ARTICLE IN PRESS

Economic Modelling xxx (2017) 1–8

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: https://www.journals.elsevier.com/economic-modelling

Can private domestic investment lead Chinese technological progress?☆

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ARTICLE INFO

JEL Codes:
O11
P33
E22
C51

Keywords:
Technological progress
FDI
Private domestic investment
State-owned investment
Stochastic frontier analysis

ABSTRACT

This study examines the effects of private domestic investment (PDI), foreign domestic investment (FDI), state-owned units' investment (SOI) and their interactions on technological progress in China. Specifically, we test whether PDI leads Chinese technological progress, and crowd-out effects from FDI and SOI. The empirical analysis is based on panel data consisting of 29 Chinese provinces and municipalities over 1989–2014. We extract technological progress using the panel stochastic frontier model and examine its determinants. Our findings suggest that while PDI, FDI and SOI all positively contribute to technological progress in China, PDI is the dominant contributor.

1. Introduction

In this paper we examine the effects of different forms of investment, namely state-owned units' investment (SOI), private domestic investment (PDI) and foreign domestic investment (FDI), and their interactions on technological progress in China. This research is important for the following reasons. First, economic theories perceive an important role for investments in promoting technological progress. Johansen (1959), for instance, states that the effect of technological progress hinges on the rate of investment, asserting that no technological change can be achieved without investment. Similarly, studies by Arrow (1962), De Long and Summer (1991) and Boucekkine et al. (1998) hypothesize that continuous investment in the purchase and use of new machines and equipment induce technical change through the process of learning-by-doing. These studies argue that the rate of acquisition and adaptation of new equipment and machines are manifested in investments by firms. Further, investment in infrastructure and fundamental industries by states induces the adaptation of better technologies by firms (Aschauer, 1989; Everaert and Heylen, 2001; Montolio and Sole-Olle, 2008; Vijverberg et al., 2011; Bottasso et al., 2013).

Second, enhanced technology shifts production curve upwards and is beneficial to long-term economic growth (Park, 1995; Ezaki and Sun, 1999). Third, majority of the existing empirical literature fails to differentiate among different forms of investment when investigating the relationship between investment and technological progress. For instance, Aitken and Harrison (1999) examine technological impacts of FDI in Venezuela; Bottasso et al. (2013) study technological impacts of public investment in OECD countries; many studies on China, such as Lin et al. (2011) and Yi et al. (2013), investigate the impact of FDI on Chinese technological progress; and Han and Shen (2015) examine technological impacts of both FDI and domestic investment in China.

Fourth, there is lack of conclusive empirical evidence on specific forms of investments and their impacts on technology. For instance, technology's impact of FDI in China is found to be positive in Lin et al. (2011) but negative in Yi et al. (2013) and Han and Shen (2015). Fifth, another group of studies, including Young (1993), Aitken and Harrison (1999) and Liu (2008), postulate that investments' impacts on technology can potentially be influenced by the interactions of different forms of investments. Young (1993) argues that complementarity or crowding-in effect between FDI and domestic investment will potentially enhance technology given that FDI inflows are, to a large extent, determined by domestic factor endowment. Complementarity is also evidenced in Narayan (2004) who studies public investment and private investment for Fiji over 1950–1975. In contrast, Aitken and Harrison (1999) and Liu

☆ The authors appreciate the helpful comments from Professor Paresh Kumar Narayan, Editor, and anonymous reviewers that strengthened the research presented in this article.
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https://doi.org/10.1016/j.econmod.2017.11.002
Received 26 September 2016; Received in revised form 2 November 2017; Accepted 2 November 2017
Available online xxxx

Please cite this article in press as: Chen, H., et al., Can private domestic investment lead Chinese technological progress?, Economic Modelling (2017), https://doi.org/10.1016/j.econmod.2017.11.002

Table 1
Estimation of stochastic frontier models.

Explanatory variable	Time-varying decay inefficiency model		Time-invariant inefficiency model	
	Coef.	s.e.	Coef.	s.e.
ln*K*	0.863***	0.193	0.678***	0.182
ln*L*	1.627***	0.373	1.123**	0.492
T	−0.023	0.024	−0.0004	0.023
$(\ln K)^2$	0.004	0.017	0.007	0.018
$(\ln L)^2$	−0.058**	0.026	−0.025	0.033
T^2	0.001***	0.000	0.001**	0.000
ln*K*ln*L*	−0.035	0.029	−0.023	0.032
*T*ln*K*	−0.005	0.004	−0.002	0.004
*T*ln*L*	0.009***	0.003	0.003	0.004
Constant	−6.387***	1.585	−3.855**	1.997
μ	0.557	0.092	0.543	0.086
σ_u^2	0.068	0.023	0.049	0.016
σ_v^2	0.008	0.000	0.008	0.000
γ	0.897	0.032	0.860	0.040

Notes: the table shows the time-varying decay inefficiency and time-invariant inefficiency estimates for Chinese provinces for the period 1988–2014; the coefficients and standard errors are given under the columns 'Coef' and 's.e', respectively; ***(**)* represent significance at the 10%(5%)1% levels; μ is mean of technical inefficiency, σ_u^2 is variance of technical inefficiency, σ_v^2 is variance of random error, and $\gamma = \sigma_u^2/(\sigma_u^2 + \sigma_v^2)$.

(2008) propose that, due to substitution or crowding-out effect, unfair competition by foreign firms may increase average production cost of domestic firms and hence lower technological adaptation by domestic firms.

