BIRTH RATE'S EFFECT ON ECONOMIC GROWTH—
A STUDY FOCUSING ON CHINA'S FAMILY PLANNING POLICY

A THESIS

Presented to

The Faculty of the Department of Economics and Business

The Colorado College

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Arts

By

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May 2017

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A Study Focusing on China's Family Planning Policy

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May 2017

Mathematical Economics

Abstract

This paper examines the birth rate's effect on economic growth focusing especially on China from the year 1979 to the year 2014 since this was the period when the one-child policy was applied. This study uses a panel dataset that contains data of 28 Chinese provinces and uses Fixed Effect and system GMM as the main estimation methods to conduct an empirical analysis. Also, this research uses the rate of people who only have one child as an instrumental variable to control for the endogeneity of the birth rate for the year 2000 to the year 2010. The results suggest that birth rate has no significant effect on the growth of GDP. Although this result is not consistent with the results of some previous research that birth rate has a positive effect on economic growth, it suggests some possible reasons for the introduction of the new two-child policy in December 2015.

KEYWORDS: (Panel Data models, IV Estimation, Birth Rate, Family Planning)
JEL CODES: C33, C36, J13

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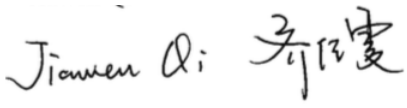

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Acknowledgement

I would like to thank my advisor, Pedro de Araujo, for all of your help since my Sophomore year. Those hard tasks that you gave me really pushed me to be a better person.

I would also like to thank the writing center specialist, Roy Jo Sartin, for always being helpful and for all of your encouragements when I lost confidence in myself.

Finally, I want to thank my families and friends for always being supportive and for continuing to believe in me.

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Introduction

The purpose of this paper is to analyze the impact of birth rate on Economic Growth in China from the year 1979 to the year 2014. Previous research has shown that the one-child policy of China is growth enhancing, but the Chinese government recently changed the family planning policy to allowing each family to have two children. This study aims to do an empirical research and find if there are any economic reason behind this policy change.

China started applying the one-child policy in 1979 because of the rapid population growth during the 1950s and 1960s. The population had risen from 540 million people in the 1950s to 850 million people in the 1970s (Zhu, 2003). The government started to encourage people to have less children and get married at a later age. However, it was not enough to control the sharp growth of population because at that time, the babies that were born in the 1950s and 1960s were about to enter the labor force and approximately more than 60% of the population were under 30 years old (Zhu, 2003). Thus, the one-child policy was officially introduced. Although some exceptions were allowed, for example minority groups did not have to follow the one-child policy, for most families, they would be penalized for having more than one child. The one-child policy did bring many advantages to the Chinese society. It not only controlled the dramatic population growth rate successfully, but also decreased the high demand for natural resources and raised the overall quality of life and education. Moreover, the one-child policy freed mothers from pregnancy and gave them more opportunity to work outside the home and gain skills, which helped relieve the problem of gender imbalance in the work force (Zhu, 2003).

Economically, Li and Zhang's 2007 empirical research on the impact of the birth rate on economic growth in China uses a panel provincial-level data of years 1978-1998. They pay attention to China's one-child policy and conclude that the birth rate has a significant negative effect on economic growth. Their result supports that China's one-child policy was good for economic growth (Li & Zhang, 2007).

However, the new two-child policy was passed by The Standing Committee of the National People's Congress of China on December 27th 2015 and effective from January 1st 2016. In the new policy statement, it was said that allowing Chinese couples to have two children would help address the anticipated problem of population ageing (Bo, 2015). The potential economic effect of this new two-child policy is not consistent with the result of the previous research. Also, some previous papers suggested that fertility rate and economic growth have a non-linear relationship (Luci & Thevenon, 2010; Dominiak et al., 2014).

The main aim of this research is using an updated dataset from years 1979 to 2014 to build an empirical model and re-analyze the impact of birth rate on economic growth in China while taking the non-linear relationship into account. Since birth rate is endogenous, this research uses Fixed Effect and General Method of Moments as the main estimation methods to deal with the endogeneity problem. The family planning rate, which is the rate of people obeying the one-child policy, is used as an instrumental variable. This instrumental variable is only applied to the model from the year 2000 to the year 2010 due to the availability of the data.

