

Year	Savings Rate	GDP	Capital Stock	Working Population	Capital Growth Rate	Working Force Growth Rate	GDP Growth Rate	Dependency Ratio
2014	47.73	8’638’338’225’840	4’159’345’402’887	998’000’000	-0.86	0.2	-0.33	0.3868
2015	47.41	8’609’716’559’868	4’123’430’735’128	1’000’000’000	-1	0.2	-0.4	0.392
2016	46.92	8’575’142’281’741	4’082’050’196’024	1’000’000’000	-1.43	0	-0.71	0.4
2017	46.33	8’513’959’087’494	4’023’799’764’284	998’000’000	-1.97	-0.2	-1.08	0.4098
2018	45.81	8’421’785’517’280	3’944’722’681’562	996’000’000	-2.21	-0.2	-1.2	0.4187
2019	45.26	8’320’430’624’740	3’857’679’676’722	993’000’000	-2.38	-0.3	-1.34	0.428
2020	44.72	8’208’739’753’945	3’765’730’611’430	990’000’000	-2.53	-0.3	-1.41	0.4374
2021	44.26	8’092’637’920’464	3’670’584’822’134	988’000’000	-2.42	-0.2	-1.31	0.4453
2022	43.84	7’986’536’112’441	3’581’750’766’261	985’000’000	-2.25	-0.3	-1.28	0.4528
2023	43.53	7’884’501’408’782	3’501’106’781’747	984’000’000	-1.98	-0.1	-1.04	0.4583
2024	43.66	7’802’521’968’536	3’431’855’390’195	987’000’000	-0.73	0.3	-0.21	0.4559
2025	43.71	7’785’805’498’199	3’406’687’296’981	989’000’000	-0.1	0.2	0.05	0.455
2026	44.01	7’789’958’045’713	3’403’418’084’863	994’000’000	0.74	0.51	0.62	0.4497
2027	43.79	7’838’397’709’170	3’428’538’121’013	992’000’000	0.11	-0.2	-0.04	0.4536

2028	43.05	7’835’008’452’324	3’432’471’646’311	983’000’000	-1.74	-0.91	-1.32	0.4669
2029	42.58	7’731’408’468’819	3’372’839’921’351	978’000’000	-2.4	-0.51	-1.45	0.4755
2030	42.09	7’619’143’092’170	3’292’043’852’400	972’000’000	-2.6	-0.61	-1.6	0.4846
2031	41.59	7’496’860’930’625	3’206’570’227’069	966’000’000	-2.76	-0.62	-1.69	0.4938
2032	41.18	7’370’232’752’050	3’118’040’626’602	961’000’000	-2.66	-0.52	-1.59	0.5016
2033	40.49	7’253’024’353’788	3’035’007’502’681	952’000’000	-3.23	-0.94	-2.08	0.5147
2034	39.83	7’101’829’213’966	2’936’896’733’867	944’000’000	-3.68	-0.84	-2.26	0.5275
2035	38.93	6’941’322’963’640	2’828’824’744’936	933’000’000	-4.49	-1.17	-2.83	0.5456
2036	38.24	6’745’192’984’709	2’701’928’496’255	924’000’000	-4.55	-0.96	-2.76	0.5595
2037	37.55	6’559’332’486’027	2’579’091’474’733	915’000’000	-4.51	-0.97	-2.74	0.5738
2038	36.94	6’379’445’249’316	2’462’751’260’136	907’000’000	-4.32	-0.87	-2.6	0.5865
2039	36.41	6’213’797’453’851	2’356’388’592’494	900’000’000	-3.99	-0.77	-2.38	0.5978
2040	35.93	6’065’992’762’081	2’262’473’987’341	893’000’000	-3.65	-0.78	-2.22	0.6081
2041	35.54	5’931’551’549’937	2’179’784’126’848	887’000’000	-3.29	-0.67	-1.98	0.6167
2042	35.36	5’814’064’790’802	2’108’079’584’036	883’000’000	-2.47	-0.45	-1.46	0.6206
2043	35.1	5’729’089’339’309	2’055’964’878’315	878’000’000	-2.19	-0.57	-1.38	0.6264

