

# DO HIGH BIRTH RATES HAMPER ECONOMIC GROWTH?

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*Abstract*—This paper examines the impact of the birth rate on economic growth by using a panel data set of 28 provinces in China over twenty years. Because China's one-child policy applied only to the *Han* Chinese but not to minorities, this unique affirmative policy allows us to use the proportion of minorities in a province as an instrumental variable to identify the causal effect of the birth rate on economic growth. We find that the birth rate has a negative impact on economic growth. The finding not only supports the view of Malthus, but also suggests that China's birth control policy is indeed growth enhancing.

## I. Introduction

THE relationship between population and economic growth has been subject to debate for hundreds of years.<sup>1</sup> The most influential school of thought, or the Malthusian school, asserts that given limited resources, population growth hampers economic growth. The other school, called the neo-Boserupian school of thought (Boserup, 1981), is more optimistic. It argues that population may have a scale effect that is beneficial to economic growth.<sup>2</sup> Moreover, it challenges the Malthusian model for treating technological progress as exogenous. Once technological progress is allowed to be endogenously derived in the model, the role of population on economic growth becomes neutral or even positive (Romer, 1986, 1990; Jones, 1999).

Despite the voluminous theoretical debate, there is still a relatively small body of well-tested propositions about the impact of population growth or birth rate on economic growth. A number of early empirical studies, such as Coale (1986), Hazledine and Moreland (1977), and McNicoll (1984), and several recent studies, including Barlow (1994), Brander and Dowrick (1994), and Kelley and Schmidt (1994, 1995), find a negative relationship between the two variables. However, the majority of the empirical analyses cannot prove a negative causal effect of population growth or birth rate on economic growth (Simon, 1989). A more accurate statement of the debate, which is in the influential survey by Kelley (1988), is that there is no definite conclusion from the body of empirical tests. Although there was a surge of empirical growth literature in the 1990s, most of it is reticent about the effect of population except in using population growth or birth rate as a control variable. As

stated in a more recent survey paper by Temple (1999), the new empirical growth literature has done little to modify the conclusions made by Kelley.

The lack of a conclusion is in part due to the difficulty in identifying a causal effect of population growth or birth rate on economic growth. A simple growth regression cannot prove causality because population growth or birth rate in the growth regression might be endogenous. One source of endogeneity is simultaneity or the feedback effect. Economic growth can affect fertility because with more income, parental human capital improves and thus raises the return to investment in the human capital of children relative to investment in the number of children (Becker & Lewis, 1973). Endogeneity of this sort is well discussed in both the theoretical literature, such as Barro and Becker (1989), Becker, Murphy, and Tamura (1990), and the empirical literature, such as Wang, Yip, and Scotese (1994). Fertility could be endogenous even in the absence of the human capital effect. For example, Galor and Weil (1996) show that with growth, the real wage of women rises, which leads to lower fertility. Endogeneity of this sort cannot be solved by using the lagged population growth or birth rate as independent variables since parents are forward looking and may take growth prospects into account when making fertility decisions. Moreover, if relevant variables, such as the extent of entrepreneurship in a society, that are correlated with both GDP growth and population growth are omitted, the regressions will be subject to omitted variables bias, or the second source of endogeneity. In general, it is difficult to solve the endogeneity problem with cross-country data because it is hard to produce any variable that can serve as an identifying instrument (Mankiw, Romer, and Weil, 1992; Temple, 1999).

In this paper, we examine the impact of the birth rate on economic growth by drawing on provincial-level data from China. Using data from one country can avoid the complication of international comparability of data.<sup>3</sup> More importantly, the unique population control policy in China allows us to identify the causal effect of the birth rate on economic growth by using instrumental variable estimation.

China started its one-child policy in 1979.<sup>4</sup> Under this policy, each family is allowed only one child, and the

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<sup>1</sup> The debate started after Malthus published his famous book *An Essay on the Principle of Population* in 1798.

<sup>2</sup> See also Simon (1975), Pingali and Binswanger (1987), Hayami and Ruttan (1987), and Kremer (1993).

<sup>3</sup> This issue has been raised by many authors, including Romer (1989) and Barro (1991).

