UCLouvain

UNIVERSITÉ DE NAMUR

Economics School of Louvain - ESL
Economics School of Namur - ESN

China's population and economic growth

The role of fertility in the growth process of the last two decades

Author : Shilei Li

Thesis Director : David de la Croix

Thesis Reader : Frédéric Docquier

Academic Year 2019-2020

Master in Economics – 120 credits – Focus : Professional

Université catholique de Louvain - Economics School of Louvain - Place Montesquieu 3, 1348 Louvain-La-Neuve
Université de Namur – Economics School of Namur – Rempart de la Vierge 8, 5000 Namur

I declare on my honour that this dissertation is my own work, completed without unauthorised external assistance, that it has been submitted to no another institution for assessment, and that it has never been published, either in whole or in part. All the information (ideas, sentences, graphs, maps, tables, etc.) taken from or referring to primary or secondary sources are properly referenced using the current university method.

I declare that I have taken note of and adhere to the Code of Ethics for students with regard to borrowing, quoting from and using various sources, and am aware that plagiarism is a serious offence

Acknowledgement

Without a doubt, this work could not be realized without the contribution of several people. First of all, I would like to express my deepest gratitude to my supervisor Professor David de la Croix for his much need advices and guidance which were essential for the realization of this thesis.

Furthermore, I would like to thank Professor Frédéric Docquier, for being my reader.

I also want to express special thanks to Ms. Mengni Chen, Mr. Adam Levai and Mr. Thomas Eisfeld for their additional advices and help.

A special thanks goes also to all of my Professors I encountered at the UCL from whom I had the pleasure to learn from and who contributed to my academic development.

Finally, I would like to thank my family and friends for their support during those years of studies in Louvain.

Table of Contents

1. Introduction

China's miraculous rise from a poor developing country to a major economic power over the past 4 decades has attracted worldwide attention of various researchers and economists to conduct abundant research topics. Since their economic reform and open-door policy in 1978, China's gross domestic product has grown at an average of 9.5 percent points per year[1]. Back in 1978, China was accounted as the tenth largest economy with a GDP of only 175.500 billion USD. Today by the end of 2018, China is the second largest economy in the world by GDP size of 14,9 trillion USD[2] and is still ranked as the most populated country in the world with a total population of 1.393 billion representing 18,34%[3] of the world population. According to the World Bank, China has experienced "*the fastest sustained expansion by a major economy in history – and has lifted more than 800 million people out of poverty*".[4] The key drivers behind China's rapid growth in the last decades were raising labour supply and rapid capital accumulation.

China was naturally progressing through the demographic transition model when it was affected first by the Great Leap Forward[5] and then later, to a greater degree, by the One-Child Policy. The One-Child Policy was intended to protect economic development from an unsustainable population. In reality, the One-Child Policy created an economically advantageous environment for investment into human capital and an immense supply of labour with few dependents. China completed the demographic transition in less than a half century. According to Liu and Hu (2013), the driver for China's economic growth was the supply of higher share of working-age population.

Throughout history, the relationship between population changes and economic growth has been a well debated subject among many authors and economists. There exist several schools

[1] Average growth from 1978 to 2018, source: World Bank data

[2] Source: World Bank, 2018, world population of 7.5 billion

[3] Calculated by dividing China's total population by world population of 7,594 billion in 2018

[4] World Bank, China At-A-Glance , see https://www.worldbank.org/en/country/china/testpagecheck

[5] The Great Leap Forward was as an economic and social campaign from 1958 to 1962. The aim was to restructure the country into a communist society. Many exaggerated quotas for agriculture output were set. The fulfilment of those quotas was forcefully ensured which led to many deaths because of the shortage of food for the farmers. As a result, family sizes were kept small.

with different views defining this debate that population growth fosters, hampers or is neutral to economic growth. On the one hand, countries, especially developed countries, experiencing a decline in population growth face a serious problem of "ageing society"[6] affecting the share of working population and reducing the labour supply. On the other hand, population growth may have a scale effect that is beneficial to economic growth (Boserup, 1981) as for developing countries. Lastly, other studies found little significant correlation between population and economic growth when controlling for factors such as education, country size, trade openness and political institutions. Despite many studies and literatures, there is no real consensus whether population is beneficial, harmful or neutral to economic growth. Thirlwall (1994) stated that "*The relationship between population growth and economic development is a complex one, and the historical evidence is ambiguous, particularly concerning what is cause and what is effect*."[7]

More recent literatures, which have put the age structure of the population in the centre of their studies, have shifted again the pendulum in the population and economic growth debate. They have decomposed the population growth into its fertility and mortality to analyse their independent effects on economic growth (Barlow 1994, Bloom and Freeman 1988, Kelly and Schmidt 1995). According to the results, fertility, especially the past birth rate, has a significantly negative effect on economic growth, while the effect of mortality is insignificant. The magnitude of the changes in fertility and mortality during the demographic transition lead to different shifts in the age distribution and therefore lead to population growth having different effects on economic growth.

After four decades of strict birth control, the rapid growth of China's population has slowly begun to decline. This long-lasting low fertility is therefore expected to have significant consequences for China's economic growth especially due the decline in working -age population and the acceleration of population ageing.

The present thesis will take China as a case to analyse empirically the relationship between population growth and economic growth in the last two decades and verify the alignments with present growth theories. The structure of this thesis is as the following: Chapter 2 consists of a theoretical review of the recent literatures on economic growth and fertility

[6] United Nations define "aging society" when more than 7% of the population is over 65 years or older. "Aged society" when more than 14% of the population is older thn 65 years.

transition. It provides a first theoretical knowledge on the demographic transition theory, the demographic dividend and an explanation on the importance of the population age structure. The second part of this chapter will present the economic growth models of the different schools, particularly the classical growth mode, the neoclassical model and finally the endogenous growth model. Chapter 3 will introduce the framework for the analysis including the data description, the empirical strategy and the regression model. Chapter 4 presents the econometric results. Finally, Chapter 5 concludes with the findings and suggestions for further analysis.

2. Literature review

This section has the object to provide the reader of this thesis with the necessary overview of the recent theories on economic growth and fertility. The first theory provided is the theory of the demographic transition. The reader will get an understanding for the role of fertility in the socio-economic development process of an economy. It is the interplay between the birth rate, death rate and the population growth which creates a window of opportunity for countries to develop sustainably, this window of opportunity is also known as demographic dividend.

2.1 Demographic transition theory

In the recent years, studies on demographic trends especially in developing countries showed that in the long run, population change is a significant variable that impacts the macroeconomic performance of a country (Loraine,1991).

The theory of demographic transition describes the shift from a population characterized by a high birth and death rate to a population with low birth and death rate. The constant population[8] at the initial phase, will know a rapid growth over time because the death rate starts to decline before the birth rate. Hence, the number of births exceeds the number of deaths which consequently leads to enhanced population growth.

Furthermore, it suggests that while the population goes through the transition, the country develops economically from a premodern to a modern economic system (Galor, 2005).

[8] No population growth because the high birth rate is balanced by the high death rate.

Kirk Dudley (1996) defines the transition as “the progress of the societies from a pre-modern regime of high fertility and high mortality to a post-modern one in which fertility and mortality are low.” Thus, the theory predicts that countries will experience a convergence of the transition of their population towards the state of low death and birth rate and a low population growth which mark the completion of their demographic transition.

2.1.1 Demographic Transition model

The demographic transition model is a five-stage model and is based on three main population indicators: the birth rate, the death rate and the total population.
Each stage is characterized by a specific relationship between the death rate and the birth rate (Figure 1).

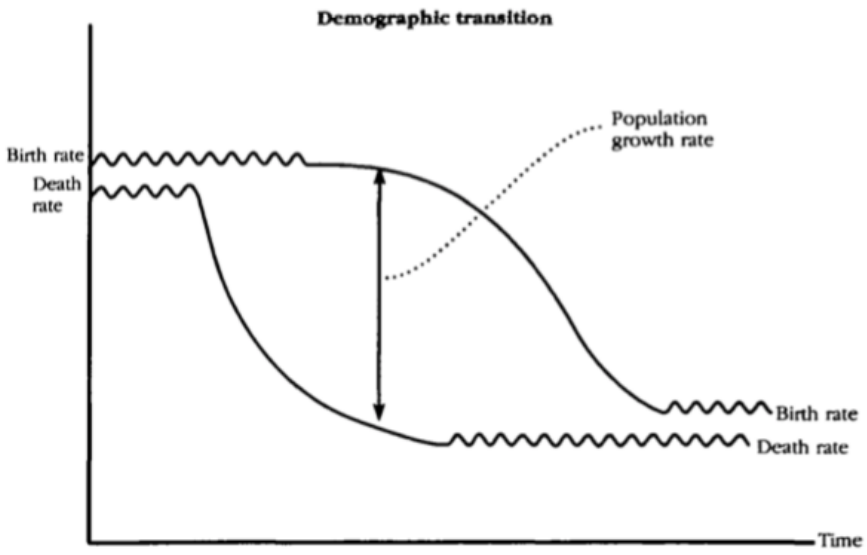


Figure 1: The Demographic Transition
Source: Bloom and Williamson (1998)

The first stage of the demographic transition is the pre-transition stage and is characterized by a fluctuating high birth rate and death rate and consequently a fairly constant level of population. While a high fluctuating death rate is due to deficits of medical knowledge, lack of proper hygiene, famines, wars or pandemics, high birth rate is often the response to high infant mortality, replacement and increase of workforces or the desire to grow one’s community. The pre-transition stage is associated to the premodern time before the industrial

revolution and countries that are relying heavily on agriculture productivity and unskilled labour. Nowadays, every country in the world has passed the first stage.

The second stage, the early transition, is initiated by a rapid decline of the death rate. As the death rate declines rapidly while the birth rate remains high, population start growing rapidly because the number of births exceeds the number of deaths. The decline of the death rate is mostly attributed to significant and permanent improvements in overall health standards, food production, vaccination, and hygiene which affect positively the life expectancy and especially infant mortality. The transition to the second stage is still a recent transition as since the mid-20th century, most countries made it not only to the second but progressed even to the third and fourth stage. Nowadays there are some countries remaining in the second stage for various economic, institutional and social reasons[9].

The third stage of the demographic transition is initiated by the start of a declining birth rate. The rate of decline is however lower than the decline of the death rate initiated in the previous stage. As a result, the birth rate remains still higher than the death rate, which slows down the population growth. Therefore, the third stage often marks the peak of the population growth. The decline of the birth rate is the result of further medical development, decrease of infant mortality, improved economic conditions, access to education and socioeconomic changes. As better birth procedures and vaccines are reducing infant mortality, parents reduce births as more children maintain better health and reach the adulthood with a significant improved probability. Furthermore, urbanization and the shift form agriculture dependency[10], reduce the family sizes, as children became investment in the future reflecting the benefits of having fewer children to foster and concentrate resources (Kirk,1996). Another factor linked to reduced fertility is education. Primary, improved female education providing women with new opportunities[11] and better understanding of their bodies, is a major driver to reduce fertility as it leads to delaying child-bearing years and elimination of early marriage (Holsinger and Kasarda,1976). Nowadays, countries in the third transition have in general

[9] Countries such as Afghanistan, Guatemala, Yemen, Sub-Saharan Africa….

[10] Previously, larger family with more member increased workforce on the fields.

[11] Improving gender equality and changes in women's status lead to shifting away from the ideal of women taking only care of their family. As a result more women are encouraged to pursuit advanced education.

some economic, social and political stability[12]. Hence, stage three is often associated with the marker of significant development.

The fourth stage is initiated by a rapid decline of the birth rate exceeding the decline of death rate until both rates are low. As a result, the population growth stabilizes. The preliminary conditions for countries[13] reaching this stage are the industrialization of the economy, technological developments, highly educated citizen, advanced healthcare system and stable government and policies.

The fifth stage of the demographic transition is rather more a theoretical stage. The necessary condition to initiate the transition is a decline of the birth rate equal or below the death rate, thus leading to a negative population growth. A negative trend of population growth occurs when the birth rate falls below the replacement level[14] which is the level of fertility at which a population replaces itself from one generation to the next keeping a stable population[15].

