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On the Performance of Foreign Direct Investment in China: 1981-2004

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Abstract

This paper centers on the measurement of the time-varying efficiency of foreign direct investment (FDI) in China from 1981 to 2004. I modify the standard stochastic production frontier approach to isolate the estimate of the technical efficiency of FDI. The estimations show that the FDI technical efficiency exhibits a U-shaped time pattern, i.e., there is efficiency deterioration in the early stage of China's reform and a gradual efficiency improvement after the mid-1990s. However, this U-shaped time pattern disappears when technical change (changing frontier) is taken into account.

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1. Introduction

The effects of foreign direct investment (FDI) on the host country have been well documented in the literature.[1] For developing countries like China, FDI is expected to bring not only capital but various spillover effects.[2] FDI has attracted significant attention in China ever since China launched the economic reform in 1978. Fig. 1 shows the magnitude of FDI in China during the period 1982-2008. The rapid increase of FDI is quite impressive. It is natural, therefore, to raise the question of how well FDI performs in China. There have been a few studies in the literature examining the efficiency of different sectors in China, including the agriculture sector (Mao and Koo 1997 and Li and Wahl 2004), the electrical power sector (Lam and Shiu 2004), and the education sector (Ng and Li 2000), etc. The measurement of FDI efficiency in China, however, has not been fully explored. The current paper, using a modified stochastic frontier approach and provincial level data, provides such a measure of FDI efficiency in China during the period 1981-2004.

Two existing papers, Mastromarco (2008) and Wu (2000), are closely related to the current study. Mastromarco (2008) also adopts a stochastic frontier approach to measure efficiency. But her primary interest was to explore, on the macroeconomic level, the evidence on "whether FDI, imported capital goods and human capital serve as channels for increasing productivity via efficiency in less-developed countries" (Mastromarco 2008, page 352). Her sample covers a panel of 57 countries, instead of focusing on different regions *within* a country. Wu (2000) studied a similar research question. He employed the Farrell efficiency measure to study the collective (in)efficiency of FDI together with other inputs (i.e., labor and domestic capital) under the framework of a *time-invariant* stochastic production frontier. Compared to Wu (2000), the current paper is different in several aspects. First, I modify the stochastic frontier approach, allowing me to isolate the FDI efficiency specifically. This modified stochastic frontier is different from Wu (2000) in the sense that it measures the efficiency of FDI only while the one in Wu (2000) measures the collective efficiency of all inputs. Second, I also take into account the influence of a time-varying stochastic frontier (i.e., technical change) on the FDI efficiency measure. This changing frontier turns out to be important but has been largely ignored in the existing literature. Third, a much larger sample (24 years across 28 provinces) is used in this paper, thus providing a more complete picture of the evolution of FDI efficiency in China.

[1] A good literature review on the effects of FDI could be found in de Mello (1997) and Meyer (2003).

[2] Cheng and Kwan (2000), Cheung and Lin (2004), and Li and Chen (2010), among others, studied the impacts and related issues of FDI in China.

The estimation ignoring technical change shows that, overall, the performance of FDI exhibits a U-shaped time pattern. Out of 28 provinces in my sample, 26 provinces feature the U-shaped time pattern.[3] This finding indicates that the performance of FDI deteriorated in the early stage of China's reform and gradually improved after the mid-1990s. This U-shaped time pattern of FDI technical efficiency, however, disappears in most of the provinces once technical change is taken into account. This implies that the U-shaped time-pattern of the overall FDI performance observed is largely driven by technical change. There is no significant evidence for improvement of FDI technical efficiency *per se* in China during this period. The time pattern of FDI technical efficiency, after controlling for the changing frontier, varies across regions and does not admit any obviously common pattern.

The remainder of this paper is structured in the following way. Section 2 introduces the stochastic frontier approach and motivates the model adopted in this paper. Section 3 describes the empirical estimations and discusses the estimation results. Section 4 concludes.