<sup>4</sup> When Deng Xiaoping gained power in 1978, he started China's economic reform, which, since then, has led to fast growth. An equally important change, that of the population policy, started at almost the same time. Deng Xiaoping and his colleagues had views similar to the neo-Malthusian school. In discussions of population issues, China's policymakers and scholars always refer to the limited availability of land and other natural resources, and that output from land will inevitably increase by less than the increase of labor. Based on this logic, China started its unique one-child-per-family policy in 1979.

second or higher-parity births are penalized.<sup>5</sup> The one-child-per-family policy, however, was initially applied only to the *Han* Chinese, and by way of affirmative policies, all ethnic minorities in China were allowed to have two or more children until the end of the 1980s (Anderson & Silver, 1995; Hardee-Cleaveland & Banister, 1988; Park & Han, 1990; Peng, 1996; Qian, 1997).<sup>6</sup> In some provinces, like Tibet, there is no restriction on the number of children per family (Deng, 1995).<sup>7</sup>

This unique affirmative policy allows us to use the proportion of minorities in a province as an instrumental variable (IV) to identify the effect of the birth rate on economic growth. The proportion of minorities is a good IV for the following two reasons. First, the provincial birth rate should be positively correlated with the proportion of minority population in a province because of the affirmative birth control policy.<sup>8</sup> Second, if we control for necessary variables that may be correlated with both the proportion of minorities and economic growth, such as investment and education, then the proportion of minorities should be uncorrelated with any omitted determinants, and should not have a direct effect on economic growth except through the birth rate.

The regression results support the neo-Malthusian school. Our GMM estimations that control for provincial fixed effects and correct simultaneity show that the birth rate has a large negative effect on economic growth. This finding is robust even if we control for other demographic and institutional variables that could be correlated with growth. According to our estimation, a decline of the birth rate by 1/1000 will increase the economic growth rate by 0.9

<sup>5</sup> To implement the birth control policies, local governments are given incentive contracts. These incentives take the form of fiscal rewards for fulfilling birth targets, and heavy penalties for falling short of them (Short and Zhai, 1998). Moreover, government officials may be demoted for allowing too many above-quota births in their community, which means that they will lose all future income and other benefits associated with government positions.

<sup>6</sup> In April 1984, five years after the one-child policy had been implemented for the *Han*, the Chinese government for the first time stated that there should also be birth control policies for minorities, but the policies should be less restrictive (Hardee-Cleaveland & Banister, 1988). More specifically, only ethnic groups with a population larger than 10 million are subject to the same policy as the *Han*, and smaller ethnic groups are allowed to have second and third children. However, this birth control policy only applies to two large ethnic groups, *Zhuang* and *Manchu*, and was not strictly implemented until the end of the 1980s (Deng, 1995).

<sup>7</sup> Tibet is dropped from the later empirical work because data for Tibet are not complete and the central government has specific policies for it.

<sup>8</sup> China has 55 ethnic minorities who live in different parts of the country. According to the 2000 census, the *Han* accounted for 91.59% of the total population in China. The three largest ethnic groups in China are *Zhuang*, *Manchu*, and *Hui*, which have a population of 16.2 million, 11.0 million, and 9.8 million, respectively. *Zhuang* mainly live in Guangxi, Yunnan, and Guangdong; *Manchu* can be found in Liaoning, Hebei, Heilongjiang, Jilin, Inner Mongolia, and Beijing; and *Hui* are widely distributed in 19 provinces in China. Among all the provinces, Tibet has the largest proportion of minority population; according to the 2000 census, up to 93.89% of its population is minority. Qinghai ranks the second, with 59.43% of its population as minorities in 2000. Jiangxi and Shanxi have the smallest proportions of minority population, both of which are lower than 0.3%.

percentage points in a year. Our estimation also indicates that the same amount of decline of the birth rate would raise the steady-state per capita GDP by 14.3%. The findings suggest that the dramatic population control policy implemented in China since the late 1970s may indeed have helped the growth of the Chinese economy.<sup>9</sup>

The rest of the paper is structured as follows. In section II, we specify the empirical strategy. In section III, we introduce the data set. In section IV, we present our empirical results. Section V concludes the study.

