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A Model for the Roles of FDI in Shaping Productivity Growth: With Empirical Evidence from China

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Abstract

This paper presents an analytic framework with empirical evidence aiming to improve our understanding of the roles of foreign direct investment (FDI) in shaping productivity growth. Specifically, the study empirically examines the effects of FDI on China's regional productivity growth. Our analyses based on two versions of our model, one excluding and one including human capital, show that FDI has both a general growth effect and a convergence effect on productivity in the Chinese provinces over the period 1996–2012. Our findings imply, at least in the case of the Chinese provinces, that apart from its direct, static level effect on output as an accumulable factor of production, FDI also exerts indirect, dynamic impacts on output through its growth and convergence effects on productivity.

JEL Classifications: F41, O47, O53

Keywords: foreign direct investment, productivity; growth, convergence

1. Introduction

1.1 Background

This paper presents an analytic framework with empirical evidence aiming to improve our understanding of the roles of foreign direct investment (FDI) in shaping productivity growth. Specifically, the paper empirically examines the effects of FDI on China's regional productivity growth. China's remarkable economic growth during the past 35 years has been accompanied by increasing influx of FDI.[1] In 1978, China initiated its economic reform and adopted the open-door policy. Regarding FDI, China gradually shifted from restrictive policies to permissive policies in the early 1980s, then to policies encouraging FDI in general in the mid-1980s, and to policies encouraging more high-tech and more capital-intensive FDI in the mid-1990s (Fung, Iizaka, & Tong, 2004).

Since 1993, China has the largest amount of FDI among the developing countries. However, the spatial distribution of FDI is highly uneven.[2] The preferential policies favoring the eastern coastal regions of China in receiving FDI led to an overwhelming concentration of FDI in the eastern provinces (Cheung & Lin, 2004). Aiming to offset the negative consequences of the widening gap between the coastal and the

[1] See, for example, Whalley and Xin (2010) for more related discussion.

[2] See, for example, Yang (1999), Zhu, Lai, and Fu (2008) and Yin (2011).

interior regions, more broadly based economic reforms and open-door policies were pushed forward in the 1990s (Madariaga & Poncet, 2007). However, the spatial pattern of uneven FDI distribution has remained rather stable over time: the share of the coastal regions in total FDI inflows has been as large as 85 percent.

China's remarkably high growth and its rapid opening up have motivated a lot of discussion in recent literature.[3] Many recent studies have emphasized the effects of FDI on China's economic growth. However, although there has been an increasing body of literature on FDI in China, few empirical studies have been devoted to a systematic treatment of the impacts of FDI on China's regional productivity growth (K. Zhang, 2006). How do FDI inflows affect productivity growth in different regions of China? To answer such a question, we need to fully analyze the roles of FDI in shaping China's regional productivity growth.

1.2 The Focus and Structure of This Paper

This paper aims to fill a gap in the literature by providing a systematic quantitative analysis exploring how FDI affects regional productivity growth in the Chinese regions. The study updates the author's previous work, Author (2013, omitted for anonymity, to be added later), and presents an analytic framework with empirical evidence expanding our understanding of the roles of FDI in shaping China's regional productivity growth. Our empirical results show that FDI has both a general *growth* effect and a *convergence* effect on productivity in the Chinese provinces. That is, besides its direct, static level effect on output as an accumulable factor input, FDI also exerts indirect, dynamic impacts on output through its growth and convergence effects on productivity.

The rest of the paper is structured as follows. In Section 2, we present our basic model, where we temporarily leave out human capital from the aggregate production function as a factor input. After the discussion of the theoretical model and the derivation of the related econometric specification, which is based on the theoretical model, we implement our empirical analysis of 28 Chinese province-level regions over the period of 1996–2012. In Section 3, we move on to augment our basic theoretical model by incorporating human capital into the aggregate production function as an additional factor input. The presentation of the augmented theoretical model and the derivation of the related econometric specification, which is based on the augmented theoretical model, are then followed by relevant empirical analysis. Finally, Section 4 concludes.

2. The Basic Model

2.1 The Theoretical Setup

In order to examine the effects of FDI on regional productivity and income growth in China, in this section we set up the basic model first, temporarily ignoring human capital as a factor input in the aggregate production function. In the next section we will augment the basic model by incorporating human capital into it. In both sections, relevant empirical analysis follows the theoretical model.

