Does Government's R&D Expenditure Stimulate Economic Growth in China?

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Abstract

Since its economic reform in the late 1970s, China has recorded a very rapid economic growth rate. In the meantime, the Chinese government has actively pursued R&D-promotion policies. Using time series data over the period 1982–2010, this paper applies small-sample cointegration tests, OLS and GMM estimations, and Granger causality tests to reveal the determinants of China's rapid economic growth. We find that the government's R&D expenditures have had a positive effect on and causes economic growth in the Granger sense. In contrast, investment, the trade dependence ratio, and the inflation rate have not caused economic growth. Our results show that China's remarkable economic growth since the 1980s can be explained by the R&D-based endogenous-growth theory.

Keywords: R&D expenditure; economic growth; China

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1 Introduction

Since opening its market in late 1978, China has experienced very rapid economic growth. It recorded an average annual real GDP growth rate of 9.9% during the period 1979–2010. In the meantime, the ratio of gross fixed capital formation in GDP increased from 28.4% in 1979 to 45.7% in 2010, averaging 33.9% throughout the period. China's trade dependence ratio, defined as (exports + imports)/GDP, continued to rise from a mere 12.5% in 1980 to 50.2% in 2010. Despite rapid economic growth, the average annual inflation rate during the same period remained at 5.5%, which is quite low compared to other developing countries (National Bureau of Statistics of China, 2012).

Although China's industrial structure started from heavy reliance on purely labor-intensive industries, such as the garment industry, the share of relatively more technology-intensive industries, such as electronics, continued to rise over time. Realizing the importance of improvements in the technology level in economic growth, the Chinese government has taken various measures to promote R&D activities. Since the late 1990s in particular, China has been pursuing a strategic transformation from an economy based on low-cost labor to one built on knowledge and innovation (Organization for Economic Co-operation and Development, 2007). The concrete policy measures of the Chinese government targeting an improvement of the technology level have consisted of the establishment of science parks, increases in government expenditures in the R&D sector and the provision of tax incentives to firms undertaking R&D activities (Mah and Yeo, 2014). The Chinese government's R&D expenditure/GDP, for instance, which decreased to about 0.5% during the mid-1990s, gradually rose to reach 1.0% in 2010 (National Bureau of Statistics of China, 2012).

Although R&D promotion might have been quite important in China's technological development and long-run economic development, it has seldom been analyzed rigorously. For instance, although Mah and Yeo (2014) explained the role of the R&D policy of the Chinese government in the development of technology intensive industries and economic development as a whole, it just described the overall R&D policy and development of technology intensive industries of China, not using econometric techniques. Therefore, this paper reveals the determinants of economic growth in China, analyzing the role of the government's R&D promotion policy. Although R&D investment from the private sector may also play a role in boosting economic activities, the current paper focuses on the role of economic policy of the government in the R&D sector in raising economic growth rate.

The structure of this paper is as follows. Section 2 addresses the relevant literature and the model for the empirical work. Section 3 shows the empirical evidence drawn from the small-sample cointegration tests, OLS and GMM estimations, and Granger causality tests. Conclusions are provided in Section 4.

2 The Model

Various factors may lead to a developing country's economic growth. Although it appears plausible to think investment leads to economic growth, Jarreau and Poncet's (2012) cross-sectional estimation results based on China's provincial data for the period 1997–2009 showed that physical capital accumulation did not have a significant effect on economic growth. Additionally, using panel data for seven southeast European transition economies over the period 1998–2007, Mehic, Silajdzic, and Babic-Hodavic (2013) showed no significant effect of investment on economic growth:

Many works have examined the effect of international-trade expansion on economic growth in developing countries, the trade- (or export-) led growth hypothesis. Krishina, Ozyildirim, and Swanson (2003) employed panel data for 39 developing countries covering the period 1951–1998, revealing exports as more important in economic growth regressions involving countries with relatively low GDP growth rates. Kim, Lim, and Park (2009) used Korean data during the period 1980–2003. The Granger causality test showed that exports did not have a significant positive effect on either productivity or GDP growth in Korea. Thus, recent empirical work does not unanimously support the trade-led economic-growth hypothesis in developing countries.