2.1.2 Demographic dividend

The key to understand the relationship between demographic transition and economic growth is to explore how the demographic dividend is realized and achieved.
The demographic dividend as defined by the United Nations refers to the economic growth potential that can result from the change in the age structure of the population.
The rapid decline of the birth rate occurring during the demographic transition leads to a change in the age structure of the population and marks the beginning of the demographic dividend (Ross,2004). With fewer births, the proportion of the young dependent population decreases in relation to the working age population[16]. Consequently, with more labour force and fewer young and elderly to support, more resources at both domestic and state level are freed up and can be invested to improve productivity and to generate economic growth.
It is what economists and demographers refer as the first demographic dividend.

[12] Countries such as India, Jamaica, Mexico South Africa, United Arab Emirates…

[13] Countries such as Argentina, Australia, China, Brazil Singapore, US, South Korea and most of Europe.

[14] The level for low mortality population is 2.1 births per women, United Nations 2015

[15] For given level of mortality and absence of migration.

[16] The working age population is defined as those aged 15 to 64 and is considered able and likely to work

However, the benefits of the demographic dividend are not automatic and simply having a large workforce is not enough, as it merely provides a window of opportunity. In order to fully take advantage from the demographic dividend, a country must also make appropriate social economic investments and policies in public health, education[17], family planning and the economy[18]. If the necessary conditions are set, the demographic dividend drives economic growth through the following mechanism: labour supply, savings and human capital.

The increase of the labour supply is mainly due to the aging of the young generation born during the periods of high fertility, who will leave the dependent years and join the working force. This lowers the ratio of the dependents. Assuming the labour market can absorb the increased labour supply, per capita production increases. Another factor associated to the increase of labour supply is based on women's increased participation in the labour force. As family sizes decrease, women are likelier to join the workforce. Furthermore, with better education their productivity in the labour market increases.

The demographic dividend is also delivered through the growth of savings.
The working-age adults tend to dispose a higher income and saving than the young dependent population who consume more than they earn (Higgins, 1998). According to life cycle theory of consumer behaviour, the dependent people are net dissavers as they have no sources of income or savings, while the working age population are net savers given their higher income than consumption. The behaviour of saving is even more amplified between the ages of 40 and 65, when the investment in their children is likely to drop and the investment for their retirement increases (Paxson,1996). Therefore, the decreasing depend ratio promotes higher national savings, thus fostering the economy. This is also called the second demographic dividend.

Finally, the demographic dividend not only affects positively the labour supply and the saving ratio but also encourages accumulation of human capital. As mortality drops and life expectancy increases along the demographic transition, people change their attitude to education, family size, work and the role of women, leading to a deep cultural change that people become valuable assets. According to Ben-Porath (1967) the return of investment in

[17] Increasing women's access to education and labour force participation

[18] Promoting labour-market flexibility, trade openness, infrastructure, savings, …

education increases with the length of the active life. With fewer births and increasing women's participation in labour, parents are economically less burdened and are able to allocate more resources per child, resulting in better health and education. In return, this investment in education leads to a more productive labour force promoting higher wages and higher standards of living.

To what extent a country will benefit from the demographic dividend, depends heavily on its policy environment. The increase in productivity due to the increasing labour force will only happen when there is sufficient flexibility in the labour market allowing for expansion and additional policies promoting investments. Similarly, only proper saving mechanisms and a healthy financial market will induce people to save. Hence, the demographic transition allows developing countries to shift from being dependent on foreign capital investment to self-contained sustainable economic development.

2.1.3 Age structure and economic growth

The magnitude of the changes in fertility and mortality during the demographic transition lead to different shifts in the age distribution and therefore lead to population growth having different effects on economic growth. According to Bloom (1997) population growth resulted from improvements in life expectancy among the elderly has an immediate negative effect on economic growth. The dependency ratio increases because there are more elderly to support. Population growth attributed to a general decline of mortality has no significant effect on economic growth because the ratio of the working-age population and dependent population remain unchanged. Population growth driven by an increase in fertility has at first, a negative effect on economic growth given there are more young to feed, then however, two decades latter it has a positive effect on economic growth due to the boom of the economically active population. The economic and social development will push the fertility to decline and slow down the natural population growth. Thus, leading to an aging of the population. The natural growth rate of population follows an inversed U shape curve. It first raises and then declines at a turning point. The growth rate of working age population follows a similar pattern with a delay about one to two generation (Figure 2).

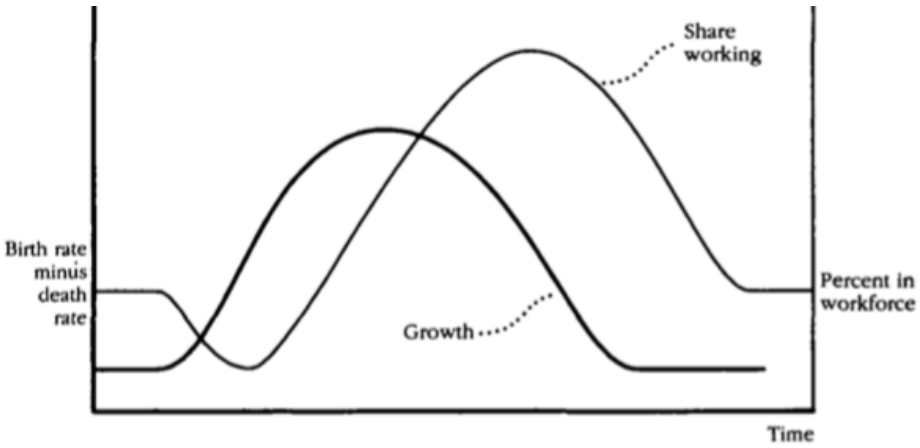


Figure 2: Population growth and age structure

Source: Bloom and Williamson (1998)

During the period in which the working population is booming, the gain in productivity and the combination of adequate supply of labour and increased savings rate create an additional source of economic growth. Thus, forming the demographic dividend. As the demographic transition progresses and exceeds this stage, the population age structure becomes less and less productive, notably due to the aging population[19]. Consequently, the benefit of the demographic dividend disappears. As the demographic transition is conditioned by the change of fertility rate, the following relationship between the fertility and the growth path of economic can represented as the following (Figure 3):

The steady state of low economic growth rate is characterized by a stage of high fertility rate. As the fertility rate declines along the demographic transition, the age structure of the population shifts and forms the demographic dividend which promotes the growth rate of the economy. When the transition exceeds a certain stage, the further decline of the fertility rate amplifies the population aging. Consequently, the growth rate of the economy decreases and converges to the low steady state again.

[19] The fertility rate is declining along the demographic transition. A further decline of the fertility rate equal or below the death rate amplifies the aging of population and could even lead to a negative population growth. A negative trend of population growth occurs when the birth rate falls below the replacement level. Stage 4 and 5 of the demographic transition

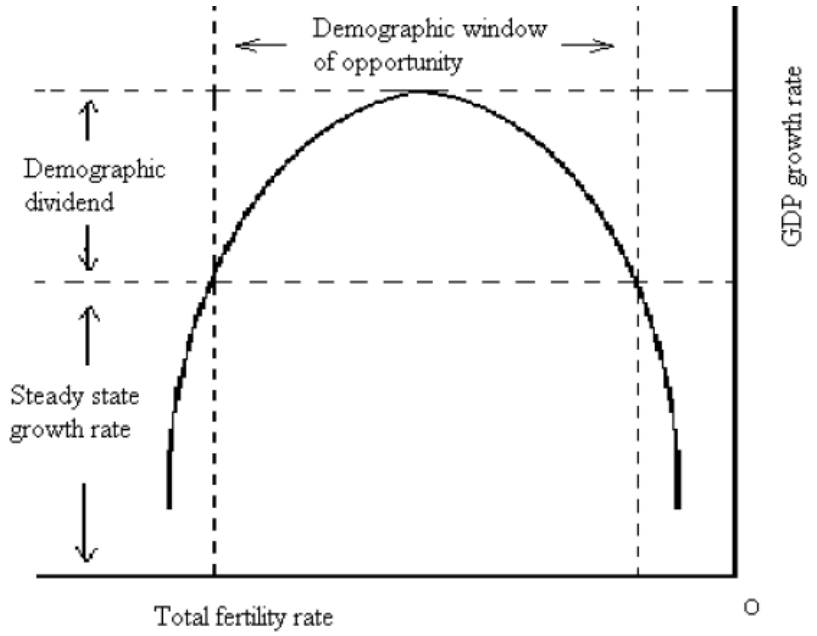


Figure 3: Population growth and age structure

Source: Cai Fang (2010)

2.2 Economic Growth and Population

The economic growth of an economy can be defined as the increase of the aggregate production over time. Thus, a country's economic growth can be referred to a long-term rise in the capacity to supply increasingly diverse goods and services to its population (Kuznets,1973). The aggregate gains in the capacity of production is often linked to technological progress and the increase of the average marginal labour productivity. That leads to an increase of national income[20], thus to higher standards of living and welfare. (Russel 2006). Nowadays a country's economic growth is measured as a percentage increase in real gross domestic product (GDP) and the standard of living is indicated in GDP per capita. Changes in population affect both consumption demand and the production capacity of an economy. However, in order to fully explain economic growth, exploring the magnitude of population change is not enough. If the only factor of production is labour, then twice as

[20] One of the main determinants of labour productivity is human capital. Higher average level of education in an economy is associated to higher is the accumulated human capital leading to higher labour productivity. Higher income is correlated with higher education.

many people would lead to a double of the output. The population would not affect output per person.
Economic growth theory attempts to find the answer to the rise and decline of economic systems. It is the pursuit to explain the main determinants of growth and the interdependence between growth and other variables such as population, capital, education, income distribution, public policies, savings, productivity, resources…
In the attempt to understand the main determinants and processes of economic growth, economists from each school do not converge to a common framework but go in different directions. There are three main economic growth theories that have emerged from the literatures: The classical, the neo-classical and the modern endogenous growth theory.

2.2.1 Classical Growth Model

The classical theory of economic growth is substantially characterized by Adam Smith's Wealth of Nation (1776) and Robert Malthus' Principle of Population (1798). The model is founded on the concept of a subsistence level[21] and diminishing returns with three main determinants: capital accumulation, population growth and technology.
Capital accumulation is considered as the primary source for growth. People save but also invest all their savings. The incentive to invest and save is directed by the profit on investment. As for example: in the past landlords employed workers to produce output and workers offering labour exchanges wages for food. Hence, the accumulation of capital allows and leads to growth of output and employment, allowing economic growth to take place.

Population change is considered as endogenous and a function of income. Malthus stated that humans are limited in their multiplication not only by limitations on resources but also to incentives to fertility reduction to prevent poverty[22]. At subsistence level, incomes are barely enough to maintain the population constant, from one generation to another. When incomes are low or below substantial level, population faces either low fertility since people avoid having children they can't support or high mortality due to food shortage or diseases. Whereas, when incomes rise above the subsistence level, fertility increases, and population

[21] A standard of living or income that provides only the basic needs

[22] Malthus called the mechanism of limitation on resources "the positive check" and the mechanism on deliberate reduction of poverty , "the preventive check"

starts to grow. In a static system with constant capital stock and diminishing marginal return, wages would converge to the substantial level in the long run. The expanding population driven by the higher wages, increases the labour force and competition and consequently, drives the wages down towards the subsistence level.