The regression result suggests that birth rate has a negative but insignificant effect on the economic growth. This result indicates that from an updated dataset, the one-child

policy is no longer birth enhancing and provides some possible reason for the implementation of the new second-child policy.

The rest of the paper takes the following structure. In Literature Review, the past studies suggest that birth rate has a negative effect on economic growth which leads to the purpose of this research that why would the policy changed. In the Data section, the data source and the descriptive statistics are discussed. In the Empirical Methodology section, the theoretical model and empirical methods are explained. Finally, the Result and the Conclusion proposed the result from the regression and link this result to possible reasons for the policy change. Also, these two sections discuss the limitations about this study and areas for further research.

Literature Review

The discussion about the relationship between population and economic growth started with the publication of Thomas Malthus's book *An Essay on the Principal of Population* in 1798. In this book, he argues that when population keeps growing and eventually the food production will not be able to match the demand, human beings will face the problem of outgrowing the carrying capacity (Malthus, 1959). Thus, he concludes that population has a negative effect on economic growth. However, Malthus does not anticipate the innovations in agriculture that made food production a lot faster. Over 150 years later, a Danish economist Ester Boserup takes these technology advances into account and challenges Malthus's theory. She disagrees with the statement that the population will be limited by the amount of food produced and argues that the food production would continue to catch up to the need of human beings. The threat of outgrowing carrying capacity will motivate people to invent new technologies in order to produce more food (Boserup, 2014). Malthus's idea forms the foundation for Li and Zhang's (2007) paper, but the change in China's family planning policy and the hypothesis of this study are more aligned with Boserup's conclusion.

Besides the theoretical debate, there are many empirical studies also trying find out the impact of birth rate or fertility rate on economic growth. Most of the recent studies conclude that population growth has a negative effect on economic growth. Brander and Dowrick (1994) use a cross country-panel dataset that contains data from 107 countries from the year 1960 to 1985 and conclude that through the investment effect, high birth rate had a negative effect on economic growth. Similarly, in other papers that are aiming to find the determinants of economic growth, they also conclude that the growth rate of

GDP is enhanced by lower fertility rate (Barro, 1996) and economic growth is negatively correlated with population growth (Catanet & Catanet, 2008). These conclusions supported China's one-child policy but not the implementation of the new two-child policy.

More recently, researchers are analyzing the effect of population growth on economic growth separately for developing countries and developed countries. Hartmann's (2010) empirical analysis on 114 developing countries finds the fertility rate influences the GDP per capital growth rate negatively and significantly. Other studies also obtain similar results. Somayeh et al. (2014) investigate the effect of health including fertility rate, mortality rate, and life expectancy on economic growth in 16 developed countries and 14 developing countries. They conclude that for developed countries, a 1% increase in fertility rate caused a 0.04% increase in economic growth. For developing countries, a 1% increase in fertility rate caused a 0.13% decrease in economic growth. In both cases, the effects of fertility rate on economic growth are significant. The result suggests that the impact of birth rate is different for developing and developed countries, and it is worth investigating with regards to China.

Other researchers focus on the economics' impact on fertility rate and state that the fertility rate and economic growth has a non-linear relationship. Luci and Thevenon (2010) conclude that fertility has an inversed J-pattern along with the economic development progress. Dominiak et al. (2014) find there is a U-shaped relationship between economic growth and fertility rate using the data of 18 high-income countries from the year 1970 to 2011. Based on this, the square of birth rate needs to be take into account when analyzing the effect of birth rate on growth.

Overall, the debate of the relationship of population and economic growth has a long history. Most studies find there is a negative relationship between them. However, recent studies have found that this relationship is different between developed and developing countries, while others suggest that the relationship between fertility rate and economic growth is non-linear. Therefore, what's missing in analyzing this problem with regards to China is that first the dataset is outdated and second, the non-linear relationship of fertility rate and the growth of GDP has not been taken into account. Thus, this study aims to use a updated dataset and expects to find a positive and significant effect for both birth rate and birth rate squared. Although it is not consistent with the results from the most past literature, this hypothesis is consistent with the new policy change and the result for developed countries.