2. Model

To explore the efficiency associated with one input X_1 (say, FDI), consider the following modified stochastic production frontier

$$X_1 = g(X_2, Y)\exp(u) \tag{1}$$

where X_2 and Y are the observed input and output, respectively; $g(X_2, Y)$ represents the frontier (technology) and u denotes the inefficiency of the input X_1. Basically the frontier $g(X_2, Y)$ gives the minimum amount of X_1 that is required to produce, together with X_2, the observed output Y. Therefore the ratio of realized (observed) input X_1 to the potential minimum input $g(X_2, Y)$ tells how inefficient the input X_1 has been used. This idea is illustrated by Fig. 2 in the input space where $L(Y)$ denotes the input requirement set for output Y. The inefficiency measure of input X_1 is given by $\frac{OD}{OC}$ and therefore the X_1 efficiency is $\exp(-u) = \frac{OC}{OD}$. It is interesting to notice that the overall inefficiency of all inputs is denoted by $\frac{OX}{OA'} = \frac{OD}{OC'}$, which is the idea used in Wu (2000).[4] And one would expect that the efficiency of X_1

[3] The two exceptions are Xinjiang and Gansu, both of which are inland provinces and account for a negligible fraction of total FDI in China.

[4] Mathematically this efficiency measure for all inputs is $\exp(-u) = \frac{OC'}{OD}$ when the stochastic production frontier is specified as $Y = f(X)\exp(-u)$. Since the functional form of $g(\cdot)$ adopted in the current paper is different from $f(\cdot)$ in Wu (2000), the resulting efficiency measure is not directly comparable.

obtained in the current paper ($\frac{OC}{OD}$) is lower than the efficiency measure of all inputs ($\frac{OC'}{OD}$).[5]

Following the general discussion above, the stochastic frontier for FDI is specified as

$$K_F = g(L, K_D, Y) \exp(u) \tag{2}$$

where L, K_D, K_F, Y denote labor, real domestic capital stock, real foreign capital stock and real output, respectively. Here u is nonnegative inefficiency measure of FDI, i.e., higher u indicates lower efficiency of FDI. In the literature, different functional forms of time-varying efficiency u have been proposed including those in Cornwell *et al.* (1990), Kumbhakar (1990), Battese and Coelli (1992), and Lee and Schmidt (1993). Different specifications impose different restrictions on the time pattern of the efficiency. In this paper, I did not impose any restriction on the specification of the functional form for time-varying efficiency because no restriction "permits the greatest degree of flexibility in the possible patterns of technical efficiency" (Coelli *et al.* 2005, page 303).

Suppose that $g(L, K_D, Y)$ takes the Cobb-Douglas functional form

$$g(L, K_D, Y) = \exp(\alpha_0) L^{\alpha_1} K_D^{\alpha_2} Y^{\alpha_3} \exp(v) \tag{3}$$

where v is a symmetric random error with normal distribution $(0, \sigma_v^2)$. Plugging (3) into (2) and taking logarithm on both sides give equation (4)

$$\ln K_F = \alpha_0 + \alpha_1 \ln L + \alpha_2 \ln K_D + \alpha_3 \ln Y + v + u \tag{4}$$

Equation (4) is the basic model estimated in this paper. Notice that equation (4), to be estimated in a panel data setup, does not specify the individual-specific effects (provincial effects in this paper). The estimated u here, hence, also includes the unobservable but time-invariant individual heterogeneity. The consequence is that the time pattern of the efficiency for each individual province is more important and informative than the magnitude. This unobservable heterogeneity also makes the comparison across individual provinces less meaningful.

3. Results

3.1 Without Technical Change

[5] It is true in this paper. But the results are not reported as they are out of the interest of the present paper.

I collected the provincial level data for GDP, labor, domestic investment and FDI for 28 provinces during the period 1981-2004.[6] Domestic capital and foreign capital are calculated based on domestic investment and FDI as in Wu (2000). The maximum likelihood estimator for equation (4) is obtained by using the computer program FRONTIER 4.1 (Coelli 1994).