The classical growth model considers technological progress, but it plays only a secondary role because it is driven by the accumulation of capital. Citing the example of Adam Smith (1776), the invention and use of machineries or tools that enhances the productivity is the result of the division of labour, which require capital accumulation. Furthermore, the gain in productivity and temporary wealth will be neutralized by the decrease in productivity, generated by the increase of population (Malthusian)[23]. As population increases, the wages will return to the subsistence level. Technological advancement leads to higher population but not to higher standard of living. (Figure 4)

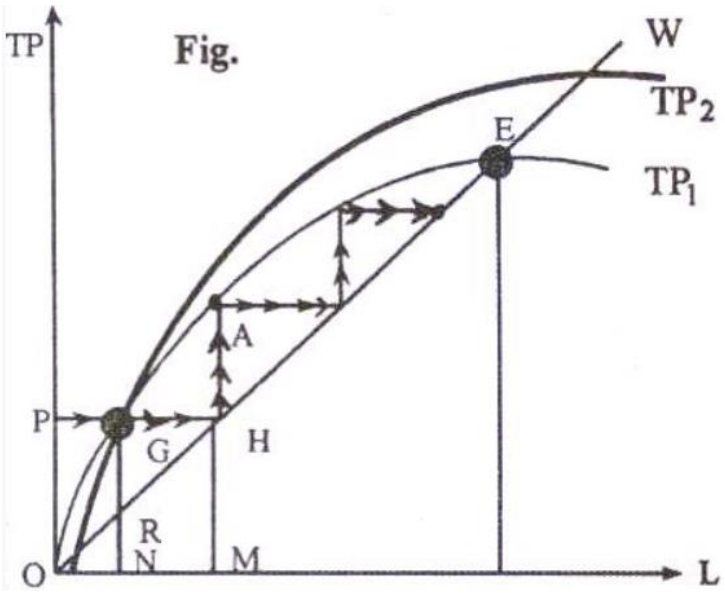


Figure 4: The dynamics of the classical growth theory

Source: Cai Fang (2010)

The vertical axe represents the total production. The horizontal axis represents labour which is also a proxy for the level of population. The subsistence level of wage is represented by the

[23] Malthus state that with fix land and labor displaying diminishing returns, growing population yields progressivly lower productivity. Hence, the gain in living standard is only temporary as it will provoke rapid population growth.

45°-degree line OW. The total production function of the economy is represented by the curve TP. The curve is convex because of diminishing returns. If the level of population increases from 0 to ON, the level of output increases from 0 to OP. If the wages are pegged to the subsistence level NR, the surplus or profit is RG.
The profit will lead to capital formation. As a result, the demand for labour increases and will lead to a rise in total wages to NG. This is only a temporary equilibrium. Higher wages stimulate population growth. Population rises to OM. As a result, the wages are driven down to the subsistence level. Because of the increase in population, surplus can be generated, and the capital accumulation process will take effect again.

This process will continue repeating until the economy reaches point E, a stationary situation where the wages exhaust total output, and no surplus can be generated. Consequently, capital accumulation incentives disappear, and population remains stationary. The classical stationary is reached. Technological changes may cause an upward shift of the production function, from TP1 to TP2 and can postpone the economic stagnation but it can ultimately not be avoided. The classical theory on economic growth state that every economy has a steady state of stagnation.

2.2.2 Neoclassical Growth Model

The core of modern analysis, the neoclassical growth theory, is characterized by the Solow Swan model, developed by the two economists Robert Solow and Trevor Swan in the second half of the 20th century. The model focuses on the impact of three determinants for growth: Capital, labour and technological advances. According to Solow (1956) the production level is based on both, the quantity and the productivity of labour and capital and the technological growth as a third factor, whose role is considered as exogenous. As both factors do not result from the choices of economic agents and technological progress is considered as a product of chance, the model is known as exogenous growth model. It shows that in the absence of technological progress, economies risk not to grow in per capita terms. The neoclassical model assume that the economy achieves equilibrium in the long run. Hence, stating the existence of conditional convergence.

The Solow Model without technology

The simple aggregate production function of the Solow model is such as[24]:

$$Y = (K, L) \tag{2.1}$$

- Y – the production
- K – the amount of capital
- L – the amount of labour

The extensive growth is determined by the capital increase by investments and the increase of labour force by demographic effect. The model assumes diminishing marginal returns to capital accumulation. Adding extra capital gives progressively lower and lower increase in output. The stock of capital in the economy varies over time according to :

$$\dot{K} = I - \delta K \tag{2.2}$$

$$= sY - \delta K$$

$$= sF(K, L) - \delta K \tag{2.3}$$

with s- saving rate, I-investment and δ- rate of depreciation

From equation (2.1), the production function in per capita terms becomes:

$$y = f(k) \tag{2.4}$$

with $y = Y/L, k = K/L$

The function (2.4) shows that output per capita depends on capital per worker.

By using the Cobb Douglas function and including the population growth rate as a constant: $n = \dot{L}/L$, the change of capital per worker accumulation function becomes:

$$\dot{k} = sf(k) - (\delta + n)k \tag{2.5}$$

This equation describes the change of capita per worker over the time. There are two sources that affect the change: investment and depreciation of capital. If in a country the quantity of capital did not grow, population growth would lead to a decrease of capital per worker. This negative effect of population growth on capita per worker is known as capital dilution.

[24] Time index are dropped

Ultimately, the result is the decline of output per worker. The higher is n, the lower is the level of capita per worker. In order to maintain the level of capital per worker unchanged, the saving rate must increase by investing a larger fraction of output into building new capital.

The saving rate growth increases temporarily the rate of capital accumulation, but it has no effect on growth on long-term, as the capital depreciation rate and the population growth act as a counter force, dragging down the rate of capital accumulation.
The steady state in the Solow model is conditioned by zero change of the capital stock:

$$\dot{k} = 0 \tag{2.6}$$

From the equation (2.5) the steady-state is derived as the following :

$$sf(k) = (\delta + n)k \tag{2.7}$$

The dynamics of the Solow model is shown in the graph below (Figure 5).
The vertical y-axis represents the level of output per worker, while the horizontal x-axis represents the level of capital per worker.
The steady state is at the intersection of the capital depreciation curve $(\delta + n)k$ and the investment curve $sf(k)$. The steady state level of output and capital is given at y_1^{ss} and k_1^{ss}. Raising the rate of population growth from n_1 to n_2 will result to an upward shift of the capital depreciation curve from $(\delta + n_1)k$ to $(\delta + n_2)k$ which will lead to a lower steady-state level of capital and output y_2^{ss} and k_2^{ss}. This is the consequence of the capital dilution coming into effect. Hence, higher population growth intensifies the dilution of capital per worker and lowers accordingly the steady-state level of output per worker.
The Solow model may provide a potential explanation for why some countries with high population growth rates are poorer than countries with low population growth rates.[25]

[25] To note that technology is not included as it is an exogeneous factor which happens by chance. If by chance, a technological progress take place, the output and the investment function would shift upwards and lead to higher steady-state output and capital.

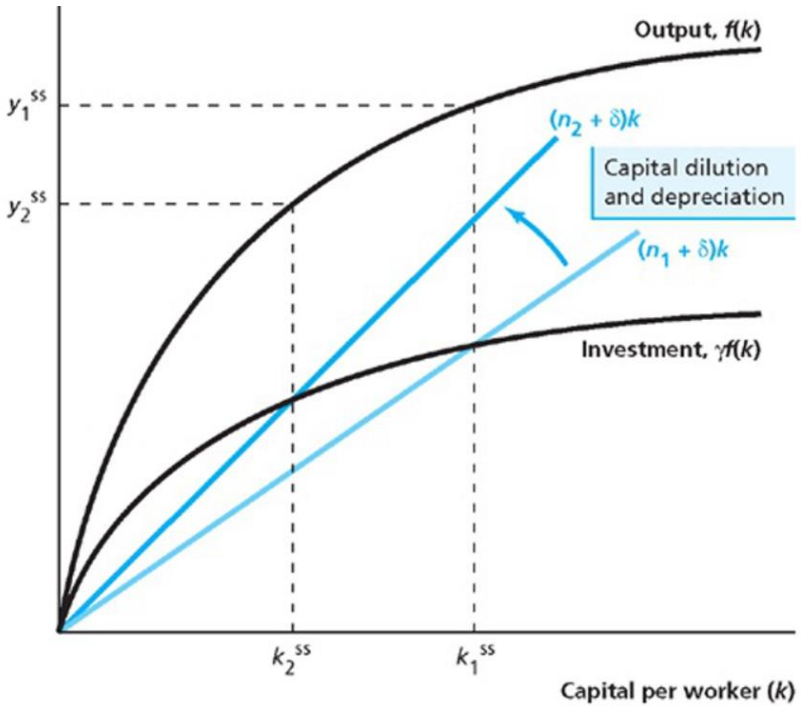


Figure 5: Dynamics of the Solow Model
Source: Weil (2012)

2.2.3 Endogenous Growth Theory

As previously seen, the classical and the neoclassical model, both provide an explanation of how population affects the level of income per capita. Countries with populations that are larger relative to their natural resources will be poorer (Malthus) and countries with rapid growing population will also be poorer because of the effect of capital dilution (Solow). Both models assume a convergence to a long-term steady-state with zero growth rates and that technological progress is independent of economic forces.
The opposite of exogenous growth models are models of endogenous growth which the AK production function[26], which is a linear function of technology (Rebelo 1991). They state that in the long run, economic growth will happen at constant non-zero growth rates, which are determined by the decisions made by economic agents. Hence, the main determinants of the endogenous model are formed inside the model. Endogenous models put emphasize on human

[26] The aggregate AK production function is characterized by either a constant or ever-increasing marginal productivity of capital. The existence of externalities off set the tendency for diminishing marginal product of capital. The output function is as following: $Y = AK$ where A is a positive constant.

capital and positive externalities. Returns to factors of production are no more diminishing but at least constant. Furthermore, the technical level of the economy is the result of investment decisions in innovation and human capital.

So far, human capital was neglected by the classical and neoclassical theory.
They have assumed labour, the human input in the production, as constant and over time: However, in the reality, the quality of labour a worker supplies can vary largely. Worker can differ in productivity, skills, education or physical characteristics. There are great evidence emphasizing a tight connection between investment in human capital and growth (Becker et al.,1990). The costs for education, health and professional development are investments in human capital (Schultz 1961). Hence, human capital drives growth as economic development relies on technological progress driven by scientific knowledge and skills. (Becker et al.,1990). The productivity growth in return, stimulates wages (Mincer 1974).

The production of human capital is capital intensive. In order to produce human capital, more human capital is needed than any other physical output (Hartmann, 2010). A good example is the education sector where human capital is used in form of number of teachers and researchers employed. Furthermore, unlike decreasing returns on physical capital, human capital displays characteristics of positive returns and connection between present human capital and extra human capital (Barro, Sala-I Marti,2004). A perfect example shows that urbanization fosters human capital accumulation as the proximity of people favours absorption of the external effects of human capital (Bertenelli et al., 2003). This implies that in countries which are rich in human capital, the investment in human capital yields higher return than investment in children. Whereas, when human capital is scarce, the return rates of investment on human capital will be lower than investment in children. Consequently, people choose higher fertility rate and invest little in the education per child (Becker et al.,1990). Hence, a country with more resources of educated people will grow faster than a country with a lower level of human capital (Aghion and Howitt 1992). Furthermore, Rosenzweig (1990) rounded the conclusion by showing that countries with high income per capita are characterized by a low birth rate and a high level of human capital.

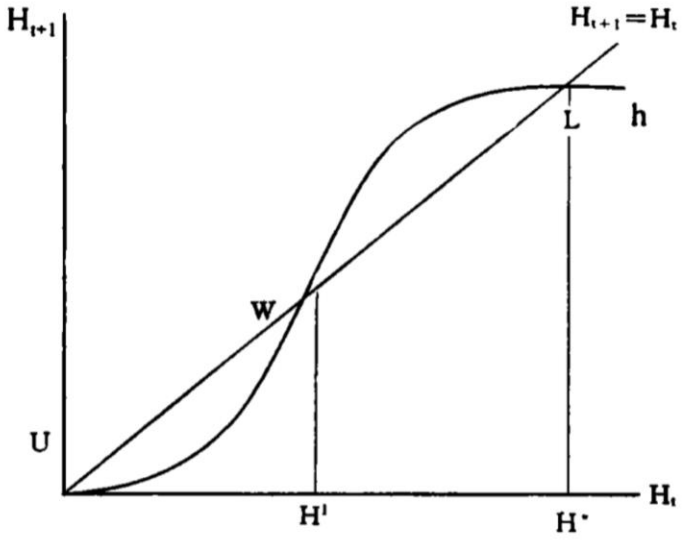


Figure 6: Steady states and human capital endowment

Source: Becker et al. (1990)

Figure 6 illustrates the dynamic growth rate of human capital. The current level of human capital per workers is represented on horizontal axis and future human capital is plotted on the vertical axis. The rate of return on investment in human capital is a function of the current level of human capital. Point U and L are two points in steady growth. When the stock volume of human capital is low, at a point lower than *H'*, the return of investment on human capital is low. This leads to high fertility as raising children becomes cheap. The economy always converges to the lower steady state U.