Data

This study uses a panel dataset from China that contains data of 28 provinces from the year 1979 to the year 2014. The economic variables are collected from *China Statistical Yearbooks* (National Bureau of Statistics of the People's Republic of China, 1999-2014), and the demographic variables are collected from *Basic Data of China's Population* (Yao & Yin, 1994)*, Basic Data of China Population Since 1990* (Zhuang & Zhang, 2003), and *Basic Data of China Population, 2000-2010* (Zhuang & Han, 2012). China has 31 provinces, but this study excludes Chongqing, Hainan, and Tibet. The reason is that Hainan was separated from Guangdong province in 1988 and Chongqing was separated from Sichuan province in 1997. Since the dataset covers the period 1979 to 2014, it is inappropriate to include Hainan and Chongqing because the dataset of those two provinces is not available for the entire period. Tibet is also excluded because 90% of its population consists of Tibetan minority people, who do not have to follow the one-child policy.

This research uses STATA to analyze the data and the descriptive statistics are reported in Table 1. The birth rate is the total number of live births over the population. The log real GDP per capita is the logarithm of real GDP per capita calculated using 1978 as the base year. In-migration rate is the total number of people moving in over the total population. It only has 784 observations and has many missing values. The unit for population is ten thousand people. The standard deviation of population is 2486.42 suggesting that the population varies across provinces. The family planning rate refers to percent of people obeying the family planning policy.

Table 1 - Descriptive Statistics

Variable Names	Obs.	Mean	Std. Dev.	Min	Max
Birth Rate	894	0.02	0.01	0.00	0.21
Log Real GDP per capita	1001	3.25	0.48	2.28	4.53
In-migration Rate	784	0.02	0.01	0.00	0.20
Population（ten thousand）	1001	4145.82	2486.42	364.14	11430
Family Planning Rate (%)	280	93.84	4.64	72.51	99.84

Since the data of the instrumental variable family planning rate is only available from the year 2000 to the year 2010, it was only applied to the model in this time period. The descriptive statistics of it suggest some evidence about the validity of this instrumental variable. First, the correlation coefficient of the family planning rate and the birth rate is -0.38 suggesting that the family planning rate is correlated with the birth rate. Second, the change of the family planning rate from the year 2000 to the year 2010 varies across the provinces. The maximum change is Jiangxi province with the family planning rate changing from 94.73% in the year 2000 to 77.05% in the year 2010. The minimum change is Tianjin province with the family planning rate changing from 98.51% in the year 2000 to 98.34% in the year 2010. These two facts suggest that this instrumental variable is valid because it is correlated with the endogenous variable birth rate and its effect will not be eliminated when applying Fixed Effect method.

Overall, the advantage of this dataset is that the data all comes from different provinces of one country. Therefore, the statistical method when collecting the data is consistent among each individual province. Also, this dataset has a small time period and large number of observations, which is suitable for applying General Method of Moments technique. However, in general, the descriptive statistics show some limitations of this dataset. The first limitation is that there are many missing values in this dataset.

Therefore, many observations are lost and this could affect the regression result. Second, many variables that have a significant effect on economic growth are omitted due to the availability. Thus, this model suffers from the omitted variable bias.

Empirical Methodology

Empirical Model

For the theoretical equation, this study adopts the structure of Li and Zhang's (2007) growth regression equation and made a few adjustments. Their original equation is:

$$\log\left(\frac{y_t}{y_{t-1}}\right) = \gamma_1 logy_{t-1} + \gamma_2 BR_t + X_t\gamma_3 + \epsilon_t \quad (1)$$

where $logy_t$ is the logarithm of GDP per capita at time t and $logy_{t-1}$ is the logarithm of GDP per capita lagged for 1 year. $logy_{t-1}$ is included as an independent variable because this is a dynamic process, so GDP per capita is determined by GDP per capita last year. BR_t is the birth rate at time t. X_t are other independent variables that determine the growth rate of GDP per capita and ϵ_t is the error term.

