ICIC Express Letters
Volume **10**, Number **7**, July **2016**
 ISSN 1881-803X
pp. 1621–1625

THRESHOLD EFFECT OF FDI SPILLOVER IN CHINA UNDER INFORMATION ECONOMY

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Received December 2015; accepted March 2016

Abstract. *Threshold model is popular for revealing parameters' structural changes. Based on this model and the panel data of 29 provinces during 2004-2012, this paper explores the impact of regional information level on the relationship of FDI spillover and economic growth. The empirical results show double-threshold effect at the national level, where FDI spillover is significantly positive to economic growth on condition of lower and higher information level. At regional level, there is single threshold effect in the East, but no threshold effect in the Central and West. This helps to make better directed developing policies on both FDI and information in China.*
Keywords: Foreign direct investment (FDI), Threshold regression, Spillover effect, Panel data, Information economy

1. **Introduction.** FDI spillover is widely recognized as an important factor to better economic growth especially for developing countries [1]. Meanwhile, the rapid development of information has promoted a new round of growth in China [2]. This makes us wonder the influence of regional information level on FDI spillover effect. Therefore, it is essential to investigate the relationship of FDI spillover and economic growth under the constraints of information level. This study not only expands the application of FDI spillover theory under the background of information economy, but also helps to make better directed developing policies.

The spillover effect of FDI is first proposed by MacDougall in 1960 [3]. In the initial stages, researches focused on testing the existence of FDI spillover, and massive studies paid attention to the disagreement about FDI spillover effect in China [4-6]. However, FDI spillover cannot happen spontaneously [7]. On the contrary, it is impacted by kinds of factors that have been ignored before, such as innovation [8], environmental regulation [9], human capital [10], technology gap [11] and financial development [12]. Moreover, the rapid development of non-linear theory gradually attracts scholars' attention at home and abroad. With econometric techniques that are appropriate for threshold regression and bootstrap method which could assess the statistical significance of threshold effect, this paper aims to investigate whether information level affects the relationship of FDI spillover and economic growth, taking the unbalanced regional FDI and information level into consideration.

This paper proceeds as follows. Section 2 outlines the estimation methods used in this paper. Section 3 reports the source and processing method of data, and discusses the estimation of different regions by fixed effects. A conclusion is given in Section 4.

2. Research Methodology.

2.1. Threshold model.

2.1. Threshold model. Threshold model [13] is a typical non-linear model with the following structural equation which can reveal parameters' structural changes:

$$y_{it} = u_i + \beta_1' x_{it} I\left(thv_{it} \leq \lambda\right) + \beta_2' x_{it} I\left(thv_{it} > \lambda\right) + \varepsilon_{it}, \quad (1 \leq i \leq n, 1 \leq t \leq T) \tag{1}$$

$I(\cdot)$ is the indicator function, and the subscripts i and t index the individual and time. According to (1), the individual observations are divided into groups distinguished by different slopes (β_1 and β_2) based on the numerical relationship of threshold variable thv_{it} and threshold value λ. Letting $\beta = (\beta_1', \beta_2')'$, Formula (1) equals

$$y_{it} = u_i + \beta' x_{it}(\lambda) + \varepsilon_{it} \tag{2}$$

Since non-linear model requires careful treatment when eliminating the individual effect, we take averages of Formula (2) over the time index t and produce

$$\bar{y}_i = u_i + \beta' \bar{x}_i(\lambda) + \bar{\varepsilon}_i \tag{3}$$

Taking the difference between (2) and (3), we get $y_{it}^* = u_i + \beta' x_{it}^*(\lambda) + \varepsilon_{it}^*$. For any given λ, let Y^*, $X^*(\lambda)$ and ε^* denote the data stacked over all individuals, and then slope coefficient β and the corresponding sum of squared errors can be obtained through least squares estimation[1]:

$$\hat{\beta}(\lambda) = \left(X^*(\lambda)' X^*(\lambda)\right)^{-1} X^*(\lambda)' Y^* \tag{4}$$

$$S_1(\lambda) = Y^{*\prime} \left(I - X^*(\lambda)' \left(X^*(\lambda)' X^*(\lambda)\right)^{-1} X^*(\lambda)'\right) Y^* \tag{5}$$