The effect of macroeconomic variables on economic growth has often been analyzed in the literature as well. For instance, the effect of rising inflation on economic growth was covered by Barro (1997, 2013) and Choi and Yi (2009). Choi and Yi (2009) used World Bank (2002) data for 207 countries from 1991 to 2000 to show that inflation has a negative impact on economic growth. Barro (2013) showed that if a number of country characteristics are held constant, then the impact effects from an increase in average inflation by 10 percentage points per year are a reduction of the growth rate of real per capita GDP by 0.2–0.3 percentage points per year and a decrease in the ratio of investment to GDP by 0.4–0.6 percentage points.

The effect of R&D expenditures on economic growth has received particular attention since the 1980s in light of the endogenous economic-growth theory. Jones (1995) explained that technological progress or productivity growth results from search for innovations partly enabled by R&D expenditure. Zachariadis (2004) used data for ten advanced OECD countries during the period 1971–1995. He considered both openness and R&D intensity, defined as R&D expenditure divided by GDP, to explain productivity growth and found that increasing R&D intensity by one percentage point raises output growth by about 0.11 percentage points. Using data for the U.S. and Germany, Gong, Greiner, and Semmler (2004) found that the endogenous-growth theory is supported only if scale effects are removed. Ulku (2007) used data for 26 OECD and 15 non-OECD countries to test the endogenous-growth theory, showing that an increase in the share of researchers in the labor force raises innovation, which raises per capita output. However, according to their analysis, a rise in the ratio of researchers to total labor force increases innovation only in the large-market OECD countries.

Since the expansion of R&D expenditure, investment, international trade, and changes in inflation rate, among others, may raise economic growth rate, in this paper economic growth is captured by the following growth equation:

$$Y(t) = a_0 + a_1 {*} R\&D(t) + a_2 {*} INV(t) + a_3 {*} TDR(t) + a_4 {*} INF(t) + u(t), \tag{1}$$

where Y, *INV, TDR*, and *INF* denote the real GDP growth rate, gross capital formation/GDP, trade dependence ratio, and inflation rate measured by consumer price index, respectively. Although one may think of using FDI inflows/GDP rather than gross capital formation/GDP as the measure of investment, it may lead to ignoring the effect of domestic investment on economic growth. For the effect of international trade on economic growth, although some papers used export values/GDP rather than trade dependence ratio, they were mainly interested in testing the export-led economic growth hypothesis. Since testing the export-led growth hypothesis is not the focus of the current paper, trade dependence ratio is used as the measure of international trade.

R&D in equation (1) denotes the government's R&D activities measured by government expenditures on science and technology divided by GDP. In equation (1), u denotes the conventionally assumed error term. The annually observed data for China cover the period 1982–2010, because data for government expenditures on science and technology starts from 1982. All data used in the current paper are drawn from various issues of the *Statistical Yearbook of China* published by the National Bureau of Statistics of China, which are available at http://www.stats.gov.cn.

3 Empirical Evidence

This paper starts by applying unit root tests to the variables to test their stationarity. Table 1 provides the results of Phillips–Perron tests using the Newey–West method of the optimal-lag selection. It shows that all variables concerned are integrated of order one at the 1% significance level. Since all variables under consideration can be assumed to be integrated of order one, it is necessary to examine whether or not there are long-run equilibrium relationships among the variables concerned, using cointegration tests.

Table 1. Phillips–Perron Unit Root Test Results

Variable	Level form	First-differenced form
Y	–3.305*	–5.525**
R&D	–1.702	–3.536**
INV	0.375	–5.094**
TDR	–1.302	–4.374**
INF	–2.232	–4.460**

Notes: ** and * indicate significance at the 1% and 5% levels, respectively.

As the data period is short, 1982–2010, this paper uses Banerjee, Dolado, and Mestre's (1998) small-sample cointegration test, which can be applied to nonstationary variables with the same order of integration. The test is based on the equation

$$A(L)\mathrm{d}Y(t) = B(L)\mathrm{d}X(t) + \beta Y(t-1) + \Theta X(t-1) + \Sigma_{i=1}^{s} \mu_i \, \mathrm{d}X(t+1) + e(t), \quad (2)$$

where Y, X and e are the regressand, the vector of regressors, and the conventionally assumed error term, respectively. L and d denote the lag operator and the first-differenced form of the respective variable. In Banerjee, Dolado, and Mestre's (1998) cointegration test, $s = 1$ or 2 in equation (2) shows good size properties. The cointegration test results depend on the significance of the estimate of the coefficient β in equation (2). Under the null hypothesis of no cointegration, $\beta = 0$; under the alternative hypothesis of cointegration, $-2 < \beta < 0$. Banerjee, Dolado, and Mestre (1998) show that in finite samples with a limited number of observations, their statistics have greater power than more frequently employed cointegration tests.