To set up the basic model, we assume a simple aggregate production function of the Cobb-Douglas form. For province i at time t, we have

$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{1-\alpha} \tag{1}$$

[3] See, for example, K. Zhang (1999), Démurger (2000), DaCosta and Carroll (2001), Yao and Zhang (2001), Démurger *et al*. (2002), Bao, Chang, Sachs and Woo (2002), Hu and Owen (2003), Wang and Gao (2003), K. Zhang (2006), Madariaga and Poncet (2007), Whalley and Xin (2010), Jiang (2011) and Ouyang and Fu (2012).

where Y is output, K is physical capital stock (including FDI stock), L is the number of workers, and A is a measure of (total factor) productivity. Therefore, in per worker terms, we have

$$y_{it} = A_{it} k_{it}^{\alpha} \tag{2}$$

where y and k are per worker output and per worker physical capital stock respectively, $y \equiv Y / L$ and $k \equiv K / L$. Equation (2) immediately leads to

$$\ln A_{it} = \ln y_{it} - \alpha \ln k_{it} \tag{3}$$

$$\Delta \ln y_{it} = \Delta \ln A_{it} + \alpha \Delta \ln k_{it} \tag{4}$$

where the sign "Δ" denotes the difference between two adjacent time periods, i.e. $\Delta \ln y_{it} \equiv \ln y_{i,t+1} - \ln y_{it}$ (and so on).

We assume that growth of A is determined by

$$A_{i,t+1} / A_{it} = f_{it}^{\rho} A_{it}^{\lambda} T_t X_i \tag{5}$$

where f denotes per worker FDI stock, T is a measure of time-varying nationwide policy or structural change that affects the growth of A, and X captures a set of time-constant province-specific factors that influence provincial productivity growth. The term f_{it}^{ρ} captures the spillover effect of FDI on provincial productivity growth and we expect ρ to be positive. The term A_{it}^{λ}, where λ is in turn assumed to be a function of per worker FDI capital stock f, captures the effect of the current level of A on its subsequent growth, and therefore, a negative value of λ implies conditional convergence in productivity across the provinces. We further assume that

$$\lambda = \lambda_0 + \lambda_1 \ln f_{it} \tag{6}$$

2.2 The Regression Specification and Data

With (5) and (6) above, we now have

$$\Delta \ln A_{it} = \rho \ln f_{it} + (\lambda_0 + \lambda_1 \ln f_{it}) \ln A_{it} + \ln T_t + \ln X_i \tag{7}$$

Using (3), (4) and (7), we can obtain the following regression specification

$$\Delta \ln y_{it} = \lambda_0 \ln y_{it} - \lambda_0 \alpha \ln k_{it} + \rho \ln f_{it} + \lambda_1 \ln f_{it} \ln y_{it} - \lambda_1 \alpha \ln f_{it} \ln k_{it} \tag{8}$$

$$+ \alpha \Delta \ln k_{it} + \eta_t + u_i + v_{it}$$

where η_t is the time intercept, u_i is the province heterogeneity, and v_{it} is a zero-mean idiosyncratic error term.

The regression specification in (8) shows that the growth of per worker output within a certain time span is dependent not only on the growth of per worker physical capital stock within the same time span, but also on the initial levels of per worker output, per worker physical capital stock, and per worker FDI stock at the beginning of the time span, as well as the interactions of the initial level of per worker FDI stock with each of the initial levels of per worker output and per worker physical capital stock. By construction, there are nonlinear restrictions on the coefficients on the explanatory variables in the regression equation. Therefore, we can estimate the parameters involved in (8) by using a nonlinear least squares regression method.

Our sample is 28 provinces (province-level regions) in mainland China over the period 1996–2012.[4] Owing to missing data, three provinces, Tibet, Chongqing and Hainan, are not included in our sample. Most data needed for our analysis can be obtained from the various official publications of the National Bureau of Statistics of China. The numbers of total employed persons (workers) for the 28 provinces in 1996–2012 are directly available from these publications, so that data on L_{it} can be obtained. Series of nominal provincial GDP and GDP indices are also available from the publications, so that the values of real provincial GDP can be calculated. The values of y_{it} are then calculated as real provincial GDP divided by the number of provincial employed persons.