Table 1 reports the results for the estimated coefficients. All the coefficients under concern have the expected sign, i.e., α_1 and α_2 are negative and α_3 is positive. Furthermore, all three coefficients are significant at 1% significance level.

The estimated FDI efficiency is reported in Fig. 3. One immediate observation is that each estimated efficiency score is very high, close to 1. As explained before, this is not informative because the efficiency measure also contains the unobservable heterogeneity. The more important observation is that, in almost all provinces (26 out of 28), there is a U-shaped time pattern of the efficiency over time. The FDI efficiency deteriorates in the early state of economic reform and improves gradually after the mid-1990s. This time pattern indicates a long learning process for FDI before it reaches efficient performance in China.[7]

3.2 With Technical Change

The FDI efficiency measure estimated above does not allow for the technical change over time, i.e., the movement of the frontier *per se*. A similar problem is shared by Wu (2000). It is interesting, however, to further explore how the technical efficiency looks after the technical change is controlled for. This section attempts to estimate a time-varying technical efficiency while accounting for the potential technical change. The stochastic frontier is specified now as:

$$\begin{aligned} \ln K_F &= \alpha_0 + \alpha_1 \ln L + \alpha_2 \ln K_D + \alpha_3 \ln Y \\ &\quad +\gamma_0 t + \gamma_1 t^2 + \gamma_2 t \ln L + \gamma_3 t \ln K_D + \gamma_4 t \ln Y + v + u \end{aligned} \tag{5}$$

Equation (5), in contrast to equation (4), includes in the frontier the quadratic time trend as well as the interactive terms of time with labor, domestic capital and output. This effort is made to control for the movement of the frontier.[8] Estimation results for equation (5) are reported in Table 2. The estimated FDI technical efficiency after controlling for the technical change is reported in Fig. 4.

[6] The data are described in detail in the appendix.

[7] If a quadratic time trend is explicitly considered in the specification of the efficiency u, the estimated coeffiients do confirm the existence of this U-shaped time pattern.

[8] A similar method is used in Coelli et al. (2005), page 300.

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The estimation results in Table 2 indicate that the time trend as well as the labor input will affect the technical frontier significantly.[9] The statistical significance of γ_0 and γ_1 will weaken the trend, if any, in the efficiency measure u. The estimated results in Fig. 4 show that, once the technical change is accounted for, the aforementioned U-shaped time pattern disappears in most provinces. This observation implies that it is the changing stochastic frontier that gives rise to the U-shaped time pattern in the overall performance of FDI. The significance of FDI technical change is confirmed by the coefficients in equation (5). But the improvement of FDI technical efficiency is not obvious. The FDI technical efficiency fluctuates and varies across provinces significantly during the sample period.[10]

4. Conclusion

Using panel data covering 28 provinces, this paper estimates FDI efficiency in China from 1981 to 2004 by applying a modified stochastic frontier approach. In contrast to existing studies, a significant U-shaped time pattern is found in terms of the overall FDI performance. FDI in China performs worse in the early stage of reform and gets better after the mid-1990s. This U-shaped time pattern of FDI technical efficiency disappears after technical change is taken into account, implying that the U-shaped time pattern is largely driven by the changing frontier itself.

This finding indicates that: first, technical change is important and it should not be ignored in the estimation process of measuring FDI efficiency over time; second, no significant evidence for the improvement of FDI technical efficiency is found during the sample period. Based on the present paper, it would be interesting to further explore the determinants of the FDI technical change and technical efficiency change, which provides direction for future research.

[9] The results are similar if the insignificant variables are removed from the estimations.

[10] This finding does not contradict those in Wu (2000) where the inverse-J shape technical efficiency was found. Since Wu (2000) did not consider technical change, the inverse-J shape may also be driven by the technical change in the frontier.