## II. Empirical Strategy

We follow the recent empirical growth literature in specifying regression equations from the steady state of a growth model (see for example, Mankiw et al., 1992 and Barro & Sala-i-Martin, 1995). Since we study provinces of a country, the model is essentially an open economy growth model like that in Shioji (2001). Specifically, the growth regression is specified as follows:

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

where  $\log(y_t/y_{t-1})$  is the growth rate of real per capita GDP from time  $t - 1$  to time  $t$ ,  $\log y_{t-1}$  is the log of real per capita GDP lagged for one period,  $BR_t$  is the birth rate in time  $t$ ,  $X_t$  are other variables that determine the steady state, and  $\gamma$ s and  $\epsilon$  are coefficients and the error term. According to Levine and Renelt (1992), although each paper in the empirical growth literature uses a different set of right-hand-side variables, most papers have four variables, that is, the initial level of real per capita GDP, the birth rate, the investment share (investment as a percentage of GDP), and the secondary school enrollment rate. Besides these variables, we also follow the literature and have a number of demographic and institutional variables in  $X$ .<sup>10</sup>

Following Brander and Dowrick (1994) and Islam (1995), we estimate the growth regression in a panel framework. We divide the total period, 1978–1998, into four five-year intervals. The right-hand side variables are either initial levels or averages over the five-year interval. For example, in the period of 1978–1983, real per capita GDP is at the 1978 level; the birth rate, the secondary school enrollment rate, the investment share, the growth rate of labor force share, and the dependency ratio are five-year averages.

Following Bond, Hoeffler, and Temple (2001) and Shioji (2001), we employ the generalized method of moments

<sup>9</sup> This statement is purely positive, which has ignored other positive or negative aspects of forced birth control policies. We do not intend to make any normative judgment about China's birth control policies.

<sup>10</sup> Besides the birth rate, migration and population structures may also affect growth. Thus, we will use the in-migration rate, the growth of labor force share, and the dependency ratio to test and control for their effects (the age-dependency effect) on growth. See Bloom and Williamson (1998) and Kelley and Schmidt (2005) for more detailed arguments.

(GMM) estimator for the growth regressions.<sup>11</sup> The first step of the GMM method is to take the first difference of the growth equation in order to eliminate the fixed effects. IV estimations are then applied to the first differences. The GMM estimator cannot only deal with omitted variable bias and the endogenous birth rate as raised in the introduction, but can also deal with the endogeneity associated with the first difference of lagged per capita GDP. Essentially,  $\log y_{t-1} - \log y_{t-2}$  is correlated with the error term  $\epsilon_t - \epsilon_{t-1}$ , and is thus an endogenous variable in the first-differenced equation.

There are two GMM approaches: the first-differenced GMM (DIF-GMM) approach and the system GMM (SYS-GMM) approach. Caselli et al. (1996) were the first to apply the DIF-GMM approach in estimating a growth regression. In the DIF-GMM estimation, to begin with, one takes the first difference of the growth equation in order to eliminate the provincial fixed effect. GMM is then applied to the first difference with the first difference of lagged per capita GDP ( $\log y_{t-1} - \log y_{t-2}$ ) instrumented by the past levels of per capita GDP, which, in our case, are  $\log y_{t-2}$ ,  $\log y_{t-3}$ , and  $\log y_{t-4}$  if the lags exist. Bond et al. (2001) and Bond (2002) argue that DIF-GMM could be subject to the weak instrument and finite sample biases. To deal with these problems, they use an SYS-GMM estimator, developed by Arellano and Bover (1995) and Blundell and Bond (1998), which may have superior finite sample properties.<sup>12</sup> The SYS-GMM estimator combines equations of the first differences instrumented by lagged levels, with an additional set of equations in levels instrumented by lagged first differences. Since the SYS-GMM estimator may be superior, we use it as our main estimator. We also report results of the DIF-GMM for comparison.

In this paper, we use the affirmative birth control policy as the identifying instrument for the birth rate. In particular, we use the proportion of minority population in a province as the IV. As discussed above, although the *Han* Chinese have been subject to the one-child policy, minorities have been allowed to have more than one child even up to now. Therefore, the birth rate in a province should increase with the proportion of its minority population.<sup>13</sup> On the other hand, if we control for necessary variables that may be correlated with both the proportion of minorities and economic growth, such as investment and education, the proportion of minorities should have no partial effect on growth, and should not be correlated with unobserved factors that affect growth.

<sup>11</sup> See also Arellano and Bond (1991), Caselli, Esquivel, and Lefort (1996), and Blundell and Bond (2000) for more details of the GMM method.

<sup>12</sup> Note that relative to DIF-GMM, SYS-GMM requires an additional assumption, related to the initial conditions. See Bond et al. (2001) for detailed discussion.