However, when the current stock of human capital raises above *H'*, the rate of return in investment of human capital raises more than proportionally. The demand for children falls es they become more expensive. Economies converge to point L as the society becomes better educated. Rates of return are low when there is little human capital, whereas when human capital is high the return rates increase progressively up to a point where they may eventually begin to decline as it becomes increasingly difficult to absorb more knowledge (Becker and Murphy,1989).

Galor and Weil (1996) provide an additional explanation for declining fertility in developed economies. The decline of fertility is the result of the reduction of the wage gap between men and women. Due to the raise of per capita income in the economy, the relative wages of women raise gradually leading to an increase of the household income. Having offspring requires parenting and financial support. Consequently, the price of children increases by

proportionally more than the raise of the couple's consolidated income. As a result, fertility will decline.

Further group of endogenous growth models recognizes intellectual capital that grows through technological progress as the main driver for economic growth (Romer,1990). The technical advancement is a result of investment in the research and development sector. Endogenous technical progress can be evidenced in two ways. Firstly, it can be expressed by increasing the number of new varieties of goods used in the production process. Secondly, endogenous technical progress is reflected by improving the quality of existing goods (Barro and Sala-I-Martin, 1995). This theory lays stress on the link between innovation and market power. In order to incentive firms to invest in research and development, one must give them some monopolistic powers which grant extra profits.
Such models may suggest the explanation why institutions play also a key role in fostering economic growth by implementing the right policies. In this case, the policies consist of optimal protection laws for intellectual properties and optimal subsidiaries to encourage research.
In Romer's model, economic growth is dependent on the level of human capital. Countries rich in human capital can develop very quickly, while the shortage of human capital can lead to economic stagnation (Romer 1990).

2.3 Case study and hypothesis

Literatures and theories provide a solid foundation to explain the effect of population changes on economic growth. The purpose of this thesis is to analyse the role of fertility in China's economic growth during the last two decades. Drawing on the reviewed literatures, the thesis has the following hypothesis:

1. The decline of fertility does not only start and advance the demographic transition of a country leading to economic welfare but allows also for more resources to invest on education of children. As a result, enhanced human capital fosters economic growth.
Therefore, fertility might have a negative effect on growth of GRP per capita.

3. Methodology

3.1 Data

For the empirical analysis, this thesis will rely on official Chinese data provided by the National Bureau of Statistics of China[27](NBS) and the China National Knowledge Infrastructure[28](CNKI). Those official data are consolidated in several Statistical Yearbooks[29] published every year. They cover historical key data reflecting the economic and social development of China. The original data is in Chinese. The China National Knowledge Infrastructure offers a translated English version of the database: The China Data Insights. It provides users with easy access to clear tables, figures and titles consolidated from over one thousand kinds of statistical yearbooks. Data from the years 1990,2000 and 2010 are the census year estimates, while the rest are estimates from the annual national sample surveys and are revised according to census results.

The database for this thesis consists of economic and demographical variables of all 31 provinces of China and are extracted from the Statistical Yearbooks of the years 2000 until 2018. (A detailed description of the variables in the database can be found in the annexe 1)

The research of this thesis is based on the following main variables:

- Gross regional product per capita (10 000 yuan)

The gross regional product (GRP) is conceptually equivalent to the gross domestic product (GDP). While the latter measures the market value of all final goods and services that are produced by resident production units in the domestic economy, the gross regional product measures the value market value of all final goods and services produced in a region.

The gross regional product per capita is the value of GRP divided by the total residents of the region. Values per capita are picked with the purpose of explaining a region's scale. As the emphasis is placed on the life quality, it will never be conducive to compare GRP variations of a region with numerous residents to a region with less residents (Hartmann, 2010).

In order to analyse growth, real GRP per capita is needed as it takes into account inflation.

[27] The NBS is the main authority responsible for collecting, investigating, researching and publishing official Chinese statistical data concerning the national economy, population and other aspects of the society.

[28] Project established by Tsinghua University and Tsinghua Tongfang Company on behalf of the World's Bank demand in 1998 to opening up information channels for knowledge, diffusion and utilization across counties.

Thus, the real GRP per capita is used to proxy economic growth.
The real GRP per capita is obtained by deflating the nominal GRP per capita with the deflator of year 2015. The following formula was used :

$$Real\ GRP\ per\ capita = \frac{Nominal\ GRP\ per\ capita}{Deflator/100}$$

The 5 years growth of real GRP per capita has been calculated according the following formula with t as the time index and i as the provinces:

$$5\ years\ Growth_{i,t} = \ln(GRP\ per\ capita_{i,t}) - \ln(GRP\ per\ capita_{i,t-5})$$

- Crude birth rate

The crude birth rate represents the childbirths per 1000 people a year. It is expressed in percentages and refers to the ratio of the number of births to the average population during a year[30]. The annual average population is the average of the number of population at the beginning of the year and that at the end of the year.

- Crude death rate

The crude death rate refers to the number of deaths per 1000 people occurred during a year. It is expressed in percentages and refers to the ratio of the number of deaths to the average population during a year.

- Urbanisation rate

The urbanisation rate refers to the proportion of urban population to the total population in the provinces at year-end. Urban concentration is often linked to the formation of agglomeration economies and productivity gains, which lead to higher economic growth (Cai and Yu,2017). Therefore, this variable might be a relevant factor fostering economic growth.

- Educational attainment composition of employment

Educational attainment composition of employment describes the education level of the employed population. Education attainment is usually used to measure the skills and quality

[30] The folowwing formula is used to obtain the birth rate: $birth\ rate\% = \frac{Number\ of\ births}{average\ population} * 1000$

of labour force. Developed countries depend on a sufficient supply of high skilled workers to promote economic development. For the analysis of this thesis, the proportion of employed people that have graduated from the senior secondary school is used as the proxy for education. In China, graduates of senior secondary school are considered as an educated person[31].

- Age composition

The age composition of a population refers to the proportionate numbers of people and is used to segregate the population based on the age. It is an indication of productivity of the population from an economic point of view. The dependent population and non-working population consist of children and old people[32]. The independent population consist of adults aged from 14 to 65, who represents the active working population.
The age composition of the population has significant impacts as higher proportion of working population is beneficial for the economic development of a country (Bloom and Williamson,1998).

3.1.1 Data quality

Enumerating and gathering data for more than one 1.3 billion people has been a great challenge for China over the years. In the past, four decades ago, the Chinese population was relatively immobile and tightly controlled by the hukou system[33]. Therefore, the data collection was easier. China was even praised for their overall data quality (Coale, 1984). However, with the successive economic liberalization and loosening of migration controls, population mobility inside the country enhanced significantly. More and more people are leaving their registered housing location to live and work in other cities or provinces. As a result, China's statistical systems including the hukou system, sample surveys and censuses

[31] although most graduates will go on to universities or vocational colleges. Given that the competition for limited university places is extremely intense, most high schools are evaluated by their academic performance in Gaokao by parents and students. Gaokao is a standardized prerequisite test for the entrance into higher education institutions.

[32] Aged from 0 to 14 and respectively older than 65.

[33] The hukou system was introduced in 1958 in order to classify the Chinese citizen as rural residents or urban residents. According to their place of origin, every citizen is provided a type of hukoubook, either rural or urban, granting the holder specific rights and entitlements. The hukou is also inherited.

are susceptible to miss or misclassify the moving people. Chinese data quality has been facing possible large under enumeration and critics of researchers. Analyses of the censuses of 1990 and 2000 have shown that a large proportion of births and children were missed (Feeney and Yuan 1996, Lavely 2003, Zhang and Cui,2002). Furthermore, Chinese data on growth of real GDP has been also questioned by Chinese and western authors (Gerards and Yimin 1996, Rawski 2001). Claims of underestimation and falsification of reported data were made. Criticism about data quality inevitably lead to questions about the statistical methods and the organisation of China's institutional statistical authorities.

In the recent years and decades, China has put significant effort to progressively enhance the data quality through restructuring the NBS'[34] internal organisation and functions, promoting closer cooperation with other government departments and improving data collection methods and systems, including new improvements and sophistication of the Chinese security systems with new ID cards and real time identity checks, that allows for more accuracy of the data. The main instruments for data collection are the population census conducted every 10 years (starting from 1990) and the annual 1% population survey.
Holz (2004) who assessed the quality of GDP data, conclude that one may evaluate the allegations of data falsification in certain years, even the critics acknowledge that long-run growth trends are relatively correct. Furthermore, the issues related to general proper assessment of data is not unique to China, as other in transition and developing countries encounter similar difficulties[35].

The recent results of the 2010 census showed that a great proportion of the population data matches with the data from the hukou system. This shows that the newest census is of reasonable quality, even when still containing potential inaccuracy (Cai, 2013).
To conclude, despite the risk of potential inaccuracy and undervaluation of Chinese official statistic data, they are reliable enough for econometric analysis. The proper application of data is essential. If the results are consistent with the prior knowledge, there is a degree of mutual confirmation. If the results are not consistent, further investigations on the data or the prior knowledge is needed to make appropriate corrections.

[34] National Bureau of Statistics of China, China's Official Statistical Agency directly under the leadership of the State Council of the People's Republic of China.

[35] Price issues related to the GDP deflator when evaluating the real GDP.

3.1.2 Data availability

Gaining access to Chinese data can be very challenging.
Even though China has taken initiatives to place more data in the public domain, there are still limits and restrictions regarding the publication of Chinese data, especially for micro-level data. In general, data is not considered as a public good and only high aggregate data is free accessible. Therefore, database provision is seen as a source of revenue for institutions. Underfunded government departments or other institutions sees access fees or the sale of data or any other relevant information as a source to raise revenue for their purposes. Even research institutes share a similar view on their data. Hence researchers and institutes are unlikely to freely contribute their data unless there is a clear benefit for them. (Cook and Keley, 2007).
Another challenge for the data availability is that the Chinese academic culture appears little value on the share of datasets to facilitate research by others. There are several datasets collected by Chinese researchers. However, unless they are part of an international project where data sharing is foreseen in the project, they are generally not in the public domain (Cook and Keley, 2007).
Given these conditions, the database for this thesis was established through the purchase of the access to the CNKI database, China Data Insights. The advantage of such an access is notably the direct provision of quality assured datasets that are already translated into English. Furthermore, the data can be implemented without the need for additional major refurbishing or transformation.

3.2 Empirical Strategy

The aim of this thesis is to determine the effect of the birth rate on economic growth by drawing on provincial data. The analysis is done by using panel data estimation methods. The main method for the analysis is the fixed effect method.
The benefit of the fixed effect is such that it allows to control for all effects that are specifically set for a certain individual and remain all the same. Thus, for the panel data of 31 provinces, the fixed effect takes the unobserved constant differences across provinces into

consideration such as: geographical location, size of provinces and all other fundamental characteristics which remain over time and can have an impact on the dependent variable.

The model of fixed effect is expressed as the following:

$$Y_{i,t} = \alpha_i + \beta_1 X_{i,t} + \mu_{i,t} \quad (3.2.1)$$

With:

- $Y_{i,t}$ being the dependent variable observed for individual i at time t
- $X_{i,t}$ being the independent variables
- β_1 being the coefficients
- α_i being the unobserved constant individual effect
- $\mu_{i,t}$ being the error term

As previously introduced, the fixed effect model eliminates the unobserved constant individual effect by demeaning the variable, such that:

$$Y_{i,t} - \bar{Y}_i = (\alpha_i - \bar{\alpha}_i) + \beta_1(X_{1i,t} - X_{1i}) + \cdots + \beta_n(X_{ni,t} - X_{ni}) + (\mu_{i,t} - \bar{\mu}_i) \quad (3.2.2)$$

where $\bar{Y}$, $\bar{\alpha}$ and $\bar{\mu}$ represent their mean

Since, $\alpha_i = \bar{\alpha}_i$ the effect of the unobserved individual effect is eliminated.
This allows us to run validly the regression with different provinces having their specific characteristics.
To confirm the validity of this method, the Hausman's test will be carried out. The test will put the use of the fixed effect method against the alternative random effect method to define which one is more appropriate. In detail the following situation is presented such that:

- Hypothesis 0 : Random Effect Model $Cor(\alpha_i, x_{i,t}) \neq 0$
- Hypothesis 1: Fixed Effect Model $Cor(\alpha_i, x_{i,t}) = 0$

In a first attempt, the basic regression model consists of two regressor, the ten-year lagged birth rate and the log of GRP per capita with a lag of 5 years.