Based on these considerations, we propose three hypotheses. First, SOI, PDI, and FDI are likely to have positive effects on technological progress in China due to technical changes involved in investment. Second, PDI is likely to lead Chinese technology progress, given its growing importance in the Chinese economy. Third, technology effects of pairwise interactions among SOI, PDI, and FDI (in short, 'interactive technology effects' or 'interactive effects') are likely to be negative; that is, the three forms of investment play substitutional roles on promoting Chinese technological progress due to competition and factor endowment.

To test our hypotheses, we proceed in two steps. First, we use a rich data set on 29 Chinese provinces for the period 1988–2014 to calculate technological progress indices. Second, we run regressions on the indices to identify contributions of different forms of investments to technological progress in China.

Our approaches lead to three new findings. Our first finding is that SOI, PDI, and FDI all positively contribute to technological progress in China. Our second finding is that PDI has the largest effect on technological progress. From the negative signs of pairwise multiplications of SOI, PDI, and FDI, we find that the three forms of investment in general have substitutional effects on Chinese technological progress, which represents our third most important findings.

These findings provide a clearer understanding of the impacts investments have on technological progress, particularly from a developing country perspective. Each of these findings contributes to two specific literature. The first literature includes, amongst others, Aitken and Harrison (1999), Lin et al. (2011), Yi et al. (2013) and Han and Shen (2015). These studies investigate the technology-investment nexus in China and draw inconclusive evidence about investment's impact on technological progress. Our findings complement the empirical literature by showing that each form of investment has a consistent and positive impact on technological progress. The reason we obtain this result is because we simultaneously consider the possibility of investment's linear effect being affected by the presence of investments of the other forms.

The second literature we contribute to is Young (1993), Aitken and Harrison (1999) and Liu (2008). These studies demonstrate the ambiguity of the technology effect of interaction between domestic investment and FDI. Our findings of negative interactive effects contribute to the literature by supporting the substitution hypothesis with quantitative evidence in the case study of China.

Finally, we test the robustness of our findings along the following lines. First, we estimate technological progress indices by using two different models. Second, we differentiate the impacts of investments of different forms by time period and by zone due to different phases of the provincial economic reforms in China. Third, we calculate two series of capital stock and apply them in subsequent analyses. The key message of these robustness tests is that our main conclusion that PDI has the capacity to lead Chinese technological progress holds.

The rest of the paper is planned as follows. Section 2 describes methodologies and model. Section 3 presents data. Section 4 discusses the empirical findings, and Section 5 draws conclusions.

2. Models and methodologies

2.1. Estimation of technology: the parametric stochastic frontier analysis

In our empirical analysis, we employ the parametric stochastic frontier analysis to estimate technology level. This method follows a well-established tradition set by pioneering studies, such as Nishimizu and Page (1982), Battese and Coelli (1988) and Coelli et al. (2005). The general form of a stochastic production frontier is written as

$$Y = \exp(f(K, L, T))\exp(-u)\exp(v), u \geq 0, \quad (1)$$

where

<i>$Y =$ </i> GDP at constant 2010 prices;
<i>K</i> = capital stock at constant 2010 prices. The perpetual inventory method is used to estimate capital stock using data on gross fixed capital formation over 1978–2014 period. Following Kruger (2003), capital stock in the initial year is approximated by $K_0 = I_0 \cdot (1 + g_I)/(g_I + \delta)$, where I_0 is investment in the initial year, g_I is average growth of investment over the subsequent five years and δ is national depreciation rate. Following Zhang et al. (2004), we set $\delta = 0.096$. The subsequent years' capital stocks are calculated as $K_t = (1 - \delta) \cdot K_{t-1} + I_t$;
L = education augmented labor input, $L = e^{EDU}POP$, where *EDU* is student enrolment in tertiary education institutions as a percentage of total population, and *POP* is total population in persons; and
T = a time variable.

The notation *f*(.) in Equation (1) denotes the production frontier assuming potential production level with full efficiency. The first error component u follows half-normal distribution, i.e., iid $N^{+}(0, \sigma_u^2)$. The notation $\exp(u)$ measures the distance between the actual productivity level and the frontier, hence captures production inefficiency. The second error component v is normally distributed, i.e., iid $N(0, \sigma_v^2)$. The notation e^v captures random shocks, and subscripts i and t, respectively, denote province and time.

The logarithmic form of a fixed-effect panel translog stochastic production frontier is defined as:

$$\ln Y_{it} = \beta_{0i} + \beta_1 \ln K_{it} + \beta_2 \ln K_{it} + \beta_3 t_t + \frac{1}{2}\left[\beta_4 (\ln K_{it})^2 + \beta_5 (\ln L_{it})^2 + \beta_6 t_t^2\right] + \beta_7 \ln K_{it} \ln L_{it} + \beta_8 t_t \ln K_{it} + \beta_9 t_t \ln L_{it} + v_{it} - u_{it} \quad (2)$$

Technological progress index, *TP*, is computed as the geometric mean between two consecutive years of partial derivatives of the production function with respect to time:

$$TP_{it} = \exp\left[\frac{1}{2}\left(\frac{\partial \ln Y_{i,t-1}}{\partial (t-1)} + \frac{\partial \ln Y_{it}}{\partial t}\right)\right] \cdot 100. \quad (3)$$

An index greater than 100 indicates positive technological progress and when it is less than 100, it indicates a decline in technology.