However, the official publications of the National Bureau of Statistics of China do not directly record data on provincial physical capital stock. Therefore, we use a perpetual inventory method, similar to that used by J. Zhang (2008), to calculate the levels of provincial physical capital stock and FDI stock. In particular, we follow the basic practice of J. Zhang (2008) and assume a uniform annual capital depreciation rate of 9.6% for all the 28 provinces over the period 1996–2012.

2.3 Regression Results

We now run a nonlinear least squares regression based on (8), adopting an annual data setup so that the sign “Δ” in (8) pertains to the difference between two adjacent years. Further, we use a time dummy variable for each year and a province dummy variable for each province to take account of the time intercept and province heterogeneity in (8). Our estimation results are summarized in Table 1. For brevity’s sake, we do not report the estimated coefficients on the time and province dummy variables in the table.

Table 1. Regression results from Equation (8)

Obs: 448				R-squared: 0.6526	
Parameter	Estimate	Std. Err.	p-value	[95% Conf. Interval]	
α	0.406	0.023	0.000	0.361	0.452
λ_0	0.112	0.024	0.000	0.065	0.159
λ_1	-0.016	0.004	0.000	-0.024	-0.008
ρ	0.134	0.033	0.000	0.070	0.198

[4] These province-level regions in mainland China include provinces, ethnic minority autonomous regions, and municipalities. For brevity’s sake, however, we call all these regions ‘provinces’.

We use a time dummy variable for each year and a province dummy variable for each province to take care of the time intercept and province heterogeneity in Equation (8). For brevity, the estimated coefficients on the time and province dummy variables are not reported in the table.

In Table 1, the four estimated parameters are all very statistically significant. The estimate of the output elasticity with respect to physical capital, α, is about 0.41 and a bit lower than its traditionally accepted value, which is around 0.50, in the case of China.[5] The positive estimate of ρ, which is about 0.13, shows the fact that we are able to identify and isolate a positive *growth* effect of FDI on productivity, whose magnitude is *unrelated* to the current level of productivity. The negative estimate of λ_1 which is about –0.016, however, shows the fact that FDI has a *convergence* effect on productivity, that is, the effect of $\ln f_{it}$ on $\Delta \ln A_{it}$ is smaller when $\ln A_{it}$ is higher, or symmetrically, the effect of $\ln A_{it}$ on $\Delta \ln A_{it}$ is smaller when $\ln h_{it}$ is higher. In other words, ceteris paribus, conditioning on a higher level of per worker FDI stock, there would be faster convergence (or slower divergence) in productivity across the Chinese provinces.

How do the provinces exhibit conditional convergence (or divergence) in productivity based on our regression exercise? This can be seen from the sign of the estimate of $(\lambda_0 + \lambda_1 \ln f_{it})$, that is, the sign of the estimated coefficient on the term $\ln A_{it}$ on the right-hand side of Equation (7). The estimates of λ_0 and λ_1 in this regression are respectively positive (which is about 0.11) and negative (which is about –0.016). Considering the range of the values of $\ln f_{it}$ in our actual sample, we do not obtain significantly negative values of $(\lambda_0 + \lambda_1 \ln f_{it})$. Therefore, this regression does not necessarily suggest conditional convergence in productivity among the Chinese provinces.

3. The Augmented Model

3.1 The Augmented Setup

In order to see how things will change if we bring human capital into the picture, in this section we augment our model in Section 2 by incorporating human capital into it. To this end, we now assume a Cobb-Douglas production function of the form

$$Y_{it} = A_{it} K_{it}^{\alpha} H_{it}^{1-\alpha} = A_{it} K_{it}^{\alpha} (h_{it} L_{it})^{1-\alpha} \tag{9}$$

in which H denotes our measure of human capital stock, and h $(\equiv H/L)$ is obviously per worker human capital stock.[6] Then, in per worker terms, we have

$$y_{it} = A_{it} k_{it}^{\alpha} h_{it}^{1-\alpha} \tag{10}$$

which, in turn, implies the following

$$\ln A_{it} = \ln y_{it} - \alpha \ln k_{it} - (1-\alpha) \ln h_{it} \tag{11}$$

$$\Delta \ln y_{it} = \Delta \ln A_{it} + \alpha \Delta \ln k_{it} + (1-\alpha) \Delta \ln h_{it} \tag{12}$$

[5] See, for example, Chow and Li (2002), Chow (2008), Zheng, Hu, and Bigsten (2009) and Brandt and Zhu (2010) for related discussions.