The reason for the lag of the birth rate is that a change in the rate affects immediately the number of children. However, in order to affect the 5 years growth rate, some time is needed. The same goes for the log of GRP per capita.
In a further analysis, the variable of education is included to see if the magnitude of the birth rate and GRP per capita are weakened or enhanced.
In the third and last stage, other demographic variables are added to the independent variables, such as: the growth of working population, death rate, urbanisation rate and gross dependency ratio and the female education ratio. This gives the conclusive overview on the impact of birth rate on the 5 years growth rate measured on the variation of GRP per capita.

3.3 Model

For the empirical analysis, this thesis specifies the regression model according to recent empirical growth literature (Li and Zhang,2007). The regression model is specified as the following:
On the left-hand side, the dependent variable is defined as the 5 years growth rate of GRP per capita[36] starting from year 1999 to 2018.
In the first part of the analysis, only 2 independent X variables are included on the right-hand side of the regression (3.2.1). The first independent variables X includes the log of the level of GRP per capita with a lag of 5 years. The second independent variables X includes the level of birth rate with a lag of 10 years. To illustrate, the growth rate of the period 1999 until 2004 is on the left side of the equation (3.2.1) and the regressors on the right side of the equation represent the log of the level of GRP in year 1999 and the birth rate from year 1994. The 5 years growth rate covers the scope of 2004 until 2018.

The model (3.2.1) will be rewritten to give the base model:

$$g_{i,t} = \beta 1 \ln (y_{i,t-5}) + \beta 2 \, \text{birth}_{t-10} + \mu \qquad (3.3.1)$$

In a further analysis, education is added to the initial regressors to analyse if the impact of the past birth rate and the past level of GRP on growth is weakened or enhanced.
The second stage model is given as following:

[36] The exact description including the formula for this variable are defined in the data section

$$g_{i,t} = \beta 1 \ln (y_{i,t-5}) + \beta 2 \, \text{birth}_{t-10} + \beta 3 \, \text{education} + \mu \quad (3.3.2)$$

In the last stage, the second stage model (3.3.1) will be extended by several demographic regressors such as urbanization rate, death rate, log of population, labour force and the gross dependency ratio and the ratio of female education.
From the model (3.3.1), the new regression model will be transformed as following:

$$g_{i,t} = \beta 1 \ln (y_{i,t-5}) + \beta 2 \, \text{birth}_{t-10} + \beta 3 \, \text{death} + \beta 4 \, \text{urban} + \beta 5 \, \text{education} + \beta 6 \, \text{female\_edu} + \beta 5 \, \text{pop} + + \beta 6 \, \text{labor force} + \text{gross\_dep\_ratio} + \mu \quad (3.3.3)$$

4. Econometric Results

4.1 Descriptive Analysis

The aim of this section is to get a first overview on the recent evolution trends of the birth rate and death rate in the 31 provinces of China and the relationship to the GRP per capita.
China's social and economic development has been considered as a miracle. China completed the demographic transition within three decades, in much shorter period than the most European countries. However, one should consider the huge regional disparities in China. The Chinese society is often seen as a duel society with segregation between urban and rural residents. Furthermore, disparities exist also between the east, central and west regions. Those disparities led to different level of birth and death rate between regions and provinces.
In general, birth rate and death rate are the lowest in the east region, the highest in the west region and middle in the central regions. Those different socio-economic development encouraged economist to challenge the fact if China has really completed the demographic transition (Li, 2000 and Ye 2001).

In the recent years new evidences has shown that fertility decline more rapidly in the west and central rural regions, closing progressively the gap of disparities.
Therefore, even there are the huge regional differences, demographic transition has already completed in the most part of China (Jiang et al. 2019).
The graphs below show that evolution of the birth and death rate in the 31 Chinese provinces. Indeed, one can notify the differences in the level of the rates between the provinces.

However, one can also notify that the birth rate as well as the death rate are converging to a flatten state. Thus, showing that some Chinese provinces are approaching the completion of the demographic transition while others have already exceeded to stage of post transition.

Figure 7: Evolution of provincial crude birth rates

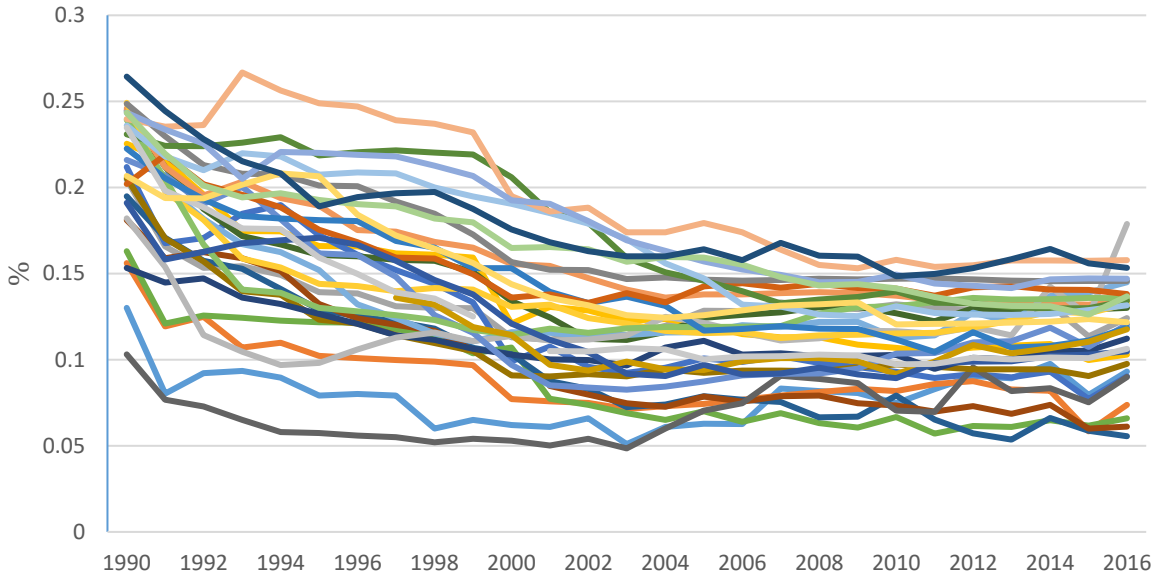
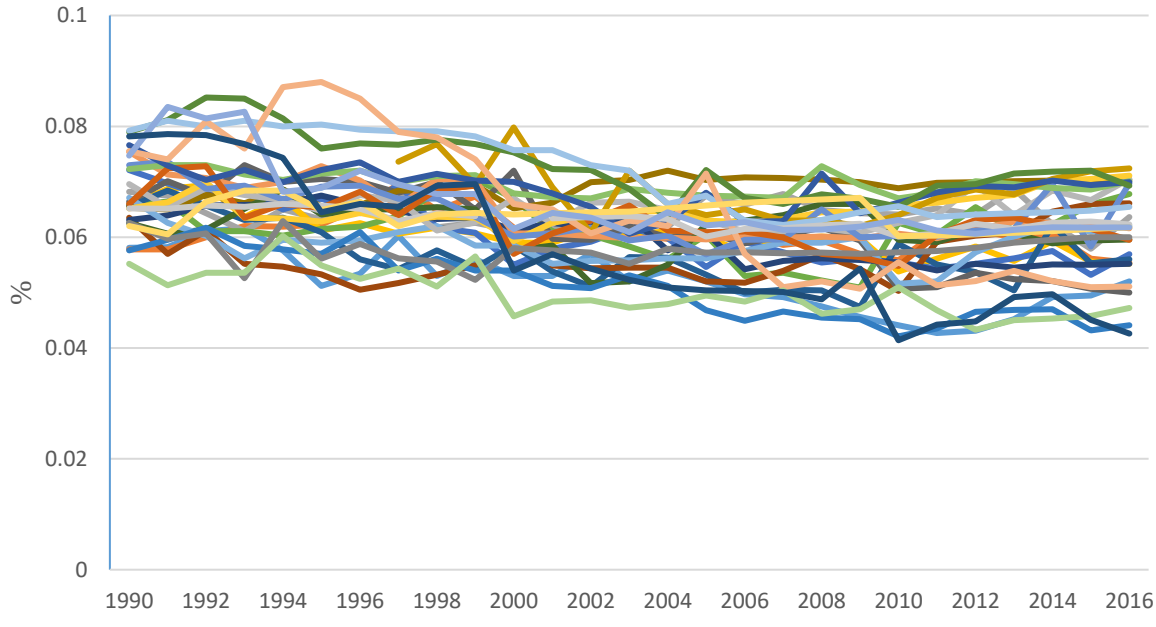


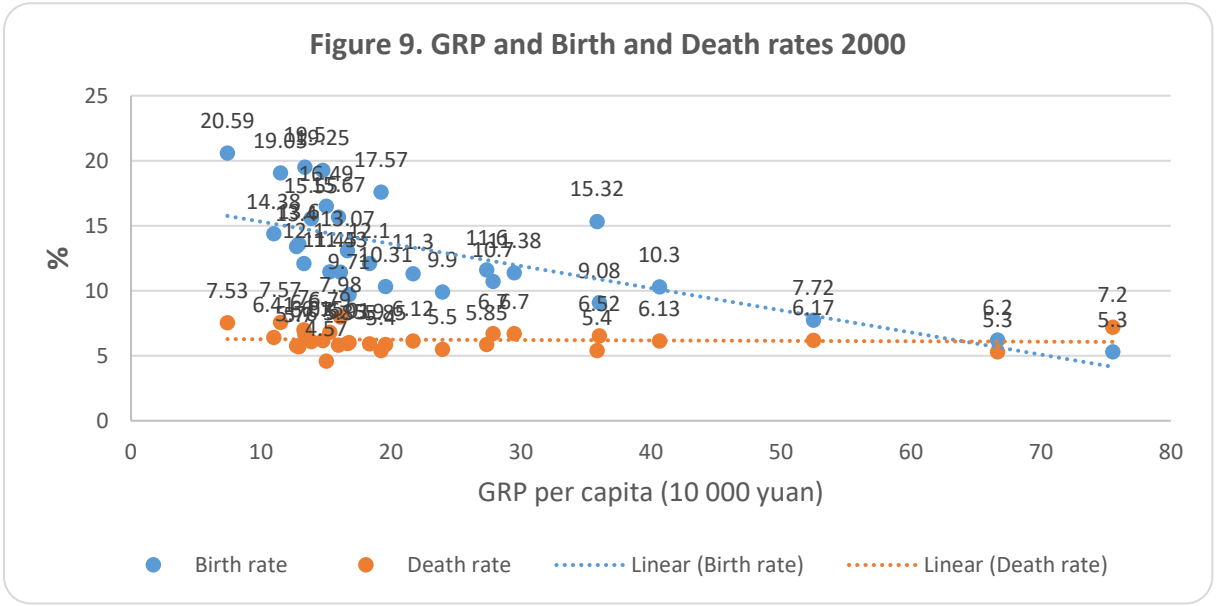
Figure 8: Evolution of provincial crude death rates



The relationship between the birth and death rate and the level of GRP per capita are displayed through snapshots in time of all 31 Chinese provinces. The periods are defined as year 2000,2005,2010 and 2016.

Figure 9 and Figure 10 are the snapshots of the years 2000 and 2005. In those years, the highest level of GRP is associated with the lowest birth rates. Whereas, the lowest level of GRP is associated with the highest birth rates. The majority of the provinces are gathered towards the bottom level of GRP per capita and only some individual provinces are at the top of the ranking. The death rates seem relatively equal across the provinces. They stabilize at around 5.5%.

Thus, it seems that the differences of the birth rates across the provinces explains the differences of the level of GRP.