The adjustments made are that first, based on the logarithmic identities:

$$\log\left(\frac{y_t}{y_{t-1}}\right) = logy_t - logy_{t-1} \quad (2)$$

Then plugging equation (2) into equation (1) results in:

$$\log y_t = (\gamma_1 + 1) logy_{t-1} + \gamma_2 BR_t + X_t\gamma_3 + \epsilon_t \quad (3)$$

Therefore, it is not necessary to have $\log\left(\frac{y_t}{y_{t-1}}\right)$ as the dependent variable. Also, theoretically, $\log y_t$ stands for the growth rate of GDP per capita. $\log\left(\frac{y_t}{y_{t-1}}\right)$ is the growth rate of the growth rate of the GDP per capita and it is not consistent with the independent variable $logy_{t-1}$ on the left hand side, so $logy_t$ is used as the dependent variable instead. Secondly, since the previous paper suggest that fertility rate and economic growth have a non-linear relationship (Luci & Thevenon, 2010; Dominiak et al., 2014), the square of birth rate is added as an independent variable in the model. Thus, the theoretical equation is specified as follows:

$$\log y_t = \gamma_1 log y_{t-1} + \gamma_2 BR_t + \gamma_3 {BR_t}^2 + \gamma_4 X_t + \epsilon_t \quad (4)$$

For all the X_t variables, although past literature on the determinants of economic growth suggest that variables like education, government consumption, investment share, inflation, and maintenance of the rule of law also have significant effects on the growth of GDP per capita (Barro, 1996), unfortunately data of these variables are not available for China from 1979 to 2014. As suggest by Li and Zhang (2007), two other demographic variables which are population and in-migration rate are added to this equation.

Since the aim of this paper is to analyze birth rate's impact on economic growth, this study only focus on the signs and the significances of the coefficients γ_2 and γ_3. Although previous papers have suggested that birth rate has negative and significant effect on economic growth for developing countries like China (Somayeh et al., 2014), because of the recent policy change from one-child policy to two-child policy, this study's hypothesis is that the coefficient of both birth rate and birth rate squared are positive and significant.

Empirical Strategy

The first main problem of this model is that it may exhibit some arbitrary distributed individual fixed effects. In order to deal with this problem, two different estimation methods can be used. The first one is Fixed Effect estimator. Fixed Effect method controls the unobserved heterogeneity that is correlated with the independent variable and is constant over time. The second one is General Method of Moments (GMM). There are two kinds of GMM approaches. The first one is Difference GMM and the second one is the System GMM. The GMM methods are often used for a panel dataset with a small time period and a large number of observations. The basic rationale of GMM approaches

is first eliminating the fixed effect by taking the first difference of the equation, then instrumenting the first difference of lagged GDP per capita ($logy_{t-1} - logy_{t-2}$) by lags of GDP per capita ($logy_{t-2}$, $logy_{t-3}$, $logy_{t-4}$,…). Therefore, the instruments are within the system itself and this is useful when external instruments are not available. The GMM approaches not only eliminate the unobserved fixed effect correlated with birth rate, but also eliminate the endogeneity of the first difference of lagged GDP per capita caused by the first difference of lagged GDP per capita being correlated with the first difference of the error term. Thus, GMM is a better estimation method than Fixed Effect is for this model, but the results of Fixed Effect are also provided for comparison (Li & Zhang, 2007).

The Difference GMM estimator is first introduced by Arellano and Bond (1991). However, Difference GMM is argued by researchers to be a biased and imprecise estimator because the lagged level instruments, in this case all the past level logarithms of GDP per capita, are weak instruments (Blundell & Bond, 1998). To solve this problem, Blundell and Bond (1998) develop System GMM. In addition to Difference GMM, they introduce another set of instrumental variables which are the lagged first differences. With this additional set of instruments, System GMM may be the most appropriate method to use for this model, and its results are provided alongside the results of Difference GMM.

Another problem in the model is that birth rate is not an exogenous variable. People may make birth decisions based on the current or their expectations for future level of economic growth. Thus, this problem cannot be solved by the instruments of the GMM methods. An external instrumental variable is necessary. When previously dealing with

this problem, Li and Zhang (2007) use the proportion of the minority group population as the instrumental variable. However, applying this instrumental variable to the model has two main problems. First, beginning in 2000s, the one child policy started to be applied to the minority group population. Since the dataset of this research contains data from period 1979 to 2014, it is no longer appropriate to use the proportion of the minority group population as an instrument. The second problem is that the data of the proportion of the minority group population of each province is only available for every 5 years. Then, applying this instrumental variable would require separating the dataset into 5-year periods, and it would cause a large loss of numbers of observations. Thus, for this model, the family planning rate, which is the rate of people obeying the one-child policy, is introduced as a new instrumental variable. The family planning rate is appropriate because first it is correlated with birth rate. As discussed above, the correlation coefficient between family planning rate and birth rate is -0.38 and this is a moderate correlation. Second, family planning rate does not have a direct impact to economic growth. Third, the change of family planning rate varies within provinces. Otherwise, its effect would be eliminated when applying Fixed Effect or GMM method. However, the data of family planning rate is only available from the year 2000 to the year 2010. Thus, it was only applied to this time period.