[6] A similar functional form has been used in a cross-country growth study of Hall and Jones (1999).

Again, as previously, the sign Δ denotes the difference between two adjacent time periods.

In this augmented model, we assume that productivity growth is determined by

$$A_{i,t+1} / A_{it} = h_{it}^{\theta} f_{it}^{\rho(h)} A_{it}^{\lambda(f,h)} T_t X_i \tag{13}$$

in which

$$\rho(h) = \rho_0 + \rho_1 \ln h_{it} \tag{14}$$

$$\lambda(f,h) = \lambda_0 + \lambda_1 \ln f_{it} + \lambda_2 \ln h_{it} \tag{15}$$

That is, productivity growth is now related also to the level of per worker human capital stock as the latter is a crucial determinant of the absorptive capacity for new technologies.[7] Equations (11), (13), (14) and (15) then yield

$$\Delta \ln A_{it} = \lambda_0 \ln y_{it} - \lambda_0 \alpha \ln k_{it} - \lambda_0 (1-\alpha) \ln h_{it} + (\rho_0 + \rho_1 \ln h_{it}) \ln f_{it} \tag{16}$$

$$+\theta \ln h_{it} + \lambda_1 \ln y_{it} \ln f_{it} - \lambda_1 \alpha \ln k_{it} \ln f_{it} - \lambda_1 (1-\alpha) \ln f_{it} \ln h_{it}$$

$$+\lambda_2 \ln y_{it} \ln h_{it} - \lambda_2 \alpha \ln k_{it} \ln h_{it} - \lambda_2 (1-\alpha)(\ln h_{it})^2 + \ln T_t + \ln X_i$$

Inserting Equation (16) back into Equation (12), we obtain the following regression specification

$$\Delta \ln y_{it} = \lambda_0 \ln y_{it} - \lambda_0 \alpha \ln k_{it} + [\theta - \lambda_0 (1-\alpha)] \ln h_{it} + \rho_0 \ln f_{it} \tag{17}$$

$$+\lambda_1 \ln f_{it} \ln y_{it} - \lambda_1 \alpha \ln f_{it} \ln k_{it} + [\rho_1 - \lambda_1 (1-\alpha)] \ln f_{it} \ln h_{it}$$

$$+\lambda_2 \ln y_{it} \ln h_{it} - \lambda_2 \alpha \ln k_{it} \ln h_{it} - \lambda_2 (1-\alpha)(\ln h_{it})^2$$

$$+\alpha \Delta \ln k_{it} + (1-\alpha) \Delta \ln h_{it} + \eta_t + u_i + v_{it}$$

where, again, η_t is the time intercept, u_i is the province heterogeneity, and v_{it} is the idiosyncratic error.

We need to calculate the levels of per worker human capital stock h_{it} before we are able to run a regression based on the augmented model. To this end, we follow the basic method used by Hall and Jones (1999) and assume that per worker human capital is positively related to educational attainment by $\ln h_{it} = \mu(E_{it})$, where E denotes the average years of schooling attained by a worker in the labor force (with $\mu(0) = 0$).[8] Following Hall and Jones (1999), we calculate the levels of h_{it} by assuming that

[7] Better-educated workers have a comparative advantage in implementing new technologies. See, for example, Benhabib and Spiegel (1994) and Prescott (1998).

[8] The derivative $d\rho / dE$ is the return to schooling estimated in a Mincerian wage regression (Mincer, 1974).

$\mu(E)$ is piecewise linear, with the rate of return being 13.4%, 10.1% and 6.8% respectively for schooling of the first four years, the second four years, and that beyond the eighth year.[9]

3.2 Regression Results

With data on provincial per worker human capital obtained via the method described above, we are now able to run a nonlinear least squares regression based on Equation (17). Just as before, we adopt a yearly data setup so that the sign Δ in Equation (17) pertains to the difference between two adjacent years. Further, we employ a time dummy variable for each year and a province dummy variable for each province to take account of the time intercept and province heterogeneity in Equation (17). The estimation results are summarized in Table 2. Again, for the sake of brevity, the estimated coefficients on the time and province dummy variables are not shown in the table.