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Appendix: Data Description

China has three different kinds of administrative units on provincial level: Province, Autonomous region, and Municipality. In this paper I generally call all provincial units as “province”. 28 provinces are included in this paper: Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, and Xinjiang. Provincial data for GDP, domestic investment, foreign direct investment, and employed workers come from various issues of China Statistical Yearbook.

All nominal variables have been deflated using GDP deflator. The GDP deflator is calculated from the GDP data which are available in both current and constant prices (base year: 1978).

FDI is recorded in US dollars and has to been transformed into the unit of RMB, which is done using the average exchange rate of each year. The exchange rates of 1981-1984 are according to China Statistical Yearbook 2001 and the figures of 1985-2008 exchange rate are according to China Statistical Yearbook 2010.

Domestic capital and foreign capital are calculated based on domestic investment and foreign direct investment according to the process described in Wu (2000).

Due to the lack of statistics on labor hours, provincial labor input (L) is replaced by the total number of employed workers. However, there is missing data for provincial employed workers during 1981-1984. This part of missing data is recovered based on the national-wide statistics of employed workers according to the following formula

$$\frac{L_i}{\sum_i L_i} = \frac{pop_i}{\sum_i pop_i}$$

where L_i is the number of employed workers in province i, pop_i is the population in province i. All employed workers and population statistics are according to the China Statistical Yearbook.[11]

[11] The estimation results are robust if the sample period is reduced to 1985-2004.

Table 1: Estimation results without technical change

	coefficient	t ratio
α_0	0.778	1.186
α_1	-1.907***	-18.338
α_2	-1.872***	-5.231
α_3	4.996***	13.668

Notes: *** represents significance at 1% significance level.

Table 2: Estimation results with technical change

	coefficient	t ratio
α_0	-3.509**	-2.041
α_1	-2.177***	-10.778
α_2	-3.412***	-5.225
α_3	5.196***	8.119
γ_0	0.325***	3.010
γ_1	-0.022***	-13.221
γ_2	0.049***	3.757
γ_3	-0.002	-0.044
γ_4	0.025	0.584

Notes: ** and *** represent significance at 5% and 1% significance level, respectively.

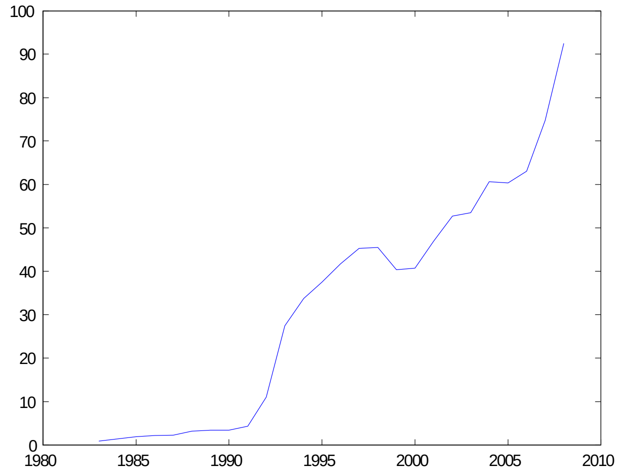

Fig. 1. Actually utilized FDI in China from 1983 to 2008 (in current $ billion)