Results

Before applying the System and Difference GMM methods to the model, an Ordinary Least Squares regression, where the dependent variable is the first difference of lagged GDP per capita and the independent variables are the lags of Log GDP per capita and the first difference of population and in-migration rate, is done in order to find how many lags of Log GDP per capita is appropriate to be included as instrumental variables for the GMM approaches. Three different regressions are done where the first one (column (1)) only includes two-year lagged Log GDP per capita, the second one (column (2)) includes both two-year and three-year lagged Log GDP per capita, and the third one (column (3)) includes all three lags. The regression results are reported in Table 2. As suggested by the results, the four-year lagged Log GDP per capita is not significant when it is included. Thus, only two-year and three-year lagged Log GDP per capita are used as instruments when applying GMM method to the model.

Table 2 - Regression of First Difference of Lagged GDP per Capita

	Dependent Variable First Difference of Lagged GDP per Capita		
Independent Variable	(1)	(2)	(3)
Two-year Lagged Log GDP per capita	0.0078***	0.3335***	0.3944***
	(5.57)	(9.90)	(10.76)
Three-year Lagged Log GDP per capita		-03302***	-0.4727***
		(-9.71)	(-8.03)
Four-year Lagged Log GDP per capita			0.0816
			(2.36)
First Difference of Population	-0.0000**	-0.0000	0.0000**
	(-1.76)	(-2.37)	(-2.34)
First Difference of In-migration Rate	-0.0083	-0.0270	-0.0308
	(-0.20)	(-0.069)	(-0.8)

t statistics in parentheses
* p< 0.1 **p<0.05 ***p<0.0

The regression results of Fixed Effect, Fixed Effect with robust, one step and two step System GMM and Difference GMM methods of the year 1979 to the year 2014 are reported in Table 3. Overall, the coefficients of birth rate and birth rate squared estimated by the System GMM method are the lowest, while the coefficients of birth rate and birth rate squared estimated by the Difference GMM method are the highest. The coefficients estimated by the Fixed Effect method lie between them. Although the coefficients of birth rate and birth rate squared estimated by different methods are quite different numerically, all of them are insignificant suggesting that both birth rate and birth rate squared have no significant effect on economic growth. These results are consistent with the past literature that the effect of birth rate on economic is negative, but are inconsistent with their findings that the effect is significantly negative (Malthus, 1959; Li & Zhang, 2007; Barro, 1996; Brander & Dorwick, 1994; Catanet & Catanet, 2008). They are also consistent with result of Dominiak et al. (2014) and Luci and Thevenon (2010) on developing countries. However, the effect of birth rate squared being insignificant does not support the findings that birth rate and economic growth have a non-linear relationship concluded by Hartmann (2010) and Somayeh et al. (2014).

For the year 2000 to the year 2010, the regression results of Fixed Effect, Fixed Effect with robust, one step and two step System GMM and Difference GMM methods are reported in Table 4. The difference is that first the instrumental variable family planning rate is applied to this time period. Second, as suggested by Roodman (2006), time dummy variables should be included when applying GMM methods in order to make the assumption that there is no correlation across individuals more likely to hold. However, for the model of time period 1979 to 2014, time dummies are excluded because the

number of instruments is too large relative to the number of observations. Since from the year 2000 to the year 2010 is a relatively short time period, time dummies are included. Similarly, the coefficients of birth rate and birth rate squared estimated by the Difference GMM method are the highest, but the coefficients of birth rate and birth rate squared estimated by the Fixed Effect method are the lowest. The coefficient of birth rate suggests that birth rate has a negative effect while the coefficient of birth rate squared has a positive effect on economic growth. Although the overall absolute values of the coefficients are bigger than the results reported in Table 3, the results in time period 2000 to 2010 suggested that birth rate and birth rate squared still do not have significant influence on economic growth which is consistent with the results in time period 1979 to 2014.