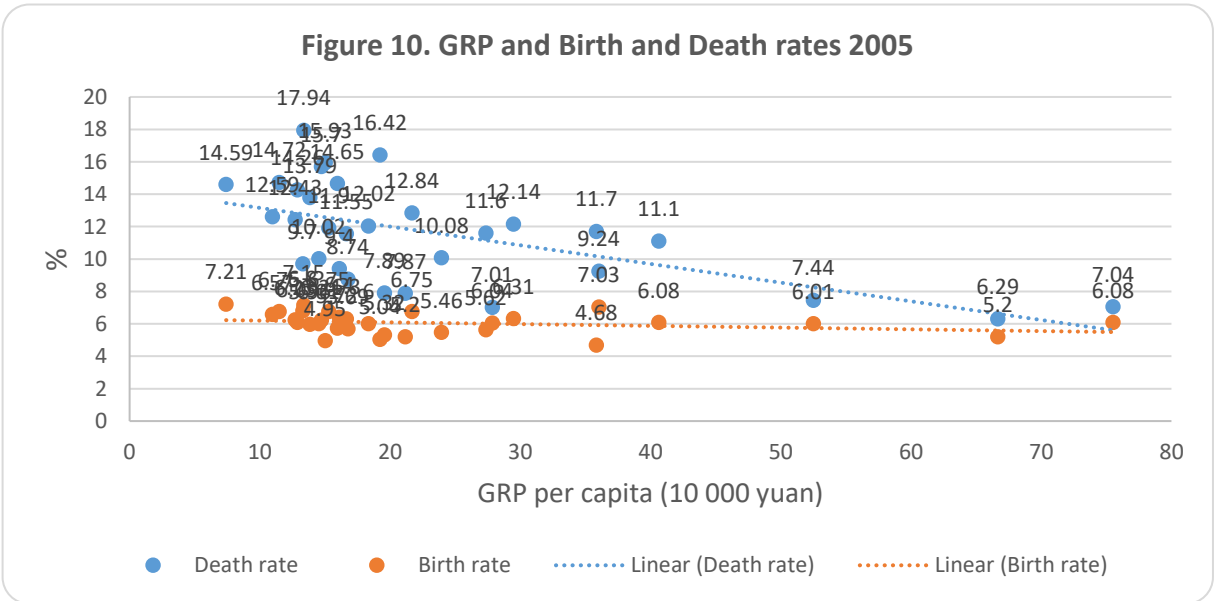
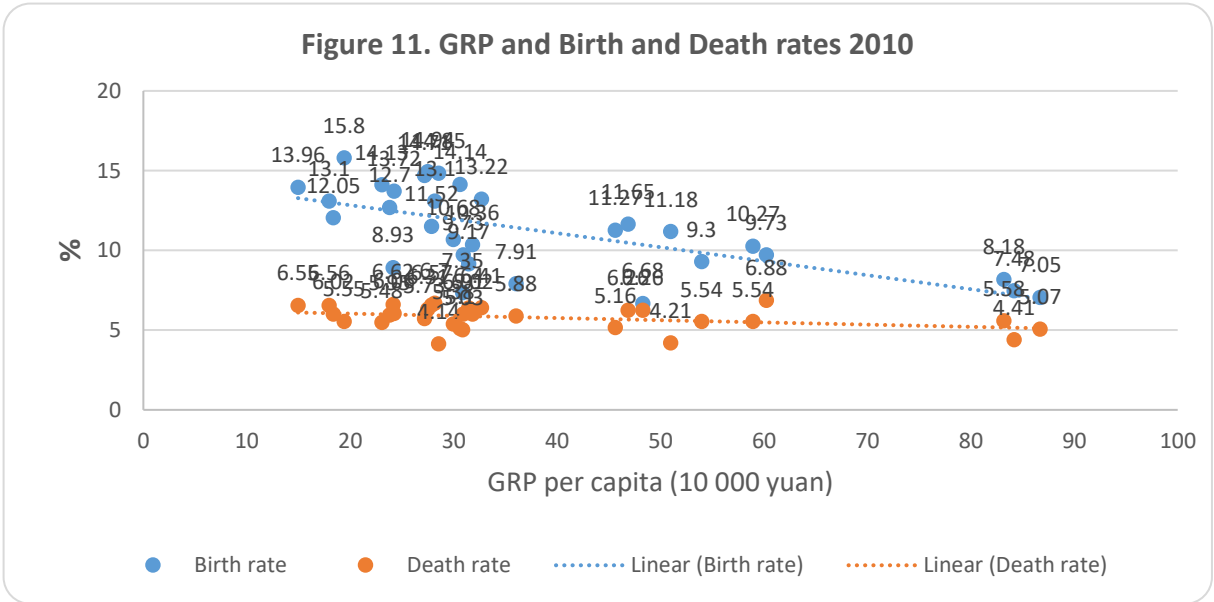
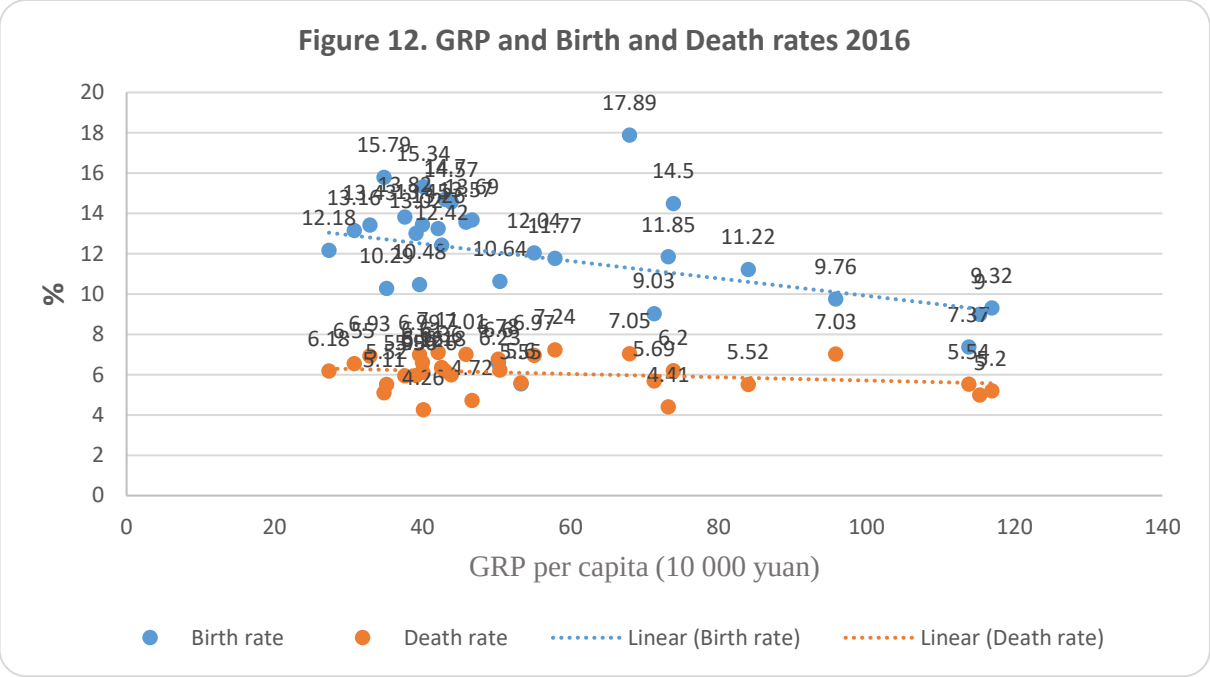


Figure 11 and Figure 12 are the snapshots of the years 2010 and 2016.
The trends are relatively similar to the trends in the previous years. The birth rates continue to decrease while the level of GRP per capita increases progressively. In contrast to the years 2000 and 2005 where the majority of provinces were grouped towards the bottom level of the GRP per capita and only some individual exceptions were leading the top ranking, it is noticeable that more and more provinces catch up with the decline of the birth rates which leads to an increase of their level of GRP.
However, there exist differences in the rates of decline of the birth rates, mostly due to the regional disparities in social economic development. Hence, there are groups of birth rates which have been established. The bottom group of high rates with the low level of GRP per capita, the top group with the low birth rates and high GRP per capita and the middle group in between.
The death rates seem to have reached the limit of decrease and stabilize around 5%. Hence, the impact of birth rate on GRP per capita is still more significant in explaining the different level of GRP per capita.

In general, the displayed link between the death rates and birth rates and the GRP per capita is much in line with the literatures on demographic transition and fertility. As the demographic transition proceeds, decreasing infant mortality reduces fertility as children are likelier to reach adulthood. Parents invest more in their children. This will foster economic growth. As a result, income per capita increases which raises the cost of children. Consequently, fertility declines further as young couples prefer fewer children. (Rosenzweig 1990, Galor and Weil 1996).





4.2 Regression Analysis

This section has the objective to test the impact of the birth rate on economic growth by providing some empirical results to support the previous first findings.
According to the defined strategy of this thesis, the fixed effect method is used to serve the purpose of our objective. The given results were compared to the results of the random effect method. The Hausman's test (with a p-value of 0) confirmed that the null hypothesis can be rejected and thus, fixed effect method is indeed the appropriate method. The results of the Hausman test are given in the annexe 3. The results of the regressions will be presented progressively and reported in one table for a better vision.

In the first attempt, the basic regression is run with the birth rate and the log of GRP per capita as independent variables. Note that the birth rate is lagged for 10 years, while the log GRP per capita is lagged for 5 years. The first regression results are consistent with the hypothesis that the economic growth decreases with the birth rate. It shows that the birth rate and the initial level of GRP per capita have in average a negative effect on growth. It is significant at the 1% level. The results of the first basic regression are reported in the first column (1) of the table below (Table 1).

Table 1. The results of the regressions

	(1) FE	(2) FE	(3) FE
Five-year lagged GRP per capita	-0.571***	-0.542***	-0.599***
	(0.000)	(0.000)	(0.000)
Ten-years lagged birth rate	-0.0226***	-0.0185***	-0.0136***
	(0.000)	(0.000)	(0.001)
Education		0.00629***	0.00372***
		(0.000)	(0.000)
Female education			0.00171
			(0.607)
Death rate			0.0217
			(0.095)
Log population			-0.0426*
			(0.021)
Growth of labor force			0.405*
			(0.042)
Gross dependency ratio			-0.00137
			(0.511)
Urbanisation rate			0.0143***
			(0.000)
Provinces	31	31	31
N	460	398	339
R^2	0.651	0.594	0.6908

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The negative coefficient of the birth rate of 0.0226 indicates that if the birth rate in all the provinces increased by 1% ten years ago, then the average 5 years growth rate decreases by 0.0226 %. The p-value is very small equal to 0, thus the result is significant at the 1% level. The same goes for the lagged GRP per capita. The negative coefficient of 0.571 is significant at the 1% level, given the p-value equal to 0. Furthermore, the regression model indicates a

R-squared[37] of 0.651 meaning that 65% of the changes in the 5 years growth rate are explained by the independent variables, birth rate and GRP per capita.
The results of the first regression are in line with literature on growth theory.
The estimated parameter on lagged GRP is used to test the concept of relative convergence where the coefficient is expected to be negative. The result is in line with the literature on growth theory. The coefficient is interpreted as the rate of convergence. Hence, the result suggests that the poor Chinese provinces converge to the rich ones.

The results of the first regressions are not satisfying since the basic regression may have omitted important variables that may affect growth. Therefore, in the second stage, education is included as an additional independent variable in the regression. Education is heavily linked to foster economic growth (Howitt, 1992). The results of the second stage regression are reported in the second column (2) of table 1.
After having included education as a variable in the model, the coefficients of the birth rate and the lagged GRP per capita increased slightly. They still have a negative effect on growth. The magnitude of the variable birth decreases slightly from (-0.0226) to (-0.0185), which represents a decrease of 0.0041 and remain statistically significant at the 1% level. The coefficient for the lagged GRP per capita variable follows the same pattern. It decreases slightly from 0.571 to 0.542 and remain also significant at the 1% level. The result for education shows a positive relationship to economic growth. The result is in line with the literature (Howitt, 1992). The coefficient of education has the value of 0.00629. That means if the share of secondary school attainments by employed people rose by 1 % in all provinces, then the 5 years growth rate would rise in average by 0.00629%. With a p-value equal to 0, the result is also statistically significant at the 1% level. The fact that education, birth rate and the initial level of GRP per capita are crucially linked to economic growth has already proven by many literatures on growth theory (various endogenous growth models).

In the final stage, the regression model is extended by additional variables including demographic variables.
According to recent researches, the age composition of the population may affect economic growth (Bloom & Williamson 1998, Kelley & Schmidt 2005).