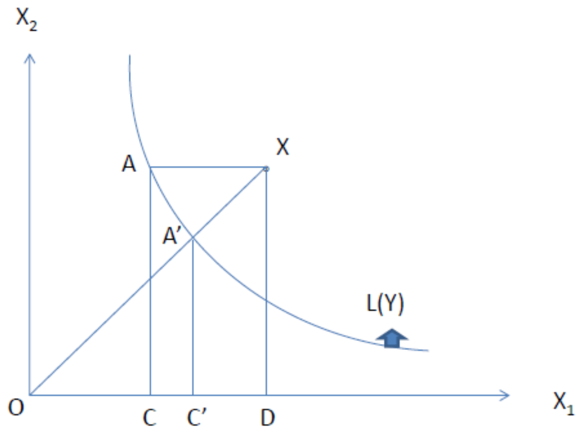

Fig. 2. Efficiency measure for X_1

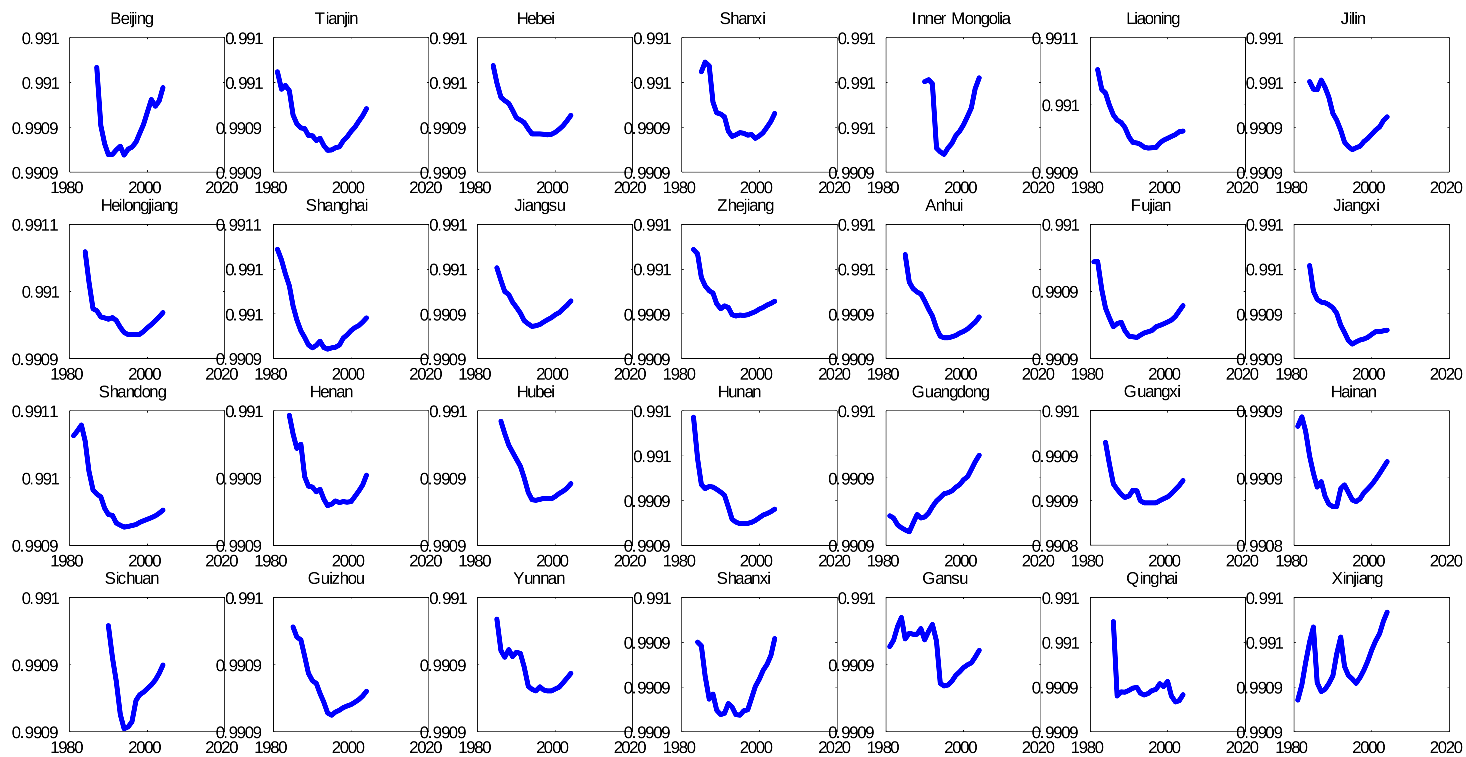

Fig. 3. Estimated FDI efficiency (without considering technical change)