<sup>13</sup> Since the one-child policy started to apply to two minority groups, *Zhuang* and *Manchu* in the 1990s, we exclude them from the total minority population for years in the 1990s.

### III. Data

We employ provincial-level data from China for the empirical test. As argued above, the Chinese data are unique because China's affirmative population policy provides a natural experiment for testing the population-growth debate. Employing data from one country can also avoid the inconsistency of data that cross-country regressions are subject to. In cross-country data, variables may not be consistently defined across countries because different countries have different statistical methods (Barro, 1991; Romer, 1989). Using data from one country can avoid this problem, to a large extent, because the measures are consistently defined across provinces. Chinese provinces are also large enough for the purpose of this study with an average provincial population of 33 million, which is larger than the population of most countries in the world.

The data set consists of demographic and economic variables of 28 Chinese provinces for the period 1978–1998.<sup>14</sup> Demographic variables come from the *Basic Data of China's Population* (SSB, 1994) and various issues of the *China Statistical Yearbooks* (SSB, 1980–1999). Economic variables are collected from the book of the *Comprehensive Statistical Data and Materials on 50 Years of New China* (SSB, 1999) as well as the *China Statistical Yearbooks* (SSB, 1980–1999). Real per capita GDP is measured at constant (1952) price. Table 1 reports summary statistics of variables.

The data show that China's provinces achieved a very high growth rate in the sample period and at the same time kept the population growth rate and birth rate low. The annual growth rate of the real per capita income was as high as 8.1% between 1978 and 1998. The annual population growth rate was a low 1.4% and the birth rate was lower than 2%.<sup>15</sup> The data also show a considerable heterogeneity in both economic growth and fertility. Guangdong experienced the most rapid growth in the period 1978–1983 with an annual growth rate of 14.6%, while the lowest growth rate of 0.3% was in Anhui from 1983–1988. Ningxia had the highest birth rate of 2.8% in the period 1978–1983, while Shanghai achieved a birth rate as low as 0.6% in the period 1993–1998. The average share of the minority population is 10.7% with a standard deviation of 15.7.

To serve as a good IV for the birth rate in the first-difference estimation, the proportion of minority population needs to have enough variation over time. In order to check this, we examine carefully the first difference of this variable, or the change of the minority proportion over the five-year period. On average, the five-year difference is about five out of a thousand for the whole sample. Although

<sup>14</sup> The starting data set consists of 31 provinces in China, but we drop three provinces: Tibet, Hainan, and Chongqing. Hainan and Chongqing are omitted because they were separated from Guangdong and Sichuan, respectively, in the 1990s.

<sup>15</sup> Note that we follow the literature and use the crude birth rate. See, for example, Brander and Dowrick (1994).

TABLE 1.—SUMMARY STATISTICS OF VARIABLES

Variables	<i>N</i>	Mean	Standard Deviation	Min	Max
Annual growth of real per capita GDP	112	0.081	0.032	0.003	0.146
Annual population growth rate	112	0.014	0.004	0.004	0.025
Birth rate (1/1000)	112	18	4	6	28
Proportion of minority population	112	0.107	0.157	0.001	0.617
Real per capita GDP (1,000 yuan at 1952 price level)	112	6.165	0.609	4.848	7.932
Secondary-school enrollment rate	111	0.777	0.130	0.444	0.998
Investment share	112	0.296	0.082	0.132	0.525
In-migration rate	112	0.002	0.004	-0.004	0.027
Growth of labor force share	112	0.011	0.013	-0.024	0.060
Youth dependency ratio	112	0.320	0.064	0.179	0.429
Old dependency ratio	112	0.049	0.015	0.022	0.114
Trade share	111	0.003	0.004	0.000	0.028
Government spending share	112	0.141	0.063	0.052	0.369

there is a high concentration in the range of (0, 2/1000), about 60% of the observations are outside this range. In fact, the standard deviation is eleven out of a thousand, which is twice as large as the mean. In general, the distribution shows that the first difference of the minority proportion over time has a reasonably large variation, and this variation is not all caused by a few outliers. The proportion of minority population may have changed for several reasons. First, the affirmative birth control policy may have an accumulative effect over time. The accumulative effect is more significant in provinces with large minority populations such as Xinjiang, Guaxi, and Inner Mongolia. Second, migration may also change the proportion. As part of the development process, people from inland and western provinces have migrated to coastal provinces where most of the industrial centers are located. Migration of this sort may affect the proportion of minority population in a province in either direction. Moreover, the central government of China has deliberately sent *Han* Chinese to western provinces, where most ethnic groups are located, for governance purposes. This type of migration tends to reduce the minority proportion in western provinces and increase it in other provinces. Finally, the proportion may also change if minority and *Han* have different mortality patterns.

