How foreign investments contribute to economic growth of industrial parks in China: a production-frontier decomposition approach

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Abstract

We study the importance of foreign direct investment for economic growth of 52 Chinese industrial parks from 2007 to 2015. For this task, we extend a production-frontier methodology, specially designed to decompose economic growth into different sources, to take two types of capital into account. Our results reveal that foreign capital is necessary for boosting economic growth of the parks, but domestic capital played the main role.

Keywords: Economic growth; Decomposition; Foreign Capital; Industrial Parks; China.

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1 Introduction

Industrial parks are playing a crucial role in boosting economy growth in China. As proof, these parks have attracted an important share of the investments in China, and, in particular, of foreign direct investment (from around 10% (30.713 billion RMB) in 2000 to 40.59% (330.1 billion RMB) in 2016).[1]

This is mainly explained by the presence of economies of scale, common infrastructures and preferential policies that helped to attract foreign direct investment within the parks. Knowing which part of economic growth of the parks is due to foreign direct investment (and, thus, which part is due to domestic investment) is therefore of high interest to policy-makers.

Typically, economic growth decomposition exercises are based on the well-known decomposition suggested by Solow (1956). Recently, production-frontier methodologies have been suggested as an alternative method for this task. The main advantage of these methodologies is their nonparametric nature. Indeed, production-frontier techniques do not depend on any assumption on the growth process, and in particular on the production function. Instead, production-frontier methodologies reconstruct the technology using the data. This is attractive as, in practice, imposing a particular production function could be difficult, and more importantly, could have huge impacts on the results, and in the worst case, bias the results.

Kumar and Russell (2002) were the first to consider a production-frontier methodology to decompose economic growth. They obtained a decomposition in three parts: (1) technological change (shifts in the production frontier), (2) technological catch-up (movements toward or away from the frontier), and (3) physical capital accumulation. Henderson and Russell (2005) extended their decomposition by adding an extra component: (4) human capital accumulation. This decomposition has been applied by, for example, Enflo and Hjertstrand (2009), Badunenko and Tochkov (2010), Piacentino and Vassallo (2011), Badunenko, Henderson and Russell (2013), and Badunenko and Romero-Avila (2014); and extended by, for example, Badunenko Romero-Avila (2013) for financial institutions, Walheer (2016a, b) for sector heterogeneity and interdependence, and Walheer (2018) for energy.

In this letter, we extend the decomposition by distinguishing between two types of capital: foreign and domestic capital. We apply the extended decomposition to

[1] As given by the Department Investment Administration of the Ministry of Commerce of China.

the case of 52 industrial parks in China for the period 2007-2015.

2 Methodology

We consider that industrial parks produce output Y using labour L, domestic capital K^d , foreign capital K^f, and human capital H. We also assume that human capital enters the technology as a multiplicative augmentation of labour input, i.e. $\hat{L} = H \times L$. As such, the production function is given by $Y(K^d, K^f, \hat{L})$. To correspond with previous works on economic growth modelling, we assume that the production function is quasi-concave, continuous, strictly increasing, and satisfies constant returns-to-scale.[2] Therefore, the variables can be rewritten as $\hat{y} = Y/\hat{L}$, $\hat{k}^d = K^d/\hat{L}$, and $\hat{k}^f = K^f/\hat{L}$; and the production function as $\hat{y}(\hat{k}^d, \hat{k}^f)$.

Our aim is to decompose the output growth between two years into four parts: (1) efficiency change, i.e. shifts in the production frontier; (2) technological change, i.e. movements toward or away from the frontier; (3) domestic capital accumulation; (4) foreign capital accumulation; and (5) human capital accumulation. Formally, by denoting c and b as the current and base years (where $y = Y/L$):

$$\frac{y_c}{y_b} = EFF \times TECH \times K^d ACC \times K^f ACC \times HACC. \tag{1}$$

The decomposition is obtained in five main steps.