[37] R-squared (R^2) measures the proportion of the variance for a dependent variable that is explained by an independent variable or regressor

Hence, the regression model is extended not only by the urbanization rate and the share of female education, but also by additional demographic variables such as the death rate, the growth rate of the population aged between 15 and 64 and the gross dependency ratio. The results of the regression are reported in the third column (3) of table 2. The results show that by adding additional demographic variables, the negative effect of the birth rate weakens progressively. The coefficient decreases by 0.0185 to 0.0136 (a decrease of 0.0049 points). Which means that if the birth rate rose by 1% in all provinces 10 years ago, the average 5 years growth rate would decrease by 0.0136%. Education decreases by nearly halve compared to the second stage model. The control for urbanisation may weaken the effect of education as urbanisation is linked with human capital accumulation (Bertenelli et al.,2013). The coefficient of the urbanisation rate itself, is highly significant. It shows an impact on growth of 0.0143% when preceded by an increase of 1%.
The growth of the population aged between 15 and 65 is considered as the labour supply of a country. Hence, the variable has a positive effect on growth. If the share of the population aged between 15 and 65 increases by 1% in all provinces, then the average 5 years growth rate increases by 0.405%. The result is statistically significant at the 5% level. Bloom, 1997 pointed the importance of the age structure for the economy of a country.

5. Conclusion and discussion

The aim of this thesis is to analyse the effect of birth rate on China's economic growth during the last two decades. The analysis is conducted by using a data set of 31 Chinese provinces and the econometric fixed effect method. As prior researches, which pointed a negative effect of birth rate on economic growth of an economy, the findings of this thesis indeed show a negative relationship between the birth rate and the economic growth of China during the last two decades.
Nowadays low fertility is quite plausible in China's current socioeconomic context, where the cost of living and raising children is increasingly high notably for education, health and housing. Young couples now prefer to have very few children (Attané et al. 2014).
Although the results and the model of this thesis is consistent with the current literature, they present several limitations to put the results in perspective.

First of all, the magnitude of the effect of the birth rate can be challenged. Bloom and Williamson (1998) showed that the age structure have an effect on economic growth. Since

the variables that are associated with the age structure, notably the growth of the labour force und the dependency ratio, are added to the model, they may consequently reduce the explanatory power of the birth rate. In fact, it is likely that through these population-structure variables the birth rate exerts its effect on growth.

Secondly, the model of this thesis does not include any variables for institutional fertility control policies that affect the process of fertility decline. China's Great Leap Forward[38] and the One Child Policy play an important role in the decline process (Liu and Yang 1989). Including variables for public spending can impact the magnitude of the birth rate effect.

Thirdly, the quantification of education in this model can be improved. To quantify education, this thesis relies on the composition of educational attainment of employed people. This proxy for education is suboptimal as it does not clearly indicate the investment in human capital at the first degree. A better representative measurement would be the rate of secondary school enrolment. This would better display the human capital level of the population
Furthermore, the thesis does not include any physical capital investment measures which might weaken or enhance the effect of the birth rate on economic growth

There are several suggestions to deepen the analysis of this thesis.
First, the average effect of the birth rate can be decomposed by regrouping provinces according to their geographical locations and GRP level. Due to the socio-economic disparities between the regions, the impact of birth rate on the economic growth of certain regions may differ.
Another suggestion might be the assessment of the causality and inverse causality question. The results of the thesis can only validate the negative relationship between the birth rate and the growth rate but not the causal effect. The assessment of the inverse causality can be challenged. Economic development can be the reason for the fertility decline. As the income per capita increases, the cost of children raises and consequently reduces the fertility.
A way of assessment would be to include a measurement of public investment or foreign direct investments and to verify their magnitude of impact.

[38] the Great Leap Forward was as an economic and social campaign from 1958 to 1962. The aim was to restructure the country into a communist society. Many exaggerated quotas for agriculture output were set. The fulfilment of those quotas was forcefully ensured which led to many deaths because of the shortage of food for the farmers. As a result, family sizes were kept small.

Reference

Accinelli, E., & Brida, J. G. (2007). Population growth and the Solow-Swan model. *International Journal of Ecological Economics and Statistics, 8*(S07), 54-63.

Attané, I., & Gu, B. (2014). *Analysing China's Population: Social Change in a New Demographic Era* (Vol. 3): Springer.

Barlow, R. (1994). Population Growth and Economic Growth: Some More Correlations. *Population and development review, 20*(1), 153-165. doi:10.2307/2137634

Becker, G., Murphy, K., & Tamura, R. (1990). Human Capital, Fertility, and Economic Growth. *Journal of Political Economy, 98*, 12-37.

Becker, G., Murphy, K., & Tamura, R. (1990). Human Capital, Fertility, and Economic Growth. *Journal of Political Economy, 98*, 12-37.

Bertinelli, L. (2003). *Does urbanization always foster human capital accumulation?* Retrieved from

Bertinelli, L., & Black, D. (2004). Urbanization and growth. *Journal of Urban Economics, 56*(1), 80-96. doi:10.1016/j.jue.2004.03.003

Bertinelli, L., & Zou, B. (2008). Does Urbanization Foster Human Capital Accumulation? *The Journal of Developing Areas, 41*(2), 171-184. Retrieved from www.jstor.org/stable/40376183

Bloom, D. E., Canning, D., & Malaney, P. N. (2000). Population Dynamics and Economic Growth in Asia. *Population and development review, 26*, 257-290. Retrieved from www.jstor.org/stable/3115219

Bloom, D. E., Canning, D., & Sevilla, J. (2001). *Economic growth and the demographic transition* (0898-2937). Retrieved from

Bloom, D. E., & Freeman, R. B. (1988). Economic development and the timing and components of population growth. *Journal of Policy Modelling, 10*(1), 57-81. doi:https://doi.org/10.1016/0161-8938(88)90035-X

Bloom, D. E., & Williamson, J. G. (1998). Demographic transitions and economic miracles in emerging Asia. *The World Bank Economic Review, 12*(3), 419-455.

Brewe, A. (2010). *The making of the classical theory of economic growth*: Taylor & Francis Group.

Cai, F. (2010). Demographic transition, demographic dividend, and Lewis turning point in China. *China Economic Journal, 3*(2), 107-119.

Cai, Y. (2010). China's below-replacement fertility: Government policy or socioeconomic development? *Population and development review, 36*(3), 419-440.

Cai, Y. (2013). China's New Demographic Reality: Learning from the 2010 Census. *Population and development review, 39*(3), 371-396. doi:10.1111/j.1728-4457.2013.00608.x

Caldwell, J. C. (1980). Mass Education as a Determinant of the Timing of Fertility Decline. *Population and development review, 6*(2), 225-255. doi:10.2307/1972729

Caldwell, J. C. (2007). *Demographic transition theory*: Springer.

Choudhry, M. T., & Elhorst, J. P. (2010). Demographic transition and economic growth in China, India and Pakistan. *Economic Systems, 34*(3), 218-236. doi:https://doi.org/10.1016/j.ecosys.2010.02.001

Chow, G. (2007). *China's Economic Transformation* (2 ed.): Blackwell Publishing.

Coale, A. (1984). *Committee on Population and Demography, Report No. 27*. Retrieved from National Academy Press:

Cook, D. S., & Keeley, J. (2007). *Micro-data scoping study-China*. Retrieved from Economic and Social Research Council, U.K. :

Craig, J. (1994). Replacement level fertility and future population growth. *Population Trends*(78), 20-22. Retrieved from http://dx.doi.org/

De la Croix, D. Economic Growth.

Donaldson, L., & Donaldson, P. (1991). *Fertility Transition: The Social Dynamics of Population Change*: B. Blackwell.

Fang, C., & Yu, D. (2017). Urban agglomeration: An evolving concept of an emerging phenomenon. *Landscape and Urban Planning, 162*, 126-136. doi:https://doi.org/10.1016/j.landurbplan.2017.02.014

Feng, W., Cai, Y., & Gu, B. (2013). Population, policy, and politics: how will history judge China's one-child policy? *Population and development review, 38*, 115-129.

Furuoka, F. (2009). Population Growth and Economic Development: New Empirical Evidence from Thailand. *Economics Bulletin, 29*, 1-14.

Galor, O. (2005). Chapter 4 From Stagnation to Growth: Unified Growth Theory. In P. Aghion & S. N. Durlauf (Eds.), *Handbook of Economic Growth* (Vol. 1, pp. 171-293): Elsevier.

Galor, O. (2005). The demographic transition and the emergence of sustained economic growth. *Journal of the European Economic Association, 3*(2-3), 494-504.

Grover, D. (2014). *What is the Demographic Transition Model*?

Hao, Y. (2012). *Essays on China's Economic Growth and Regional Economic Development.* (Phd Essay). University of Hamburg, Retrieved from https://d-nb.info/1026332907/34

Higgins, M. (1998). Demography, National Savings, and International Capital Flows. *International Economic Review, 39*(2), 343-369. Retrieved from https://EconPapers.repec.org/RePEc:ier:iecrev:v:39:y:1998:i:2:p:343-69

Howitt, P. (2010). *Endogenous growth theory*: Palgrave Macmillan UK.

Ji, J. (2003). An Assessment of the Demographic Transition in China. *Journal of Developing Societies, 19*(1), 1-25. doi:10.1177/0169796x0301900101

Jiang, Q., Yang, S., Li, S., & Feldman, M. W. (2019). The decline in China's fertility level: a decomposition analysis. *Journal of biosocial science, 51*(6), 785-798.

Jiani, M. A. (2017). Why and how international students choose Mainland China as a higher education study abroad destination. *Higher Education, 74*(4), 563-579. doi:10.1007/s10734-016-0066-0

Kirk, D. (1996). Demographic transition theory. *Popul Stud (Camb), 50*(3), 361-387. doi:10.1080/0032472031000149536

Kuznets, S. (1973). Modern Economic Growth: Findings and Reflections. *The American Economic Review, 63*(3), 247-258. Retrieved from www.jstor.org/stable/1914358

Lanza, V. (2012). *The Classical Approach to Capital Accumulation*

(Bachelor). UMEA,

Lewis, W. A. (2013). *Theory of economic growth*: Routledge.

Li, H., & Zhang, J. (2007). Do High Birth Rates Hamper Economic Growth? *The Review of Economics and Statistics, 89*(1), 110-117.

Li, Y. (2016). The Relationship between Fertility Rate and Economic Growth in Developing Countries.

Lin, J., Cai, F., & Li, Z. (1998). The China Miracle: Development Strategy and Economic Reform. *The China Journal, 4*. doi:10.2307/2667712

Liu, T.-Y., Su, C. W., & Jiang, X.-Z. (2015). Is economic growth improving urbanisation? A cross-regional study of China. *Urban Studies, 52*(10), 1883-1898. Retrieved from https://journals.sagepub.com/doi/abs/10.1177/0042098014540348

Malthus, T. R., Winch, D., & James, P. (1992). *Malthus: 'An Essay on the Principle of Population'*: Cambridge University Press.

Mincer, J. (1974). *Progress in Human Capital Analysis of the distribution of earnings* (0898-2937). Retrieved from

Novales, A., Fernández, E., & Ruíz, J. s. (2009). *Economic Growth Theory and Numerical Solution Methods*: Springer.

OpenStax. (2016). *Principles of Economics*. Retrieved from https://opentextbc.ca/principlesofeconomics/chapter/20-2-labor-productivity-and-economic-growth

Paresh, K. N., & Russell, S. (2006). Higher Education, Real Income and Real Investment in China: Evidence from Granger Causality Tests. *Education Economics, 14*(1), 107-125. doi:10.1080/09645290500481931

Paxson, C. (1996). Saving and growth: Evidence from micro data. *European Economic Review, 40*(2), 255-288. Retrieved from https://EconPapers.repec.org/RePEc:eee:eecrev:v:40:y:1996:i:2:p:255-288

Piętak, Ł. (2014). Review of Theories and Models of Economic Growth. *Comparative Economic Research, 17*. doi:10.2478/cer-2014-0003

Popa, F. (2014). ELEMENTS OF THE NEOCLASSICAL GROWTH THEORY. *STUDIES AND SCIENTIFIC RESEARCHES*(20). doi:10.29358/sceco.v0i20.296

Purdy, M. (2013). China's Economy, in Six Charts. *Harvard Business Review*. Retrieved from https://hbr.org/2013/11/chinas-economy-in-six-charts

Rosenzweig, M. (1990). Population Growth and Human Capital Investments: Theory and Evidence. *Journal of Political Economy, 98*(5), S38-70. Retrieved from https://EconPapers.repec.org/RePEc:ucp:jpolec:v:98:y:1990:i:5:p:s38-70

Ross, J. (2004). Understanding the Demographic Dividend. *Policy Project*. Retrieved from http://www.policyproject.com/pubs/generalreport/demo_div.pdf

Sala-i-Martin, X. X., & Barro, R. J. (1995). *Technological diffusion, convergence, and growth*. Retrieved from

Scharping, T. (2013). *Birth Control in China 1949-2000: Population policy and demographic development*: Routledge.