2044	34.84	5’650’072’340’520	2’010’894’069’510	873’000’000	-2.12	-0.57	-1.34	0.6323
2045	34.62	5’574’120’587’596	1’968’282’276’629	868’000’000	-1.95	-0.57	-1.26	0.6371
2046	34.46	5’503’854’040’530	1’929’931’615’264	863’000’000	-1.73	-0.58	-1.15	0.6408
2047	33.96	5’440’487’805’784	1’896’609’872’794	854’000’000	-2.59	-1.04	-1.82	0.6522
2048	33.84	5’341’656’480’540	1’847’481’890’145	849’000’000	-2.15	-0.59	-1.37	0.6549
2049	33.64	5’268’557’255’848	1’807’733’879’363	843’000’000	-1.96	-0.71	-1.33	0.6595
2050	33.52	5’198’396’930’968	1’772’362’921’652	838’000’000	-1.68	-0.59	-1.14	0.6623

Table 1: Forecasts via Solow Model with dynamic saving. Source: World Bank (2005-2013), my calculation (2014-2050)

Year	Savings Rate	GDP	Capital Stock	Working Population	Capital Growth Rate	Working Force Growth Rate	GDP Growth Rate	Dependency Ratio
2014	50	8’903’815’751’277	4’424’975’809’655	998’000’000	0.61	0.2	0.4	0.3868
2015	50	8’939’851’309’985	4’451’907’875’639	1’000’000’000	0.4	0.2	0.3	0.392
2016	50	8’966’899’777’812	4’469’925’654’993	1’000’000’000	0.3	0	0.15	0.4
2017	50	8’980’464’930’728	4’483’449’888’906	998’000’000	0.15	-0.2	-0.02	0.4098
2018	50	8’978’277’302’958	4’490’232’465’364	996’000’000	-0.02	-0.2	-0.11	0.4187
2019	50	8’968’187’485’681	4’489’138’651’479	993’000’000	-0.11	-0.3	-0.21	0.428
2020	50	8’949’641’940’074	4’484’093’742’841	990’000’000	-0.21	-0.3	-0.25	0.4374
2021	50	8’926’869’246’089	4’474’820’970’037	988’000’000	-0.25	-0.2	-0.23	0.4453
2022	50	8’906’494’832’434	4’463’434’623’044	985’000’000	-0.23	-0.3	-0.27	0.4528
2023	50	8’882’808’870’251	4’453’247’416’217	984’000’000	-0.27	-0.1	-0.18	0.4583
2024	50	8’866’488’344’388	4’441’404’435’126	987’000’000	-0.18	0.3	0.06	0.4559
2025	50	8’871’859’062’767	4’433’244’172’194	989’000’000	0.06	0.2	0.13	0.455
2026	50	8’883’534’760’888	4’435’929’531’384	994’000’000	0.13	0.51	0.32	0.4497
2027	50	8’911’836’144’043	4’441’767’380’444	992’000’000	0.32	-0.2	0.06	0.4536
2028	50	8’917’066’287’317	4’455’918’072’021	983’000’000	0.06	-0.91	-0.42	0.4669

2029	50	8’879’232’492’172	4’458’533’143’658	978’000’000	-0.42	-0.51	-0.47	0.4755
2030	50	8’837’813’881’400	4’439’616’246’086	972’000’000	-0.47	-0.61	-0.54	0.4846
2031	50	8’790’091’319’374	4’418’906’940’700	966’000’000	-0.54	-0.62	-0.58	0.4938
2032	50	8’739’228’973’390	4’395’045’659’687	961’000’000	-0.58	-0.52	-0.55	0.5016
2033	50	8’691’327’901’282	4’369’614’486’695	952’000’000	-0.55	-0.94	-0.74	0.5147
2034	50	8’626’810’436’265	4’345’663’950’641	944’000’000	-0.74	-0.84	-0.79	0.5275
2035	50	8’558’544’064’105	4’313’405’218’132	933’000’000	-0.79	-1.17	-0.98	0.5456
2036	50	8’474’816’584’828	4’279’272’032’053	924’000’000	-0.98	-0.96	-0.97	0.5595
2037	50	8’392’487’073’301	4’237’408’292’414	915’000’000	-0.97	-0.97	-0.97	0.5738
2038	50	8’310’849’714’977	4’196’243’536’651	907’000’000	-0.97	-0.87	-0.92	0.5865
2039	50	8’234’096’513’341	4’155’424’857’488	900’000’000	-0.92	-0.77	-0.85	0.5978
2040	50	8’164’299’979’409	4’117’048’256’670	893’000’000	-0.85	-0.78	-0.81	0.6081
2041	50	8’097’947’473’038	4’082’149’989’705	887’000’000	-0.81	-0.67	-0.74	0.6167
2042	50	8’037’836’097’554	4’048’973’736’519	883’000’000	-0.74	-0.45	-0.6	0.6206
2043	50	7’989’879’870’374	4’018’918’048’777	878’000’000	-0.6	-0.57	-0.58	0.6264
2044	50	7’943’423’413’723	3’994’939’935’187	873’000’000	-0.58	-0.57	-0.58	0.6323