Step 1. Decompose the growth of output into the growth of human capital and the growth of output per unit of augmented labour:

$$\frac{y_c}{y_b} = \frac{H_c}{H_b} \times \frac{\hat{y}_c}{\hat{y}_b}. \tag{2}$$

Step 2. Isolate the effect of pure efficiency and technical change:

$$\frac{y_c}{y_b} = \frac{H_c}{H_b} \times \frac{\theta_c}{\theta_b} \times \frac{\hat{y}_c(\hat{k}_c^d, \hat{k}_c^f)}{\hat{y}_b(\hat{k}_b^d, \hat{k}_b^f)}. \tag{3}$$

[2]Note that it is straightforward to extend the decomposition to other assumptions on the production function (as, for example, non-convexity, variable returns-to-scale).

where $\theta_t = \frac{\hat{y}_t}{\hat{y}_t(\hat{k}_t^d, \hat{k}_t^f)}$, for $t = \{b, c\}$, is interpreted as the inverse of the maximal amount that output $\hat{y}_t$ can be expanded while keeping the production factors constant. θ_t is bounded from above by 1. If $\theta_t = 1$, it means that $\hat{y}_t = \hat{y}_t(\hat{k}_t^d, \hat{k}_t^f)$, output is at its maximal level. If $\theta_t < 1$, it means that $\hat{y}_t < \hat{y}_t(\hat{k}_t^d, \hat{k}_t^f)$, output can, in principle, be expanded (for constant level of production factors).

Step 3. Isolate the effect of domestic and foreign capital:

$$\begin{aligned}\frac{\hat{y}_c}{\hat{y}_b} &= \frac{\theta_c}{\theta_b} \times \frac{\hat{y}_c(\hat{k}_c^d, \hat{k}_c^f)}{\hat{y}_b(\hat{k}_c^d, \hat{k}_c^f)} \times \frac{\hat{y}_b(\tilde{k}_c^d, \hat{k}_b^f)}{\hat{y}_b(\hat{k}_b^d, \hat{k}_b^f)} \times \frac{\hat{y}_b(\tilde{k}_c^d, \tilde{k}_c^f)}{\hat{y}_b(\tilde{k}_c^d, \hat{k}_b^f)} \times \left(\frac{\hat{y}_b(\hat{k}_c^d, \hat{k}_c^f)}{\hat{y}_b(\tilde{k}_c^d, \tilde{k}_c^f)} \frac{H_c}{H_b}\right), \\ &= EFF \times TECH^c \times K^d ACC^b \times K^f ACC^b \times HACC^b, \end{aligned} \tag{4}$$

where $\tilde{k}_c^d = K_c^d/(L_c H_b)$ and $\tilde{k}_c^f = K_c^f/(L_c H_b)$ are, respectively, domestic and foreign capital under the counterfactual assumption that human capital has not changed from its base period. Note that (4) is obtained from (3) by multiplying top and bottom by $\hat{y}_b(\hat{k}_c^d, \hat{k}_c^f)$, $\hat{y}_b(\tilde{k}_c^d, \hat{k}_b^f)$, and $\hat{y}_b(\tilde{k}_c^d, \tilde{k}_c^f)$. Also, (4) is obtained by taking b as the reference year for the technology. We can obtain another decomposition by taking c as the reference year. It is obtained by multiplying top and bottom of (3) by $\hat{y}_c(\hat{k}_b^d, \hat{k}_b^f)$, $\hat{y}_c(\tilde{k}_b^d, \hat{k}_c^f)$, and $\hat{y}_c(\tilde{k}_b^d, \tilde{k}_b^f)$:

$$\begin{aligned}\frac{\hat{y}_c}{\hat{y}_b} &= \frac{\theta_c}{\theta_b} \times \frac{\hat{y}_c(\hat{k}_b^d, \hat{k}_b^f)}{\hat{y}_b(\hat{k}_b^d, \hat{k}_b^f)} \times \frac{\hat{y}_c(\hat{k}_c^d, \hat{k}_c^f)}{\hat{y}_c(\tilde{k}_b^d, \hat{k}_c^f)} \times \frac{\hat{y}_c(\tilde{k}_b^d, \hat{k}_c^f)}{\hat{y}_c(\tilde{k}_b^d, \tilde{k}_b^f)} \times \left(\frac{\hat{y}_c(\tilde{k}_b^d, \tilde{k}_b^f)}{\hat{y}_c(\hat{k}_b^d, \hat{k}_b^f)} \frac{H_c}{H_b}\right), \\ &= EFF \times TECH^b \times K^d ACC^c \times K^f ACC^c \times HACC^c, \end{aligned} \tag{5}$$

where $\tilde{k}_b^d = K_b^d/(L_b H_c)$ and $\tilde{k}_b^f = K_b^f/(L_b H_c)$ are, respectively, domestic and foreign capital under the counterfactual assumption that human capital has not changed from its current period. As a final remark, note that the two decompositions in (4) and (5) are only equivalent if neutrality of technological change is assumed (as in Solow (1956)).

Step 4. Take the geometric average:

$$\frac{y_c}{y_b} = EFF \times \left(TECH^b \times TECH^c\right)^{1/2} \times \left(K^d ACC^b \times K^d ACC^c\right)^{1/2}$$
$$\times \left(K^f ACC^b \times K^f ACC^c\right)^{1/2} \times \left(HACC^b \times HACC^c\right)^{1/2},$$
$$= EFF \times TECH \times K^d ACC \times K^f ACC \times HACC. \tag{6}$$

Taking the geometric weight, also called the Fisher Ideal decomposition, has been introduced by Caves, Christensen, and Diewert (1982) and Färe et al (1994), and is a commonly agreed procedure in this context.

As a final remark, all the output levels are computed, for every park, by linear programs. This is one more advantage of production-frontier methodologies. Given our assumptions about the production function, the linear programs for $\hat{y}_b(\hat{k}_c^d, \hat{k}_c^f)$ is given by:

$$\hat{y}_b(\hat{k}_c^d, \hat{k}_c^f) = \max \left\{ \hat{y} \mid \hat{y} \leq \sum_{\tau=1}^{b} \sum_j \lambda_{j\tau} \hat{y}_{j\tau}; \hat{k}_c^d \geq \sum_{\tau=1}^{b} \sum_j \lambda_{j\tau} \hat{k}_{j\tau}^d; \hat{k}_c^f \geq \sum_{\tau=1}^{b} \sum_j \lambda_{j\tau} \hat{k}_{j\tau}^f; \forall j, \forall \tau : \lambda_{j\tau} \geq 0; \hat{y} \geq 0 \right\}. \tag{7}$$

Note that, in (7), we adopt a reconstruction of the production function that precludes technological degradation. This method of reconstructing the technology, introduced by Diewert (1980), is used in most production-frontier growth decomposition exercises. The other output levels are obtained by changing the corresponding variables in (7).

3 Industrial parks in China

We combine different sources to obtain the data for our four production factors and output. Our main data source is the China Torch Statistic Year Book. This database has been designed to study parks. Unfortunately, the distinction between foreign and domestic capital is not done in a clear manner in that database. Fortunately, foreign capital is given in the China Commerce Yearbook. It turns out that domestic capital is obtained as the difference between total and foreign capital. Finally, we deflate the data by the inflation rate, collected from the National Bureau of Statistics of China.

We end with a sample of 52 parks from 2007 to 2015. We present our main findings below. In particular, we present in Table 1 the averages and medians of the growth decomposition for the period considered (as such 2007 is the base year and 2015 the current year; also note that percentages are obtained by subtracting 1 from the index and multiplying by 100).

We consider 4 different specifications. In our first specification, we compute the contribution of total capital, denoted by $KACC$, and include human capital (as such, this modelling is similar to the one of Henderson and Russell (2005)). Our second specification distinguishes between foreign and domestic capital (as such, this specification corresponds to the one explained in Section 2). For our third and fourth specifications, we exclude human capital for the decomposition. Our main reason to exclude human capital is that it is not so clear for empirical macroeconomics whether human capital should be included as a production factor. As such, our third specification is similar to the one used in Kumar and Russell (2005), while our fourth specification could be seen as a special case of the decomposition explained in Section 2 when human capital is not included.