Here, the value of $\hat{\lambda}$ corresponding to the minimum sum of squared errors is marked as λ_0 representing the real threshold value. Once $\hat{\lambda}$ is available, the residual variance is obtained according to $\hat{\sigma}^2 = \hat{\varepsilon}^{*\prime} \hat{\varepsilon}^* / [n(T-1)] = S_1\left(\hat{\lambda}\right) / [n(T-1)]$.

Formula (1) is a single threshold model, while there may exist multiple thresholds in some applications. For example, the double threshold model takes the form as follows:

$$y_{it} = u_i + \beta_1' x_{it} I\left(thv_{it} \leq \lambda_1\right) + \beta_2' x_{it} I\left(\lambda_1 < thv_{it} \leq \lambda_2\right) + \beta_3' x_{it} I\left(\lambda_2 < thv_{it}\right) + \varepsilon_{it} \tag{6}$$

Let $\beta = (\beta_1', \beta_2', \beta_3')'$, and then the principles and methods of estimation are the same as the single threshold model depicted above.

2.2. Bootstrap and test for threshold. To determine whether the threshold effect is statistically significant, the null and alternative hypothesis can be represented by linear constraints: H_0: $\beta_1 = \beta_2$, H_1: $\beta_1 \neq \beta_2$. The likelihood ratio test of H_0 is based on $F_1 = \left(S_0 - S_1\left(\hat{\lambda}\right)\right) \big/ \hat{\sigma}^2\left(\hat{\lambda}\right)$, where S_0 and σ^2 denote the sum of squared errors under H_0 and H_1 respectively. Since classical tests have non-standard distributions, it is popular to perform a bootstrap test by generating B bootstrap samples (indexed by j). The p-values constructed are also asymptotically valid: $p\left(\hat{\lambda}\right) = 1 - F_1$, and its empirical analog is $\hat{p}^*\left(\hat{\lambda}\right) = 1 - \hat{F}_1^* = \frac{1}{B}\sum_{j=1}^{B} I\left(\lambda_j^* > \hat{\lambda}\right)$. The null hypothesis suggesting no threshold effect will be rejected if p-value is smaller than the desired critical value α.

To test the authenticity of threshold value, null and alternative hypothesis can be represented by: H_0: $\hat{\lambda} = \lambda_0$, H_1: $\hat{\lambda} \neq \lambda_0$. The likelihood ratio test will be rejected if $LR(\lambda) > c(\alpha)$, where $c(\alpha) = -2\ln\left(1 - \sqrt{1-\alpha}\right)$ and $LR(\lambda) = \left(\left(S_1\left(\hat{\lambda}\right) - S_1(\lambda_0)\right) \big/ \hat{\sigma}^2\left(\hat{\lambda}\right)\right)$.

[1]Detailed derivation is omitted.

3. Empirical Studies.

3.1. Empirical model and data.
According to World Bank's report, the source of economic growth usually comes from capital accumulation, employment growth, human capital and TFP (Total Factor Productivity) growth [14]. In this paper, the TFP growth is considered coming from two parts: FDI spillover effect and local R&D (Research and Development) effect. Thus, threshold model in logarithmic form is constructed as follows:

$$\begin{aligned}\ln GDP_{it} &= a_0 + a_1 \ln K_{it} + a_2 \ln L_{it} + a_3 \ln H_{it} + a_4 \ln RD_{it} \\ &+ \phi_1 \ln FDI_{it} \cdot I(Info_{it} \leq \lambda_1) + \phi_2 \ln FDI_{it} \cdot I(\lambda_1 \leq Info_{it} \leq \lambda_2) \\ &+ \phi_3 \ln FDI_{it} \cdot I(Info_{it} \geq \lambda_2) + \varepsilon_{it}\end{aligned} \tag{7}$$

