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DEA analysis of FDI attractiveness for sustainable development: Evidence from Chinese provinces

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ABSTRACT

The paper extends the Malmquist productivity index to establish a theoretical model to evaluate *foreign direct investment* (FDI) attractiveness. This model and its implementation mechanism consider cost efficiency and profit efficiency changes that represent the influence of price level on inputs and outputs respectively. Using data from China from 1997 to 2008, we assess the attractiveness of FDI in terms of human capital stock, material capital stock, energy consumption situation, and degrees of market openness. We use *data envelopment analysis* to find the bottleneck of FDI attractiveness and to identify the potential market of each province. This study contributes to the literature by providing sound investment advices to multinational corporations. It also offers policy advice and guidelines to developing nations for setting policies and programs to attract FDI. Specifically, our results provide useful inputs for policy makers to create a mechanism design to attract FDI in the host country.

1. Introduction

Over the last several decades, both developed and developing countries have attempted to attract foreign direct investment (FDI) to increase gross domestic product. For example, U.S. was ranked as the top country in attracting FDI in 2009. In 2002, the United Nations Conference on Trade and Development adopted a performance index and a potential index to assess the national FDI performance for the first time [39]. It reported that macroeconomic management mechanism, such as growth prospects, skilled labor, natural resources, fundamental and advanced facilities, and export channels could benefit from FDI.

There are numerous studies on FDI impact and attractiveness. In this paper, we broadly define FDI attractiveness as the capability of the host country to attract FDI. Deng et al. [17] stated that the economic development of a country, human capital, and balance of international payment are key factors affecting the ability of a host country to attract FDI. Basile et al. [6] investigated foreign subsidiaries in 50 European regions to examine the determinants of attracting FDI, such as training, infrastructures and R&D. Several authors discovered that there are numerous positive effects of FDI on the host economy including GDP growth, technology and equipment transfer, international management expertise, job opportunity, and increased export [1–3,5,7,9,16,18,33,36,38]. Nourzad [29] argued that a general consensus is that FDI contributes to economic growth through several channels, of which the most important is technology transfer. Rashmi [32] estimated the total productivity growth of Japanese and U.S. FDI in India and found that only Japanese FDI positively affect productivity growth. However, Tanaka [37] found that excess skilled-labor has a negative effect on Japanese multinational enterprises, though vertical FDI activity was more popular in Japanese multinational enterprises than in the U.S. Franco [21] found FDI spillover effects in U.S. foreign subsidiaries operating in Organization for Economic Co-operation and Development (OECD) countries. Also, from the empirical evidence of OECD and the World Bank, Pica and Mora [30] found that countries with similar economic environments tend to associate with larger bilateral FDI. Fu et al. [22] suggested that there were dual FDI characters in the UK retail sector and found that human resource management capabilities had a positive effect on FDI attractiveness. Fu and Gong [23] explored the spillover effects of FDI in China using total factor productivity growth from 2001 to 2005. Criscuolo and Narula [15] showed that FDI spillovers occur in firms with high absorption capacity. Balasubramanyam and Sapsford [4] found that when a host country has adequate human resources, improved infrastructure and stable economic environment, FDI is a powerful tool for economic progress.

There is considerable theoretical and empirical literature examining the impact of FDI on the host country's economy and FDI attractiveness by using *data envelopment analysis* (DEA) models proposed in Ref. [10]. While DEA is a fairly established nonparametric technique used in empirical research for making inferences, it has recently being used to evaluate performances of complex entities without referencing to their input or output prices. For example, it has been used to predict performances of public and private entities including the microcosmic and macroscopic view [34,43]. Being a nonparametric technique, DEA has

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the benefit of not assuming the input or output prices are of a particular functional form. Thus, its output is not adversely affected by outliers. However, DEA evaluates output efficiency under static conditions. A methodological contribution of this paper is that we combine the Malmquist productivity index with DEA to assess output efficiency under dynamic condition. Whereas the traditional price influence efficiency model consider either profit efficiency [31] or cost efficiency [26,28] separately, we build an extended Malmquist productivity model to consider both profit efficiency and cost efficiency simultaneously.

Dees [16] found that market size and degrees of market openness, labor force, innovation, and currency exchange rate are determinants of FDI attractiveness in China. Cheng and Kwan [11] examined the determinants of FDI in Chinese regions and found that large regional market, good infrastructure, education, and preferential policy had a positive impact; however, labor cost had a negative impact. Hu [25] provided a simple input–output DEA model to evaluate FDI attractiveness in China, and subsequently, He [24] continued the study by using group method of data handling and DEA to explore FDI attractiveness in China. Sun et al. [35] used Malmquist to assess the total factor productivity growth for Taiwanese industries and found that outward FDI promoted some industries, but led to lower innovation.

Over the last two decades, economic globalization has created an enormous influx of FDI in China. It is not uncommon to find multinational corporations that have outsourced or relocated their domestic manufacturing facilities to China. Since opening its market to foreign investors in 1978, China's FDI has accumulated to U.S. $1.06 trillion. While the recent financial crisis has caused a significant decline in global FDI by nearly 40% [40], China attracted $94 billion of FDI in 2009. Indeed, China was ranked second in total FDI after the U.S. in 2009. Correspondingly, although two thirds of cross-border mergers and acquisitions occurred in developed countries, the percent of developing countries that served as hosts of cross-border mergers and acquisitions increased from 26% in 2007 to 31% in 2009.