#### IV. Empirical Results

This section systematically tests whether the birth rate has a negative effect on economic growth. We first provide the basic results and then conduct some sensitivity tests.

##### A. Basic Results

To test whether the IVs have explanatory power for the two endogenous variables, we run regressions with the first difference of the birth rate ( $BR_t - BR_{t-1}$ ) and the first difference of the five-year lagged LogGDP ( $\log y_{t-1} - \log y_{t-2}$ ) as dependent variables, and report the results in table 2. Note that GMM does not have a first-stage regression. Thus, we can think of these regressions as the first stage of a two-stage least squares approach, with the second

stage using covariates in specification (2) of table 3. The IVs included are the first difference of the proportion of minority population, and the ten-year, fifteen-year, and twenty-year lagged LogGDP. For the lags of LogGDP, we experiment by including one, two, and then all three of them respectively. The *t*-statistics and *F*-statistics reported in the table are corrected for heteroskedasticity and serial correlation.

Results of these regressions show that the IVs have explanatory power for the first difference of the birth rate (columns 1–3), as the *P*-values of the joint significance tests for IVs in all three columns are smaller than 0.01. The proportion of minority population has a positive effect on the birth rate, and this effect is significant at the 1% level. These results indicate that the one-child policy is indeed effective in reducing the fertility of the *Han* Chinese relative to minorities. For the equation of the first difference of LogGDP, the joint significance test statistic for IVs is not significant when we use only the first difference of the proportion of the minority population and the ten-year lagged LogGDP as IVs [column (4)], but it becomes significant when we also include the fifteen-year or fifteen-year and twenty-year lagged LogGDP [columns (5) and (6)]. This suggests that we should use all three lags of LogGDP where available, as well as the first difference of the proportion of minority population, as IVs in our GMM estimations in order to avoid the weak instrument problem as raised by Bond et al. (2001) and Bond (2002).

In table 3, we report the GMM estimates with *t*-statistics that are heteroskedasticity robust. We apply the Blundell and Bond (1998) two-step estimator, using Windmeijer (2005) finite-sample corrections to the covariance matrix. To statistically examine the validity of our IVs, we conduct the Hansen overidentification restriction test.<sup>16</sup> The *P*-values

<sup>16</sup> The Hansen test is a test of overidentifying restrictions. The joint null hypothesis is that the excluded instruments are correctly excluded from the structural growth equation, and that the structural equation is correctly specified. Under the null, the test statistic is asymptotically distributed as *chi*-squared in the number of overidentifying restrictions. We employ the efficient GMM estimator allowing heteroskedasticity. In this case, the test

TABLE 2—REGRESSIONS EXAMINING THE EXPLAINING POWER OF INSTRUMENTAL VARIABLES FOR THE FIRST DIFFERENCE OF THE BIRTH RATE AND THE FIRST DIFFERENCE OF THE FIVE-YEAR LAGGED LOGGDP

	Dependent Variables:					
	First Difference of the Birth Rate			First Difference of the Five-year Lagged LogGDP		
	(1)	(2)	(3)	(4)	(5)	(6)
IVs						
Proportion of minority population (first difference)	0.014*** (4.85)	0.012*** (4.56)	0.015*** (4.56)	0.632 (1.70)	0.262 (0.76)	0.275* (1.75)
Ten-year lagged LogGDP	-0.002* (-1.84)	0.0001 (0.01)	-0.003 (-0.58)	-0.057 (-0.63)	1.164*** (5.74)	0.945*** (4.42)
Fifteen-year lagged LogGDP		-0.002 (-0.71)	0.007 (0.69)		-1.245*** (-6.24)	0.048 (0.17)
Twenty-year lagged LogGDP			-0.007 (-0.90)			-1.113*** (-6.60)
Other variables						
Secondary-school enrollment (first difference)	-0.001 (-0.25)	-0.008* (-1.72)	-0.015*** (-3.61)	0.459** (1.98)	0.145 (0.68)	0.503* (1.78)
Investment share (first difference)	-0.005 (-0.63)	-0.0003 (-0.04)	-0.003 (-0.36)	-0.099 (-0.20)	0.163 (0.50)	0.236 (0.79)
Period 1983–1988	0.009*** (2.91)			0.248 (0.64)		
Period 1988–1993	0.010*** (3.29)	0.016*** (4.17)		0.577 (1.40)	0.587** (2.22)	
Period 1993–1998	0.008** (2.50)	0.014*** (3.53)	0.024*** (3.38)	1.034** (2.38)	0.908*** (3.39)	0.605* (1.72)
Joint significance test of IVs						
(E-statistics)	15.68	11.14	14.36	1.65	14.85	38.48
(P-value)	<0.01	<0.01	<0.01	0.21	<0.01	<0.01
Provinces	28	28	28	28	28	28
Observations	83	56	28	83	56	28
R-squared	0.58	0.65	0.81	0.95	0.98	0.99