Table 1: Decomposition of economic growth (%)

		$PROD$	EFF	$TECH$	$KACC$	$HACC$	K^dACC	K^fACC
1	*Median*	20.45	22.23	29.57	102.99	3.59	-	-
	Average	62.79	21.90	39.09	108.47	5.42	-	-
2	*Median*	20.45	8.41	35.18	-	3.46	76.71	22.18
	Average	62.79	15.95	45.97	-	5.29	68.02	21.97
3	*Median*	20.45	23.15	29.57	103.67	-	-	-
	Average	62.79	15.86	22.40	119.21	-	-	-
4	*Median*	20.45	7.31	30.83	-	-	79.07	23.53
	Average	62.79	30.80	44.42	-	-	80.73	21.69

An initial observation is that $PROD$ is equal for the four specifications. This is intuitive as economic growth is given by that data and not by the model. The first specification reveals that capital accumulation has played the main role in boosting economic growth of the industrial parks. This is not surprising as the main motivation of creating industrial parks is to attract massive investments. Next, efficiency and technical progress have played important roles, but their respective contribution is clearly smaller than the one of capital. The role of human capital is rather small. These results are clearly confirmed when dropping human capital (see specification

3).

Next, when considering the two types of capitals (specification 2), as expected, the contribution of $KACC$ is mostly taken by K^dACC and K^fACC. That is, the other components are very similar when pooling or splitting capital. Importantly, the contribution of domestic capital is higher than the one of foreign capital, while the latter is not negligible and has a clear contribution to economic growth of the parks. The main role of domestic capital is not really a surprise. Indeed, investments in parks are regulated and made under supervision of the (local) governments. Also, it is worth noting that a large proportion of the foreign direct investments in parks takes place through partnerships with domestic firms. In a sense, foreign investments are necessary for helping to develop the parks quickly, via sharing advanced technology, management skills, etc., while domestic capitals plays the main role. These results are, once more, confirmed when removing human capital from the model (specification 4).

As a last step, we investigate the relationships between $PROD$ and the different components. To do so, we make use of Spearman correlations. The correlation of Spearman is by nature nonparametric, and thus better fits in this context. The coefficients are shown in Table 2.

Table 2: Spearman correlation coefficients

		EFF	$TECH$	$KACC$	$HACC$	K^dACC	K^fACC
1	*Coefficient*	0.13	0.11	0.57	0.14	-	-
	$p-value$	0.33	0.40	0.00	0.31	-	-
2	*Coefficient*	0.22	0.14	-	0.14	0.48	0.30
	$p-value$	0.10	0.30	-	0.29	0.00	0.04
3	*Coefficient*	0.13	0.12	0.52	-	-	-
	$p-value$	0.33	0.38	0.00	-	-	-
4	*Coefficient*	0.18	0.17	-	-	0.47	0.31
	$p-value$	0.18	0.20	-	-	0.00	0.03

The correlation coefficients are positive for every component under all the specifications, but only the coefficients for capital, and domestic and foreign capital are significant. Once more, it reveals the main role of this production factor for the economic growth of the parks. Also, the correlation coefficients of domestic capital are higher than the ones of foreign capital for both specifications. This confirms our results of Table 1: foreign capital is necessary for parks, but domestic capital plays the main role.

4 Conclusion

In this letter, we investigated how foreign and domestic capital have contributed to economic growth of Chinese industrial park. To do so, we extended a production-frontier methodology to distinguish between these two types of capital. Our results reveal the importance of foreign capital, but also show that domestic capital is the main driver. The proposed approach can be extended to take more production factors into consideration, use to study the convergence between industrial parks, and also for any contexts when two types of capital are involved.

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