Since the 1990s, China has had an overall excellent FDI attractiveness; however its provinces and regions exhibited a wide variation in FDI attractiveness. Understanding the causes of the variation is interesting academically, but more importantly it is crucial for investors to improve their returns on investments and for the host country to enhance its FDI attractiveness uniformly. Therefore, one of the goals of this paper is to determine the best way to combine FDI attractiveness with the strengths of China's different provinces. Research results could identify the unique patterns of FDI attractiveness and find a breakthrough to improve FDI in China.

This paper differs from the existing literature in several aspects. First, instead of using traditional DEA and cross-sectional data, we use the extended Malmquist model to analyze panel data to evaluate FDI attractiveness. Second, the traditional Malmquist model ignores the price influence on cost and profit although FDI attractiveness is affected by price levels because the primary objective of FDI is monetary benefit. To address this deficiency, we build an extended Malmquist model to consider the price influence on cost and profit to assess FDI attractiveness of each Chinese province. Third, we consider both the FDI performance and FDI potential of each province's sustainable development strategy. Fourth, as opposed to the traditional literature that focuses on FDI spillover effects, this study uses data from 1996 to 2008 to examine the FDI attractiveness of 30 Chinese provinces. In summary, this study not only adds to the literature by providing investment advice to multinational corporations but also provide inputs to assist policy makers in developing nations to create a mechanism design to attract FDI. Policy makers can use the extended Malmquist model to create appropriate market conditions (mechanisms) to increase FDI (outcome) while respecting the fact that provinces (agents) have private information that they may disclose in response to an appropriate incentive-compatible mechanism.

2. A conceptual FDI attractiveness model

The Malmquist productivity index (MPI) is a nonparametric index that is often used in decision-making unit (DMU) efficiency research. Caves et al. [8] proposed the MPI and defined it as “the best practice frontier” to identify the influence of pure technical efficiency, scale efficiency, and technology changes [19]. Chou et al. [14] extended the traditional Malmquist to evaluate the performance of a region or industry. This study uses MPI to estimate China's provincial FDI attractiveness in terms of two outputs: FDI performance index (A) and FDI potential index (P). Four input factors: material capital (M), human capital (H), energy (E), and degrees of market openness (O) are considered in this study.

Traditional MPI ignores the effect of local price level on the efficiency of input allocation and the efficiency of output structure that may affect the DMUs' total factor productivity (TFP). In order to accurately estimate FDI attractiveness, we incorporate price levels of each province in the traditional MPI model. Specifically, we add two new variables to the traditional TFP: *total factor return productivity* (TFRP) to measure the cost of inputs, and *total factor profit productivity* (TFPP) to measure the cost of inputs and profit of outputs. Essentially, we build a new FDI attractiveness model as shown in Fig. 1.

3. Basics of decomposing FDI attractiveness

The decomposing method of our proposed FDI attractiveness model follows the process of the traditional MPI, except that the new MPI index considers both the cost of inputs and profit of outputs as shown in Fig. 2.

3.1. The first stage of FDI attractiveness model decomposition

If we assume inputs x are used to produce outputs y at period t, then the standard production set is notated as,

$$S^t = \left\{ \left(x^t,\ y^t \right) : x \geq X\lambda, y \leq Y\lambda, \lambda \geq 0, x^t \text{ can produce } y^t \right\}, t = 1, \ldots, T. \quad (1)$$

Alternatively, based on the concept of a distance function, the distance function within Eq. (1) is formulated as,

$$D^t\left(x^t, y^t\right) = \sup\left\{\rho : \left(x^t, y^t\right) \in S^t\right\} = \left(\inf\left\{\rho : \left(x^t, y^t\right) \in S^t\right\}\right)^{-1}. \quad (2)$$

The distance function measures the maximum reduction that inputs can be adjusted. When $D^t(x^t, y^t)$ equals 1, it indicates that the function is efficient because (x^t, y^t) is on the isoquant.

Decomposition properties of the traditional MPI suggests that we can decompose the new MPI into two mutually exclusive and exhaustive components: changes in technical efficiency over the time (catching-up) with price influence as the overall technical efficiency changes (OEC) and shifts in technology over the time (frontier-shift) as technology changes (TC). The decomposition is as follows:

$$M_p = \underbrace{\frac{\overline{\overline{D}}^t\left(x^t, p_i^t, y^t, p_o^t\right)}{\overline{\overline{D}}^{t+1}\left(x^{t+1}, p_i^{t+1}, y^{t+1}, p_o^{t+1}\right)}}_{①} \times \underbrace{\left[\left(\frac{\overline{\overline{D}}^{t+1}\left(x^{t+1}, p_i^{t+1}, y^{t+1}, p_o^{t+1}\right)}{\overline{\overline{D}}^t\left(x^{t+1}, p_i^{t+1}, y^{t+1}, p_o^{t+1}\right)}\right)\left(\frac{\overline{\overline{D}}^{t+1}\left(x^t, p_i^t, y^t, p_o^t\right)}{\overline{\overline{D}}^t\left(x^t, p_i^t, y^t, p_o^t\right)}\right)\right]^{1/2}}_{②}. \quad (3)$$

In Formula (3) above, part ① indicates that OEC is similar to the catching-up components of the traditional MPI proposed by [19]. That is, OEC measures the catching-up effect of productivity set