Notes: We report *t*-statistics that are robust to heteroskedasticity and serial correlation in parentheses. \*, \*\*, and \*\*\* represent significance levels of 10, 5, and 1%. LogGDP is the log of real per capita GDP. We lose one observation in regressions (1) and (4) because there is one missing value for the variable secondary-school enrollment rate (Guangxi province for the period 1983–1988).

for the Hansen J-statistics reported in all regressions in table 3 are larger than 0.1, which suggests that conditional on a correctly specified model, and conditional on at least one of the instrumental variables being a valid instrument, there is no evidence to reject the validity of these IVs. We also report the Arellano-Bond tests for the first-order and second-order serial correlations in the first-differenced residuals. The test statistics suggest that we can reject the null of no first-order serial correlation, but we cannot reject the null of no second-order serial correlation (only the latter is a necessary condition for consistent estimates).

Regression results are consistent with the hypothesis that economic growth decreases with the birth rate. In the first column, we report a regression with the birth rate, the five-year lagged real per capita GDP, and time dummies as independent variables. This regression shows that the birth rate has a negative effect on economic growth, and this effect is significant at the 10% level. This simple regression suggests that poor Chinese provinces are not converging to rich ones, since initial GDP has a very small coefficient and it is not significant at the 10% level.

Regression 1 may have omitted many important variables on the right-hand side of the growth equation. We now add

these variables in column (2). Following the literature (Levine and Renelt, 1992; Temple, 1999), the control variables include the secondary-school enrollment rate and the investment share. We keep a minimum number of control variables here and leave more comprehensive sensitivity tests to the next subsection.

After controlling for other variables that affect GDP growth, it still decreases with the birth rate. In column (2), the coefficient of the variable birth rate is negative and significant at the 1% level. The magnitude of the effect more than doubled with other variables controlled for. Some simple calculations using the estimated coefficients show that the decline of the birth rate has made a reasonably large contribution to China's economic growth. In the sample period (1978–1998), China's birth rate decreased by 1 out of 1,000 every five years, which implies an increase of the annual per capita GDP growth rate by 0.9 percentage points,<sup>17</sup> or about 11% of the annual growth rate of 8.1% that China's provinces achieved in the sample period. The implied increase in the steady-state per capita GDP, that is, the permanent improvement of the living standards of

statistic is Hansen's J-statistic, which is the minimized value of the GMM criterion function. Note that the test relies on the assumption that at least one of the instruments is valid. For further discussion see, for example, Hayashi (2000, pp. 227–228, 407, 417).

<sup>17</sup> A decrease of the birth rate by one would increase the growth rate of per capita GDP in the five-year period by 4.5%, where we have used the estimated coefficients and the mean values of the independent variables for the prediction. This five-year growth rate can be converted to a 0.9% annual growth rate, with a 95% confidence interval of (0.004, 0.014), which is calculated from the delta method.