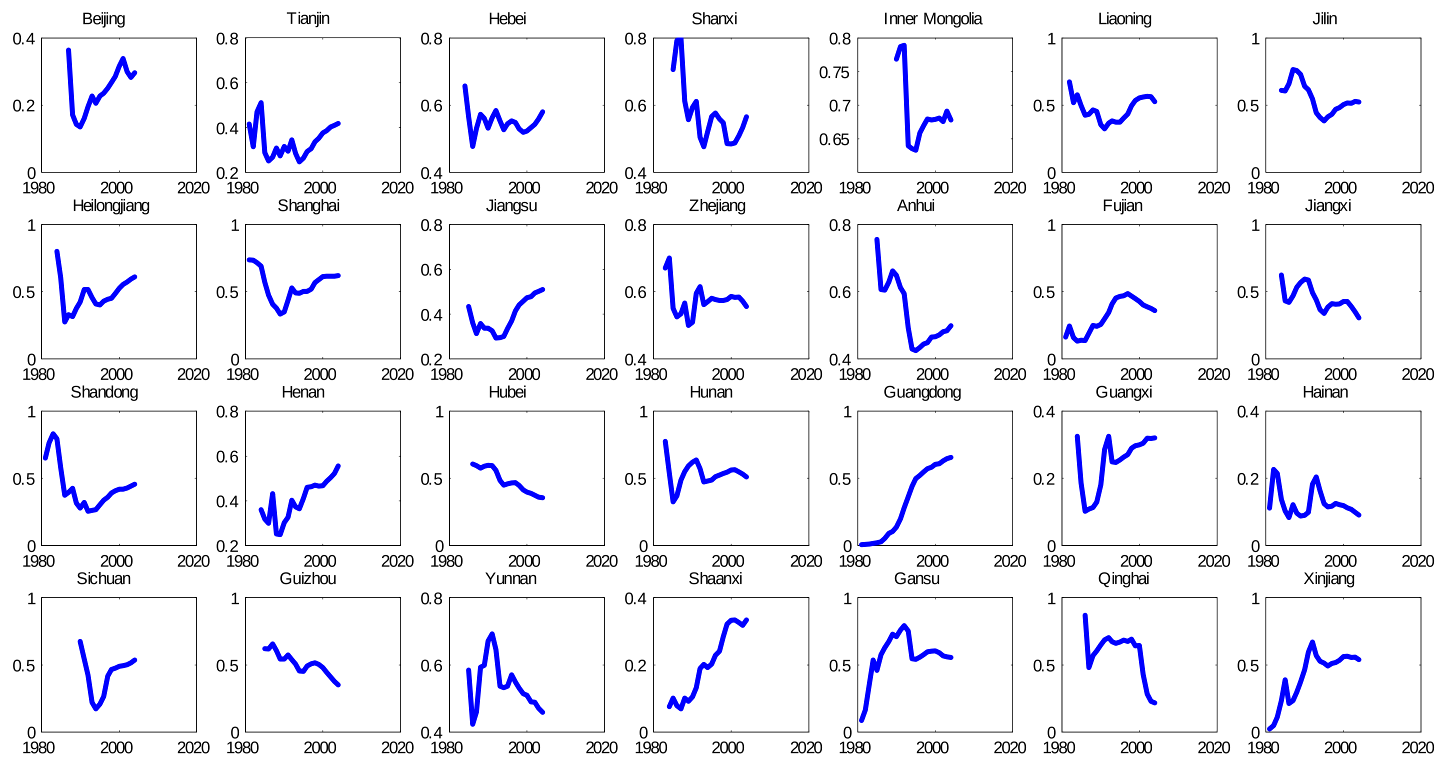

Fig. 4. Estimated FDI efficiency (allowing for technical change)