In Table 2, the estimates of the parameters are all statistically significant at the usual 5% level. We see that the estimate of α (which is 0.466) is very much close to its traditionally accepted value (around 0.50) in the case of China. The negative estimate of λ_1 (which is –0.025), again, shows that FDI has a *convergence* effect on productivity. The negative estimate of λ_2 (about –0.34) shows that human capital has a *convergence* effect on productivity, too. The positive and large estimate of θ (about 3.45) shows that human capital has a large general *growth* effect on productivity. The positive estimate of ρ_1 (which is 0.036) shows that human capital magnifies the *growth* effect of FDI on productivity. That is, given a higher level of per worker human capital stock, ceteris paribus, per worker FDI stock has a larger *growth* effect on productivity.

Table 2. Regression results from Equation (17)

Obs: 448				*R*-squared: 0.6351	
Parameter	Estimate	Std. Err.	*p*-value	[95% Conf. Interval]	
α	0.466	0.027	0.000	0.414	0.519
λ_0	0.370	0.097	0.000	0.179	0.561
λ_1	-0.025	0.012	0.047	-0.049	-0.000
λ_2	-0.336	0.150	0.026	-0.631	-0.041
ρ_0	0.056	0.043	0.193	-0.028	0.139
ρ_1	0.036	0.008	0.000	0.019	0.052
θ	3.454	0.822	0.000	1.836	5.071

9 These rates of return are based on Psacharopoulos (1994)'s survey of evidence from many countries on return-to-schooling estimates. For a recent discussion of human capital and economic growth in China, see Fleisher, Li, and Zhao (2010).

We use a time dummy variable for each year and a province dummy variable for each province to take care of the time intercept and province heterogeneity in Equation (17). For brevity, the estimated coefficients on the time and province dummy variables are not reported in this table.

According to our model, it can be judged from the sign of the term $(\lambda_0 + \lambda_1 \ln f_{it} + \lambda_2 \ln h_{it})$ whether conditional convergence in productivity exists among the Chinese provinces. In this regression the estimates of λ_0, λ_1 and λ_2 are respectively positive (about 0.37), negative (about –0.03), and negative (about –0.34). Given the actual range of the values for $\ln f_{it}$ and $\ln h_{it}$ in our sample, we do not significantly negative values of $(\lambda_0 + \lambda_1 \ln f_{it} + \lambda_2 \ln h_{it})$. Therefore, this regression does not suggest conditional convergence in productivity among the Chinese provinces.

The estimated coefficients on the province dummy variables (i.e. the estimated province intercepts) from the regression based on Equation (17) above are also meaningful. These estimated province intercepts are meant to capture 'permanent' province-specific factors that affect provincial per worker output growth. Obviously, one such 'permanent' factor, among many others, would possibly be provincial per worker resource endowment. However, measures of provincial per worker resource endowment were not explicitly included in our theoretical aggregate production function, and hence were not explicitly included in our regression equation as explanatory variables. Nevertheless, as a preliminary test, we can use provincial population density (persons per square kilometer of the provincial area) as a rough (inverse) proxy for provincial per worker resource endowment. We can then find a significant negative correlation between the provincial population density and the estimated province intercept (in any given year in our sample period). Take the year 2004 (which is the midpoint year of our sample period 1996–2012) for example, a simple regression of the estimated province intercepts on the provincial population densities for this year shows that the latter has a significantly (p-value = 0.009) negative effect on the former, and this one-explanatory-variable simple regression has a goodness-of-fit as large as $R^2 = 0.23$.

4. Concluding Remarks

This paper presents an analytic framework with empirical evidence aiming to improve our understanding of the roles of FDI in shaping productivity growth. Specifically, the paper empirically examines the effects of FDI on China's regional productivity growth. Using a nonlinear regression approach based on the theoretical model, this paper has empirically investigated how FDI affects and shapes productivity growth in the Chinese provinces. Our estimation results, which are based on the two versions of our model, one excluding and one including human capital, have shown that FDI generates both a general growth effect and a convergence effect on productivity across the Chinese provinces. This major finding implies that on top of its direct, static level effect on output as an accumulable production input, FDI also exerts indirect, dynamic impacts on output via its growth and convergence effects on productivity. The modeling of the roles of FDI and the related empirical analysis in this paper were aimed to expand our understanding of the roles of FDI in shaping productivity and income growth in an economy or across different economies.

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