A regional sample from 2004 to 2012 is selected, and year 2000 is chosen as the base year. In model (7), the real GDP (Gross Domestic Product) denotes the economic growth. K denotes the capital stock level calculated according to Shan Haojie's method [15]. L is the labor represented by the number of employed persons by three strata of industry (at year-end). H is the human capital measured by the average labor force schooling proposed by Barro and Lee [16]. ε is the random item. The subscripts i and t index the individual and time.

Besides, RD denotes the research and experimental development level. The variable RD can be calculated by $RD_{it} = R\&D_{it}/GDP_{it}$, where the capital stock $R\&D$ is measured by $R\&D_{it} = rd_{it} + (1-\delta)R\&D_{it-1}$ based on Perpetual Inventory Method (PIM). Here, rd_{it} denotes the expenditures on research and development. The replacement rate δ is set as 15%. The initial value of $R\&D$ is estimated according to $R\&D_{it(t=2004)} = rd_{it(t=2004)}/(g+\delta)$ where g is the geometric growth rate. All the data are obtained from China Statistical Yearbook (2004-2013).

FDI is the foreign investment level represented by the ratio of actual foreign direct investment stock (PIM, $\delta = 15\%$) and real GDP. The flow data of FDI are obtained from the choice financial terminal database and deflated by American CPI (Consumer Price Index) and exchange rate.

Threshold variable *Info* is the information capital stock. In this paper, it is used to denote the regional information level. The fixed-assets investments on "Information Transmission, Software and Information Technology" are chosen as the proxy of information capital. Thus, threshold variable *Info* can be measured with PIM ($\delta = 20\%$) using Price Indices of Investment in Fixed Assets.

3.2. Threshold estimates.
To determine the number of thresholds, model (7) was estimated by least squares, allowing for zero, one, two and three thresholds sequentially. The F-statistics along with the bootstrap p-values are shown in Table 1, from which we

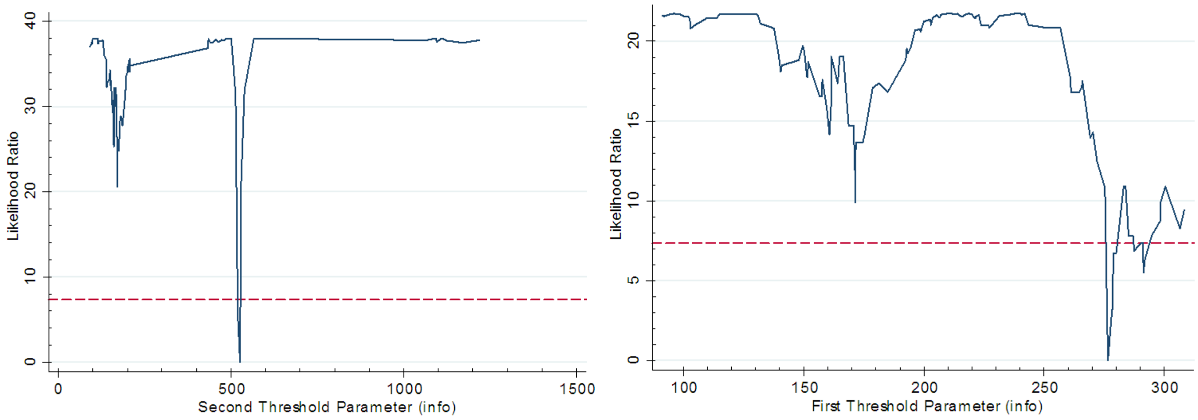
Table 1. Threshold estimates

	Nationwide		*East*		*Central*		*West*	
	Info	F^a	*Info*	F	*Info*	F	*Info*	F
Single[b]	276.66	15.58* (0.078)	285.16	34.45** (0.042)	205.32	7.06 (0.252)	206.00	9.77 (0.304)
Double	526.04 276.66	31.75*** (0.004)	411.66 285.16	5.52 (0.348)	271.13 205.32	4.21 (0.132)	518.85 174.57	0.56 (0.254)
Triple	171.41	14.22* (0.060)	1122.73	1.78 (0.542)	373.71	3.58 (0.474)	39.68	1.43 (0.610)