Although this result does not match with the hypothesis of this study that birth rate has a positive but significant effect on economic growth, it still provides economic reason for the recent policy change from the one-child policy to the two-child policy because birth rate no longer has a significant growth enhancing effect. However, as mentioned above, this model suffers from omitted variable bias and missing values. Those missing values could cause significant change to the result. Also, omitted variable bias causes positive or negative bias on the estimate of coefficient and positive bias on the standard error of coefficient. Thus, this bias can either be reinforced or cancelled when calculating the t statistics, and it could affect the significance of birth rate and birth rate squared in this model.

Table 3 - Fixed Effect and GMM Results for Period 1979-2014

	Dependent Variable: Log GDP per Capita					
Independent Variable	Fixed Effect	Fixed Effect Robust	One Step System GMM	Two Step System GMM	One Step Difference GMM	Two Step Difference GMM
Birth Rate	-0.2863	-0.2863	-0.1963	-0.2192	-0.4234	-0.3970
	(-1.47)	(-0.86)	(-0.92)	(-0.60)	(-0.87)	(-0.60)
Birth Rate Squared	0.0002	0.0002	0.0001	0.0001	-0.0002	0.0002
	(1.47)	(0.86)	(0.92)	(0.60)	(0.87)	(0.59)
one-year Lagged Log GDP per capita	2.3513***	2.3513***	2.3224***	2.3254***	2.3852***	2.3864***
	(400.60)	(254.89)	(375.69)	(206.93)	(221.50)	(204.31)
Population	-0.0000***	-0.0000***	0.0000***	0.0000***	-0.0001***	-0.0001***
	(-5.86)	(-3.66)	(2.70)	(2.61)	(-15.88)	(-13.65)
In-migration Rate	-0.1371	-0.1371	-0.1200	-0.1265	-0.9048	-0.1037
	(-1.06)	(-1.22)	(-1.19)	(-1.04)	(-1.14)	(-1.03)

t and z statistics in parentheses
* p< 0.1 **p<0.05 ***p<0.01

Table 4 - Fixed Effect and GMM Results for Period 2000-2010

	Dependent Variable: Log GDP per Capita					
Independent Variable	Fixed Effect	Fixed Effect Robust	One Step System GMM	Two Step System GMM	One Step Difference GMM	Two Step Difference GMM
Birth Rate	-6.9212	-6.9412	-7.4849	-5.2067	-9.1309	-13.9053
	(-1.39)	(-1.59)	(-0.09)	(-0.43)	(-1.11)	(-1.30)
Birth Rate Squared	55.4826	55.4826	60.7478	62.0451	73.9319	81.9867
	(0.31)	(0.49)	(0.75)	(0.60)	(0.57)	(0.97)
one-year Lagged Log GDP per capita	2.3779***	2.3779***	2.2321***	2.2400***	2.0356***	1.9672***
	(255.51)	(218.83)	(103.73)	(96.77)	(17.37)	(15.59)
Population	-0.0001***	-0.0001***	-0.0000***	-0.0000***	-0.0001***	-0.0001***
	(-7.99)	(-5.64)	(-6.99)	(-6.32)	(-4.72)	(-3.55)
In-migration Rate	0.0300	0.0300	0.0499	0.0428	0.0304	0.0409
	(0.36)	(0.32)	(0.99)	(0.58)	(1.19)	(1.35)

t and z statistics in parentheses
* p< 0.1 **p<0.05 ***p<0.01

Conclusion

This study used a provincial level panel data set from the year 1979 to the year 2014 in China to examine birth rate's effect on economic growth. The result suggests that both birth rate and birth rate squared have no significant effect on economic growth, meaning that the old one-child policy is no longer good for economic growth. Thus, this result provides possible economic reason behind the recent establishment of the two-child policy.

The limitations of this research are problems of omitted variable bias and having missing values in the dataset. Further research could work on collecting a more complete dataset with fewer missing values and data of variables that have significant effect on economic growth as suggested by previous research. Further study could also compare the results of this paper to other developing and developed countries, especially developing countries with high GDP growth rate and developed countries in the period before they became developed countries, and explore the relationship of population and economic growth for countries transitioning between the two stages.

Since previous researchers state that the effect of birth rate is significant and positive for developed countries and is significant and negative for developing countries (Somayeh et al., 2014), this study's finding of a negative but insignificant effect of birth rate on economic growth may also suggest that China is transitioning from developing country to developed country.

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