TABLE 3.—GMM ESTIMATES OF THE EFFECT OF THE BIRTH RATE ON GDP GROWTH

	Dependent variable: First difference of LogGDP					
	GMM (SYS) (1)	GMM (SYS) (2)	GMM (DIF) (3)	GMM (SYS) (4)	GMM (SYS) (5)	GMM (SYS) (6)
Birth rate	-0.016* (-1.82)	-0.036*** (-3.40)	-0.034** (-2.72)	-0.027** (-2.17)	-0.031** (-2.33)	-0.027** (-2.09)
Five-year lagged LogGDP	-0.023 (-0.31)	-0.249* (-1.85)	-0.301 (-1.03)	-0.134 (-1.19)	-0.293* (-1.71)	-0.157 (-0.99)
Secondary-school enrollment		-0.174 (-0.67)	-0.132 (-0.27)	-0.045 (-0.18)	-0.174 (-0.62)	-0.129 (-0.47)
Investment share	0.489** (2.11)	0.442 (1.02)	0.352 (1.31)	0.579* (1.89)	0.438 (1.50)	
In-migration rate				1.572 (0.45)		0.551 (0.16)
Growth of labor force share				0.0001 (0.68)		0.0001 (0.95)
Youth dependency ratio			0.589 (1.44)		0.694 (1.49)	
Trade share					9.732* (1.74)	7.912* (1.91)
Government spending share					-0.053 (-0.12)	0.011 (0.04)
Period 1983–1988	0.095*** (3.19)	0.058 (1.12)	0.089 (0.98)	0.091** (2.20)	0.074 (1.44)	0.097** (2.24)
Period 1988–1993	0.249*** (6.25)	0.348*** (4.67)	0.390** (2.60)	0.349*** (5.75)	0.362*** (4.48)	0.357*** (5.76)
Period 1993–1998	0.102 (1.43)	0.211 (1.67)	0.290 (1.20)	0.187** (2.51)	0.261* (1.77)	0.213* (1.94)
Hansen test of overidentification restriction (Hansen J-statistics)	12.23	10.48	4.66	11.53	13.02	12.21
(P-value)	0.14	0.23	0.46	0.17	0.11	0.14
Arellano-Bond test for First-order serial correlation (z-statistics)	-2.12	-1.56	-1.50	-1.81	-1.71	-1.87
(P-value)	0.03	0.11	0.13	0.07	0.09	0.06
Second-order serial correlation (z-statistics)	1.10	1.38	1.36	1.20	1.38	1.20
(P-value)	0.27	0.17	0.17	0.23	0.17	0.23
Provinces	28	28	28	28	28	28
Observations	112	111	83	111	111	111

Notes: Heteroskedasticity robust *t*-statistics are reported in parentheses. \*, \*\*, and \*\*\* represent significance levels of 10, 5, and 1%. LogGDP is the log of real per capita GDP. All specifications in the table treat the first difference of the birth rate and the first difference of five-year lagged LogGDP as endogenous variables. All specifications estimate the first-differenced equations with the first difference of the proportion of minority population and the ten-year, fifteen-year and twenty-year lagged LogGDP (when the lags exist) as IVs. For the SYS-GMM specifications [columns (1–2) and (4–6)], we also have three LogGDP-level equations with the lagged first difference as IVs for the lagged LogGDP on the right-hand side. We lose one observation in regressions 2–6 because there is one missing value for the variable secondary-school enrollment rate (Guangxi province for the period 1983–1988).

Chinese, is 14.3%,<sup>18</sup> with a 95% confidence interval of (-0.026, 0.311).

With the control variables in column (2), the coefficient of the lagged per capita GDP becomes larger in magnitude and is marginally significant. The investment share in column (2) has a strong positive effect on growth, with a positive and significant coefficient. The secondary-school enrollment rate is not significant at the 10% level.

In the third column, we report a regression using the DIF-GMM estimator. The estimated coefficient of the lagged GDP is smaller than that of the SYS-GMM estimator reported in column (2), suggesting that the DIF-GMM estimator is more likely to be biased downward as argued by Bond et al. (2001). Bond et al. (2001) also suggest that one can use the ordinary-least-squares (OLS) and simple fixed-effect (FE) estimates to check whether the GMM estimators

are biased. They argue that the OLS estimate is biased upward, while the FE estimate is biased downward, and thus they provide the upper and lower bounds for biases. We estimate the same equation as that in column (2) using OLS and FE estimators. The OLS estimate of the coefficient on the lagged LogGDP is -0.061, and the FE estimate is -0.307. We can see that the DIF-GMM estimate (-0.301) is very close to the FE estimate, suggesting a potential downward bias with the DIF-GMM estimate. As a contrast, the SYS-GMM estimate is -0.249, which comfortably lies between the upper and lower bounds. These results suggest that the SYS-GMM estimator may indeed be a better choice.