Thirlwall, A. (1994). Population Growth and Economic Development. In (pp. 143-167).

Truesdell, D. (2012). *China's demographic limits to economic growth.* (Postgraduate). Naval Postgraduate School,

UN. (2015). *World Fertility Report 2015 - Highlights*. Retrieved from https://www.un.org/en/development/desa/population/publications/pdf/fertility/worldFertilityReport2015_highlights.pdf

Wanjun, Y., Kinugasa, T., & Hamori. (2013). An empirical analysis of the relationship between economic development and population growth in China. *Applied Economics, 45*. doi:10.1080/00036846.2013.795284

Wei, S.-J. (1995). The open-door policy and China's rapid growth: evidence from city-level data. In *Growth Theories in Light of the East Asian Experience, NBER-EASE Volume 4* (pp. 73-104): University of Chicago Press.

Weil, D. (2012). *Economic Growth : International Edition*. London, UNITED KINGDOM: Taylor & Francis Group.

Whyte, M. K., Feng, W., & Cai, Y. (2015). Challenging myths about China's one-child policy. *The China Journal*(74), 144-159.

Xia, C., Ding, C., Zheng, R., Zhang, S., Zeng, H., Wang, J., . . . Chen, W. (2017). Trends in geographical disparities for cervical cancer mortality in China from 1973 to 2013: A subnational spatial-temporal study. *Chinese Journal of Cancer Research, 29*, 487-495. doi:10.21147/j.issn.1000-9604.2017.06.03

Yang, L. (2013). China's Growth Miracle: Past, Present, and Future. *United Nation Research Institute for Social Development, 7*.

Zhang, J., & Chen, J. (2017). Introduction to China's new normal economy. *Journal of Chinese Economic and Business Studies, 15*(1), 1-4. doi:10.1080/14765284.2017.1289454

Annexes

Annexe 1: Database summary

Variable	Obs	Mean	Std. Dev.	Min	Max
year	899	2004	8.371257	1990	2018
province	0				
id	899	16	8.949251	1	31
birth_rate	828	13.38465	4.410086	4.85	26.68
death_rate	828	6.227633	.7730171	4.14	8.8
age0_14	527	18256.53	42688.69	73	309790
age15_64	527	74015.09	168920.3	168	1288354
age65_over	527	9950.222	23806.51	12	178471
gross_dep_~o	527	35.29142	8.681563	8.61	57.58
child_dep_~o	527	30.33273	16.90398	9.64	82.68
old_dep_ra~o	527	12.0349	3.092308	4.33	21.88
male_edu	465	55.49062	2.508997	48.6	63.8
female_edu	465	44.50951	2.509338	36.2	51.4
no_educ	465	5.638602	7.047556	.2	55.1
primarysch~l	465	24.35424	10.20076	2.4	58.1
junior_sch~l	465	43.33546	9.499852	6.1	59.6
senior_sch~l	465	13.94426	5.197105	.7	36.1
college	465	6.894882	3.574683	.3	19.77
undergradu~e	465	4.581699	4.436229	0	29.5
graduate	465	.4634409	.9570806	0	7.87
grp_per_ca~a	620	34.86519	24.18561	4.46	129.77
urban_rate	372	51.45331	14.72396	20.85	89.6
population	496	110395.3	239133	2556	1681666
ln_grp_cap~a	620	3.318476	.6999115	1.495149	4.865764
gdp_5ylag	465	3.112513	.6570488	1.495149	4.614724
birth_10lag	580	14.24521	4.714625	4.85	26.68
log_popula~n	496	10.6115	1.261965	7.846199	14.3353
growth_5y	465	.4429467	.1596363	-.1524196	.9512262
education	465	81.63396	9.323497	36.52	93.1
highedu	465	11.94002	8.654311	.3	55.87

Annexe 2: Chinese provinces and division into geographical regions

Source: Zhang et al.,2017.Trends in geographical disparities for cervical cancer mortality in China from 1973 to 2013: A subnational spatio-temporal study - Scientific Figure on ResearchGate.
Available from: https://www.researchgate.net/figure/Schematic-diagram-of-the-division-of-China-into-seven-geographical-regions_fig1_322362241

Annexe 3: Hausman Test

	Coefficients (b) fe	(B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
gdp_5ylag	-.5711324	-.2858523	-.2852801	.0363468
birth_10y	-.0225925	-.0178754	-.0047171	.0015971
year				
2005	.0575413	.0398536	.0176877	.
2006	.1225851	.0873064	.0352787	.
2007	.1860555	.1275893	.0584662	.0033184
2008	.2310743	.144445	.0866293	.00965
2009	.2551047	.1402851	.1148196	.0144661
2010	.2932828	.1529568	.1403261	.0190957
2011	.3420936	.1753876	.166706	.0230607
2012	.363764	.1643273	.1994367	.0275682
2013	.3823626	.1560498	.2263128	.0313922
2014	.4099651	.159398	.250567	.0344505
2015	.4077046	.1243448	.2833599	.0385315
2016	.4136038	.1016645	.3119393	.0423
2017	.4142655	.078839	.3354265	.0452046
2018	.4249423	.0693746	.3555676	.0478394

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(16) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 66.86
Prob>chi2 = 0.0000
(V_b-V_B is not positive definite)

Rejection of the null hypothesis of random effect model as the p-value is 0.000.

Hence, the fixed effect model is appropriate

Annexe 4: Stata output

First stage model

```
. eststo: xtreg growth5y gdp_5y birth_10y i.year, fe

Fixed-effects (within) regression               Number of obs      =       460
Group variable: id                              Number of groups   =        31

R-sq:                                           Obs per group:
     within  = 0.6508                                         min =        12
     between = 0.4067                                         avg =      14.8
     overall = 0.3588                                         max =        15

                                                F(16,413)          =     48.12
corr(u_i, Xb)  = -0.8429                        Prob > F           =    0.0000
```

growth5y	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
gdp_5ylag	-.5711324	.0454346	-12.57	0.000	-.6604442	-.4818205
birth_10y	-.0225925	.0034323	-6.58	0.000	-.0293395	-.0158456
year						
2005	.0575413	.0225093	2.56	0.011	.0132942	.1017885
2006	.1225851	.0231162	5.30	0.000	.077145	.1680252
2007	.1860555	.0242792	7.66	0.000	.1383292	.2337818
2008	.2310743	.0264772	8.73	0.000	.1790274	.2831212
2009	.2551047	.0293213	8.70	0.000	.1974671	.3127423
2010	.2932828	.0331293	8.85	0.000	.2281599	.3584058
2011	.3420936	.0361278	9.47	0.000	.2710763	.4131109
2012	.363764	.0401683	9.06	0.000	.2848041	.4427239
2013	.3823626	.0438273	8.72	0.000	.2962102	.468515
2014	.4099651	.0468552	8.75	0.000	.3178606	.5020695
2015	.4077046	.0510809	7.98	0.000	.3072936	.5081156
2016	.4136038	.0550749	7.51	0.000	.3053418	.5218658
2017	.4142655	.058272	7.11	0.000	.2997188	.5288122
2018	.4249423	.0611651	6.95	0.000	.3047086	.5451759
_cons	2.231736	.1423374	15.68	0.000	1.95194	2.511532
sigma_u	.18508884					
sigma_e	.08600331					
rho	.82243026	(fraction of variance due to u_i)				

```
F test that all u_i=0: F(30, 413) = 10.94                     Prob > F = 0.0000
```

Second stage model

```
. eststo:xtreg growth5y gdp_5y birth_10y education i.year, fe

Fixed-effects (within) regression               Number of obs      =       398
Group variable: id                              Number of groups   =        31

R-sq:                                           Obs per group:
     within  = 0.5942                                         min =        10
     between = 0.4288                                         avg =      12.8
     overall = 0.3394                                         max =        13

                                                F(15,352)          =     34.36
corr(u_i, Xb)  = -0.8959                        Prob > F           =    0.0000
```

growth5y	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
gdp_5ylag	-.5415323	.047044	-11.51	0.000	-.634055	-.4490095
birth_10y	-.0185245	.0037296	-4.97	0.000	-.0258597	-.0111894
education	.0062875	.0011373	5.53	0.000	.0040508	.0085241
year						
2005	.0682713	.0198477	3.44	0.001	.0292363	.1073063
2006	.1262521	.0205956	6.13	0.000	.0857462	.1667581
2007	.1828503	.0221672	8.25	0.000	.1392535	.2264471
2008	.2228273	.0249676	8.92	0.000	.173723	.2719317
2009	.2477736	.0286603	8.65	0.000	.1914066	.3041405
2010	.2951773	.033793	8.73	0.000	.2287156	.3616389
2011	.348503	.0379061	9.19	0.000	.2739521	.4230538
2012	.3702067	.0426895	8.67	0.000	.2862483	.4541652
2013	.3925517	.0472132	8.31	0.000	.2996962	.4854072
2014	.4289456	.0510863	8.40	0.000	.3284728	.5294184
2015	.4758049	.0591229	8.05	0.000	.3595263	.5920835
2016	.4813162	.0634554	7.59	0.000	.3565169	.6061156
_cons	1.563424	.179168	8.73	0.000	1.211049	1.915798
sigma_u	.2068642					
sigma_e	.0741717					
rho	.88608493	(fraction of variance due to u_i)				

```
F test that all u_i=0: F(30, 352) = 14.01                     Prob > F = 0.0000
```

Final stage model

```
. eststo:xtreg growth5y gdp_5y birth_10y education female_edu death log_population labor gross_dep_ratio urban i.year

Random-effects GLS regression                   Number of obs     =       339
Group variable: id                              Number of groups  =        31

R-sq:                                           Obs per group:
     within  = 0.6908                                         min =         9
     between = 0.3065                                         avg =      10.9
     overall = 0.4205                                         max =        11

                                                Wald chi2(19)     =    576.92
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =    0.0000
```

growth5y	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
gdp_5ylag	-.5993821	.0475484	-12.61	0.000	-.6925752	-.506189
birth_10y	-.0135616	.0040112	-3.38	0.001	-.0214233	-.0056999
education	.0037243	.0010404	3.58	0.000	.0016852	.0057635
female_edu	.0017102	.003324	0.51	0.607	-.0048047	.0082251
death	.0216812	.0129951	1.67	0.095	-.0037888	.0471512
log_population	-.0425676	.0184104	-2.31	0.021	-.0786514	-.0064838
labor	.4054053	.1995095	2.03	0.042	.0143739	.7964367
gross_dep_ratio	-.0013696	.0020838	-0.66	0.511	-.0054538	.0027145
urban_rate	.0143126	.0019204	7.45	0.000	.0105487	.0180766
year						
2006	2.06474	1.053824	1.96	0.050	-.0007178	4.130197
2007	1.043957	.5272686	1.98	0.048	.0105295	2.077385
2008	1.07922	.5293351	2.04	0.041	.0417426	2.116698
2009	1.100138	.5295531	2.08	0.038	.062233	2.138043
2011	.3004111	.1112746	2.70	0.007	.0823168	.5185053
2012	1.190519	.5334788	2.23	0.026	.1449193	2.236118
2013	1.198256	.5305682	2.26	0.024	.1583614	2.238151
2014	1.214388	.5287563	2.30	0.022	.1780443	2.250731
2015	.1742898	.0782898	2.23	0.026	.0208447	.3277349
2016	2.415064	1.107645	2.18	0.029	.2441193	4.586008
_cons	.6027043	.6154021	0.98	0.327	-.6034616	1.80887
sigma_u	.07585444					
sigma_e	.06438092					
rho	.58127214	(fraction of variance due to u_i)				