2045	50	7’897’712’295’679	3’971’711’706’861	868’000’000	-0.58	-0.57	-0.57	0.6371
2046	50	7’852’371’673’621	3’948’856’147’840	863’000’000	-0.57	-0.58	-0.58	0.6408
2047	50	7’807’215’234’572	3’926’185’836’811	854’000’000	-0.58	-1.04	-0.81	0.6522
2048	50	7’744’057’158’003	3’903’607’617’286	849’000’000	-0.81	-0.59	-0.7	0.6549
2049	50	7’690’063’628’305	3’872’028’579’002	843’000’000	-0.7	-0.71	-0.7	0.6595
2050	50	7’636’081’722’033	3’845’031’814’153	838’000’000	-0.7	-0.59	-0.65	0.6623

Table 2: Forecasts via Solow Model with constant saving. Source: World Bank (2005-2013), my calculation (2014-2050)

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Education

Pennsylvania State University *University Park, PA*
Schreyer Honors College Student, Evan Pugh Scholar, High Distinction *Expect Graduation May 2014*
Major Candidate: Economics (B.S.), Mathematics (B.S.), Statistics (B.S.)
Minor Candidate: Psychology

Work Experience

Penn State Economics Department *University Park, PA*
REU Program Research and Teaching Assistant *January 2012-Dec 2012*
- Conduct study instructed by professor or under supervision of graduate research assistant, answer students' questions, grade homework and exams
- Clean raw dataset, correct data error, manipulate data, create and match panel data
- Perform time series and regression analyses with Stata, create graph and simulation by Matlab
- Gain first-hand research experience, further improve technical programming skills, analytical intelligence and logical ability

Goldman Sachs Group, Inc. *Hong Kong*
Global Leadership Development Program *July 2011-Aug 2011*
- Responsible for collecting statistical data of Fortune 500 companies such as sales volume
- Participate in group case study. Topics include real life issues such as Middle East Oil Crisis
- Further improve cooperation skills, analytical techniques, presentation skills, and creativity
- My team won program outstanding group award. I won best professionalism award.

Penn State Learning Center *University Park, PA*
Economics, Statistics and Math Tutor *August 2010-January 2012*
- Help tutees review knowledge, identity weaknesses, and answer questions
- Lead study group and review lecture, go over course materials, answer questions, engage listeners
- In my role as a mentor and coach, I help students rebuild confidence and become motivated to learn
- I won Service Learning Award (Personal) with 100% tutee satisfaction rate

Leadership

International Student Council (ISC) *University Park, PA*
President, Former Chief of Staff, Social Activity Director *May 2010-Present*
- Chief executive officer of ISC, overall coordinate ISC running, propose new cultural event ideas
- Build up connections between international student organizations and ISC
- Represent international community to vote and debate for policies on university assembly meetings
- Give keynote speech in member meeting, introduce organization updates
- Current organization has 1016 members, 20% increase from last year
- ISC won many awards such as Organization International Achievement Award

University Park Allocation Committee (UPAC) *University Park, PA*
Associate Chair, Former Committee *September 2010-Present*
- Use Economics principles, I allocate over four million dollars student semester activity fee to the most meaningful and well-programmed events as activity funding
- Review applications, interview event organizers, make funding request final decisions
- Research and debate with committee for improving the service quality and funding policies of UPAC
- UPAC won Best Service Organization Award with highest 99.6% overall student satisfaction rate

Honors/Awards

University Period Honors and Awards
First Price, Chinese University Mathematical Contest in Modeling. Top 1 percent of the competition teams. *May 2012*
The President's Freshman Award, The President Sparks Award. Top 0.5% of the academic class *March 2011, March 2012*
USA Today Student Leadership Award (With Scholarship), one of five winners from over 500 applicants *April 2011*
W. LaMarr Kopp International Achievement Award (With Scholarship), only undergraduate winner *April 2011, April 2012*
College of Liberal Arts Scholarship, one of two undergraduate winners in the entire college *February 2012*

High School Period Honors and Awards

First Price, National High School Math League. Eligible to enter national team of China Math Olympiad *March 2007*

First Price, National High School Essay Contest. Award was presented by Minister of Ministry of Education *September 2007*

Technical Skills

SAS (Advanced Programmer Certificate), Stata, R, Matlab, Minitab, SPSS, C++ (basic), Microsoft Office, LaTeX