### B. Robustness Tests

In this section, we test the robustness of our main estimates of the effect of the birth rate on economic growth. We conduct these tests by including other demographic and institutional variables that may covary with economic growth. The first demographic variable we include is the

<sup>18</sup> The implied semielasticity of the steady-state per capita GDP with respect to the birth rate is  $-0.036/0.249 = -0.143$ . Thus, a decrease of the birth rate by one would increase the steady-state per capita GDP by 14.3%.

in-migration rate. Omitting in-migration could make our IVs invalid. For example, if provinces with smaller minority populations grow faster and attract in-migration from provinces with more minorities, and if minorities and Chinese have an equal chance to migrate, then in-migration will tend to increase the proportion of minorities in the receiving provinces. Since migration in this example is correlated with both growth and the IV, that is, the proportion of minorities, omitting it in the growth regression will invalidate this IV.

Prior research has also shown that the population structure, and more specifically the share of labor force and youth dependency ratio, may have an effect on economic growth (Bloom & Williamson, 1998; Kelley & Schmidt, 2005; and others). Because these variables are also correlated with the birth rate, including them may reduce the explanatory power of the birth rate itself. In fact, it is likely that through these population-structure variables the birth rate exerts its effect on growth.

Growth regressions including these demographic variables continue to show that the birth rate has an independent effect on economic growth. The fourth column of table 3 reports a GMM regression with three new independent variables: the in-migration rate, the growth of labor force share, and youth dependency ratio. Controlling for these variables, the birth rate still has a negative and significant coefficient. The magnitudes of the coefficients and the implied sensitivity of the steady-state per capita GDP to the birth rate are not much different from those of previous regressions. However, none of these newly included variables is significant.

The second set of variables that may covary with growth is institutional or reform variables. These variables are from two related literatures. The empirical growth literature argues that institutions such as government size and trade may have an effect on growth (Barro, 1991; Levine & Renelt, 1992). The literature on China's economic reforms argues that the "open-door" policy and marketization may have an important positive effect on growth (Bao et al., 2002; Jin, Qian, and Weingast, 2005; Li & Zhou, 2005). To capture these institutional or reform effects, we follow the literature and include the trade share as a percentage of GDP and the government spending share as a percentage of GDP (as a measure of government size and marketization) as control variables.

The regression results including these institutional variables again support the hypothesis that economic growth decreases with the birth rate [columns (5) and (6)]. The birth rate has a negative coefficient, and it is significant at the 5% level. The trade share has an expected positive effect on economic growth and is marginally significant, but the government-spending share is not significant.

In interpreting results associated with columns 4–6, we should exercise some caution. Both the demographic and institutional variables could be endogenous. The demo-

graphic variables are endogenous in the same way as the birth rate is. Institutional variables could be endogenous as well. For example, trade could be endogenous because foreign countries are more likely to trade with provinces that have high growth potential. Ideally, we should use IVs to identify all these variables, but empirically, it is very difficult to find appropriate IVs for them. Nonetheless, the burden of finding good IVs in this context is not too great in our context. We are mainly interested in examining whether the correlation of these variables with the birth rate reduces the partial correlation of growth with the birth rate by a large amount, and we find it is not the case.

Finally, to test whether extreme values of variables affect our estimation results, we have carried out regressions that exclude observations with extreme values for the GDP growth rate, the minority share, or their first differences. We find that the empirical results do not change qualitatively. Due to space limitations, we do not report these regressions.

To summarize, our GMM regressions show consistently that economic growth decreases with the birth rate for the sample of Chinese provinces. This finding is robust even if we control for a number of demographic and institutional variables. Our findings support the Malthusian prediction that high birth rates are detrimental to economic growth for a developing country like China.

## V. Conclusion

In this paper, we examine the impact of the birth rate on economic growth by using a data set of 28 provinces in China. We find that the birth rate has a negative impact on economic growth, and this finding is robust even after we control for a number of demographic and institutional variables. Our finding provides some new evidence that shows the negative causal effect of population on economic growth, as asserted by Malthus.

China started its unique population control policy in the late 1970s. Our study is among the first to provide some evidence that can be a basis for evaluating the effect of this population control policy. While the birth control policy has many negative aspects for human beings, and there may be other policies that can control population, the one-child policy may indeed have contributed to the rapid growth of the Chinese economy since the late 1970s.

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