Table 2 shows Banerjee, Dolado, and Mestre's small-sample cointegration test results with respect to all variables in equation (1). Since either international trade or R&D expenditures may raise productivity and thus the economic growth rate according to the endogenous-growth theory, the table also shows the cointegration test results without TDR among the right-hand-side variables. Regardless of the number of leads of s in equation (2), the null hypothesis of noncointegration is not rejected at the 5% significance level. That is, the cointegration test shows that the variables under consideration are not cointegrated.

Table 2. Banerjee, Dolado, and Mestre's Small-Sample Cointegration Test Results†

Variable	Lead number = 1	Lead number = 2
Y, R&D, INV, TDR and INF	–1.524	–1.747
Y, R&D, INV and INF	–1.841	–2.092

Notes: †The numbers are t-values of the estimated β in equation (2).

Since the variables under consideration are revealed to be not cointegrated, Table 3 columns (a) to (c) show the regression results of growth equation (1) with ordinary least squares (OLS) estimation,[1] and columns (d) to (f) show the generalized method of moments (GMM) estimation using the first-differenced form of each variable.

When all right-hand-side variables in equation (1) are used in the estimation, column (a) in Table 3, each variable is revealed to have a positive effect on the real GDP growth rate, although none of their estimated coefficients is significant at the 5% level. With *INF* dropped from equation (1), column (b) in Table 3, the estimated coefficient of *R&D* is positive and significant at the 5% level. This result supports our hypothesis that R&D expenditures have a positive effect on economic growth. The estimated coefficient of *TDR* is also significant at the 5% level. With *TDR* excluded, column (c) in Table 3, the coefficient of each variable is estimated to be positive but insignificant at the 5% level. The Jarque–Bera normality test results show that the null hypothesis of a normally distributed error is not rejected at any reasonable level of significance.

In growth equation (1), the dependent variable, the real GDP growth rate, may affect the explanatory variables. Therefore, to solve any endogeneity problem in the explanatory variables, we reestimated equation (1) by GMM, columns (d) to (f) in Table 3. The first-differenced forms of the instrumental variables used in GMM estimation are $Y(t-i)$, $R\&D(t-i)$, $INV(t-i)$, $TDR(t-i)$, $FDI(t-i)$, $INF(t-i)$, and $XR(t-i)$, $i = 1, 2$, where *FDI* and *XR* are FDI inflows/GDP and renminbi/US dollar exchange rate, respectively. The estimated coefficients of R&D are 9.499, 21.382, and 12.739, respectively, and they are significant at the 5%, 1%,

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[1] In OLS estimation, trend is included in the explanatory variables to correct for serial correlation of error terms. Detailed OLS results for this extra variable are available upon request.

and 1% levels, respectively. This result also supports our hypothesis that R&D expenditures have a positive effect on economic growth.

The coefficients of *INV* estimated by GMM are all positive and significant at the 1% level, while the estimated results of TDR are mixed: negative and insignificant — column (d) in Table 3 — and positive and significant at the 1% level — column (e) in Table 3. The estimated coefficients of INF are not significant at the 5% level, column (d) in Table 3, and are significant at the 1% level, column (f) in Table 3, respectively. In columns (d) and (f) in Table 3, Hansen's (1982) J-statistics have *p*-values of 0.186, 0.167, and 0.223, which means that the overidentifying restrictions of the model are supported by the data.

In Table 3, regardless of the specifications, it is noteworthy that the estimated coefficient of R&D is substantially larger than the other coefficients, although all right-hand-side variables in equation (1) are expressed per GDP.