p-value in parentheses, $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$; [a]F-value. [b]the number of thresholds.
Note: In this paper, we choose 500 bootstrap replications. ($\alpha = 0.05$)

can find that there are two significant thresholds at the national level, one significant threshold in the East, while zero in the Central and West[2].

Plots of the concentrated likelihood ratio function LR (λ) are shown in Figure 1. The 95% confidence intervals can be found from LR (λ) by the values of λ for which the likelihood ratio lies beneath the dotted line. We can examine the significance and effectiveness of the estimated threshold by checking whether it falls in the 95% confidence intervals or not. In this paper, threshold effects are significant and effective.



Note: corresponding to the second and first estimates at the national level

FIGURE 1. Confidence interval construction in double threshold model

3.3. **Regression estimates.** Table 2 reports the estimates of model (7) with fixed effect using Stata12.0. At the national level, what is unexpected is that there is significant positive FDI spillover effect on economic growth with lower and higher regional information level, while not significant negative effect otherwise. If the information level is relatively lower, the capital spillover effect of FDI dominates. On the contrary, the technology spillover effect of FDI dominates with relatively higher information level. To some extent, this reflects the development process of FDI in China.

TABLE 2. Regression estimates

	Whole Fe^a	*East* *Fe*	*Central* *Fe*	*West* *Fe*
lnFDI			-0.053^{**}	0.086^{***}
lnFDI $(info < \lambda)$		0.013^{***}		
lnFDI $(info > \lambda)$		0.004		
lnFDI $(info < \lambda_1)$	0.008^{***}			
lnFDI $(\lambda_1 < info < \lambda_2)$	-0.010			
lnFDI $(info > \lambda_2)$	0.016^{***}			
lnH	0.499^{***}	-0.136	0.548^{***}	0.326^{*}
lnRD	0.102^{***}	0.290^{***}	0.202^{***}	-0.169^{***}
lnK	0.619^{***}	0.587^{***}	0.569^{***}	0.754^{***}
lnL	0.135^{***}	0.205^{***}	0.042	0.122
cons	2.537^{***}	4.545^{***}	3.769^{***}	1.599^{*}
Adj-R^2	0.978	0.983	0.987	0.980

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$; ^{a}Fixed-effect model. ($\alpha = 0.05$)

[2]Referring to division by the National Bureau of Statistic of China, we give a provincial-level division of the People's Republic of China as east, central and west China. The region of Tibet is out of our consideration because of unavailable data. Sichuan includes Sichuan and Chongqing.

In the East, FDI has significant positive spillover effect when regional information capital stock is lower than 285.16, but not significant positive effect otherwise. There is no threshold in Central and West. The crowding-out effect of FDI dominates in the Central, while there is a positive FDI spillover effect in the West.

4. **Conclusions.** Based on the new economic theory, this paper investigates the influence of information development on FDI spillover effect by constructing a threshold model from regional perspective that has been neglected before.

The estimates are exhibited at two levels. At the national level, the results highlight the influence of information level on the non-linear relationship of FDI spillover effect and economic growth. At the regional level, quite different effects are obtained. Several extensions could be made in the future, including allowing for random effects and further discussing the relationship of FDI spillover and China's ICT industry.

Acknowledgements. This research is supported by the National Natural Science Foundation of China (No. 70973011) and the Natural Science Foundation of Hebei University of Science and Technology (QD201502).

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