Table 3. Estimation Results of Equation (1)

	(a)†	(b)†	(c)†	(d)‡	(e)‡	(f)‡
	OLS	OLS	OLS	GMM	GMM	GMM
Constant	1.420	1.449	1.918	0.079	–2.061**	–0.220
	(2.147)	(0.973)	(2.423)	(0.182)	(0.198)	(0.160)
R&D	15.600	12.944*	15.756	9.499*	21.382**	12.739**
	(13.572)	(5.443)	(13.419)	(3.375)	(2.138)	(2.402)
INV	0.531	0.590	0.463	0.605**	0.500**	0.379**
	(0.305)	(0.296)	(0.356)	(0.193)	(0.109)	(0.124)
TDR	0.168	0.178*		-0.096	0.334**	
	(0.094)	(0.078)		(0.076)	(0.057)	
INF	0.078		0.127	0.108		0.049**
	(0.098)		(0.087)	(0.056)		(0.012)
D.W.	2.057	2.019	2.0.31			
Jarque-Bera	0.269	1.213	0.397			
Normality	[0.874]	[0.545]	[0.820]			
Hansen's				6.185	6.463	5.691
J-statistics				[0.186]	[0.167]	[0.223]

Notes: †Newey and West's (1987) heteroscedasticity and autocorrelation consistent covariance matrix is used for standard errors; ‡Instrumental variables = {Y(t-i), R&D(t-i), INV(t-i), INF(t-i), TDR(t-i), FDI(t-i), XR(t-i), i = 1, 2}; ** and * indicate significance at the 1% and 5% levels, respectively. Standard errors are in parentheses, *p*-values are in brackets.

Table 4 shows the Granger causality test results in case of taking the lag number equal to two or three between *Y* and the right-hand-side variables appearing in equation (1). First, *R&D* is shown to Granger Cause *Y* at the 5% significance level regardless of the lag number. There is mixed evidence of *Y* Granger causing R&D, depending on the lag number. Even in the case of taking the lag number equal to one, the overall results remain similar to the case of two or three lags. Second, regardless of the number of lags, no causality is found between *Y* and *INV*. The same conclusion holds for causality between *Y* and *TDR*. That is, neither changes in *INV* nor those in *TDR* are revealed to cause economic growth in China. Third, there appears to be a unidirectional causality from *Y* to *INF* at the 1% significance level, which means that changes in inflation rate do not cause economic growth in China.

Table 4. Granger Causality Test Results

Null hypothesis (H_0)	*F*-statistics	
	Lag number = 2	Lag number = 3
R&D does not Granger cause Y.	5.761**	3.864*
Y does not Granger cause R&D.	0.677	7.300**
INV does not Granger cause Y.	0.997	1.156
Y does not Granger cause INV.	0.659	0.899
TDR does not Granger cause Y.	0.653	0.386
Y does not Granger cause TDR.	0.151	0.681
INF does not Granger cause Y.	2.388	1.772
Y does not Granger cause INF.	8.287**	8.678**

Notes: ** and * indicate significance at the 1% and 5% levels, respectively.

The results of the small-sample cointegration test, OLS, and GMM estimation using the first-differenced data, and the Granger causality tests shown in Tables 2 to 4 indicate that the Chinese government's R&D expenditures have positively affected economic growth and have caused economic growth in the Granger sense. Investment positively influences economic growth in China, although the former does not cause the latter. Neither trade dependence ratio nor inflation is revealed to cause economic growth.

4 Conclusion

Since its market reforms in late 1970s, China has recorded remarkable economic growth. In the meantime, together with the rise in the investment and the trade dependence ratios, the industrial structure has gradually changed from a heavy reliance on such labor-intensive industries as garments to more technology-intensive industries. Realizing the benefits of more value-added, technology-intensive industries in long-run economic growth, the Chinese government has placed an emphasis on its R&D promotion policy.

According to the empirical evidence in this paper, which comprise the unit root test, small-sample cointegration test, OLS and GMM estimations, and the Granger causality test on data from China, the government's R&D expenditures have had a positive effect on and have caused economic growth in the Granger sense. That is, the active role of the government in R&D activities is revealed to lead to long-run economic growth in China. Although investment positively influences economic growth in China, it does not cause economic growth. It is an interesting result in the sense that the endogenous-growth theory may be valid in explaining the economic growth of a rapidly growing, large developing economy such as China.

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